

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

FERVO ENERGY CO.

Petitioner

vs.

ORMAT TECHNOLOGIES INC.

Patent Owner

Case IPR2024-00665

U.S. Patent No. 7,320,221

Declaration of Robert Schaaf

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I, Robert Schaaf, hereby declare as follows:

I. Introduction

A. Background

1. My name is Robert Schaaf. I am a consultant working in the field of oil/gas/geothermal drilling and operations.

2. I am over the age of eighteen and am otherwise competent to make this declaration.

3. Petitioner is challenging Claims 1-38 of the '221 patent (the "Challenged Claims").

4. I have been retained to act as an expert witness on behalf of Fervo Energy Co., ("Fervo" or "Petitioner") in connection with the above captioned Petition for Review of U.S. Patent No. 7320,221 ("the '221 patent"), titled "Method and Apparatus for Using Geothermal Energy for the Production of Power". The '221 patent is provided as Exhibit 1001.

5. I have also been retained to provide an analysis regarding what a person of skill in the art ("POSITA") would have understood at the time of the invention of the '221 patent. Furthermore, I have been asked to consider whether certain prior art references teach or suggest the features recited in the Challenged Claims of the '221 patent.

6. I have reviewed and am familiar with the '221 patent as well as its prosecution history. The file history of the '221 patent is provided as Exhibit 1002. Additionally, I have reviewed the references identified in Section VI.

7. As set forth below, I am familiar with the geothermal extraction techniques and the use of geothermal heat in power generation as of the effective date of the '221 Patent. I have been asked to provide my technical review, analysis, insights, and opinions regarding the documents and prior art references that form the basis for the Petition. In forming my opinions, I have relied on my own experience and knowledge, my review of the '221 patent and its file history, and of the prior art references cited in the Petition.

8. My opinions expressed in this Declaration rely to a great extent on my own personal knowledge and recollection. However, to the extent I considered specific documents or data in formulating the opinions expressed in this Declaration, such items are expressly referred to in this Declaration.

9. I am being compensated for my time in connection with this Declaration at \$250 per hour. My compensation is not contingent upon and in no way affects the substance of my testimony.

B. Qualifications

10. I have been working as a patent litigation consultant as an oil and gas drilling and operations expert since 2014.

11. My curriculum vitae is attached to this report as EX1005. It includes my professional experience, qualifications, a list of the publications that I have authored, and a list of the cases in which, since 2013, I have testified as an expert by deposition and have provided a declaration. I expect to testify regarding my background, qualifications, and experience relevant to the issues in this investigation.

12. I have served as the Chairman of the Los Angeles Basin Society of Petroleum Engineers and I continue to be on the Board of Directors. I have received awards from the Society of Petroleum Engineers for Projects and Service. I also received the Outstanding Engineering Merit Award for 2015 from the Orange County Engineering Council.

13. Before I became a consultant, I was a senior project manager at Occidental Petroleum Corporation (“Occidental”). I was also project manager for Aera Energy, LLC (“Aera”). For the 25 years before that, I worked for Chevron Corporation (“Chevron”), where I became Engineering and Drilling Manager for Chevron’s Congo operations. During my time at Chevron, I also served in various roles for Chevron’s operations in Kuwait, Angola, Zaire, Bakersfield, and the Los Angeles Basin.

14. During my over 40 years in the practice of petroleum and drilling engineering I have engaged in a number of projects which have provided me with

relevant experience and expertise in a number of the foundational technologies within the scope of the '221 invention.

15. From 1979 to 1981, I was employed as a Reservoir Engineer for Chevron in Bakersfield, California. As part of my duties, I designed water and steam injection projects. The work included the placing of injection and production wells in order to maximize recovery from a reservoir.

16. From 1981 to 1983, I was employed as a drilling engineer for Chevron where I supervised drilling rigs for an ongoing development program and designed and oversaw drilling programs for a wide variety of development and exploration wells. I designed new wells and also oversaw the actual drilling process. My responsibilities included making sure the wells were drilled to the designed specifications.

17. From 1983 to 1985, I was the lead engineer for Chevron for field operations in the Los Angeles Basin. There, I oversaw rig operations, new facilities installations, and production optimization. Among the projects that I supervised included optimizes water and steam injection and production wells. The work required determining optimal injection rates to maximize ultimate oil recovery while preventing well and formation damage.

18. I was a production engineer from 1985 to 1987 where I worked in oil fields in California. I developed drilling and workover programs for both onshore

and offshore fields as part of this assignment. A large part of the work in this position required the design of injection and production wells to maximize ultimate oil recovery. This work required close monitoring of injection pressures and temperatures. Well production rates were closely watched to determine if the injection rates were resulting in the optimum effect on the reservoirs.

19. Then, from 1989 to 1993 I was Chief Engineer in Zaire for Chevron. During my time there, I oversaw the first horizontal well drilled in West Africa. I was also in charge of achieving the proper injection rates for various water injection projects.

20. From 1993 to 1997 I was a senior staff engineer in Angola. While in Angola, I designed development drilling programs to build on existing production, as well as oversaw expansion into new fields. I worked on various injection projects that included both horizontal production and injection wells. My duties included optimizing injection rates in order to achieve maximum oil recovery.

21. From 1997 to 1999, I was the planning manager for the Southern Africa Business Unit that oversaw the offshore operations in West Africa. From 1999 to 2001, I was the chief engineer for the Congo where I was in charge of drilling new wells, well completions, and increasing production of existing wells. This assignment required me to oversee field developments that included drilling

horizontal injection and production wells. My tasks included placing these wells so as to recover the most amount of oil with the fewest amount of wells.

22. I was a technical consultant for Chevron in Kuwait from 2001 to 2003, where I worked on the Burgan Oil Field. From 2003 to 2004, I was the drilling and engineering manager for Chevron in the Congo. From 2005 to 2011, I worked for Aera as a project manager. All these assignments, I worked on oil fields that required the placement of horizontal production and injection wells so as to maximize recovery.

23. I earned my Bachelor of Science in Chemical Engineering from the University of Southern California in 1979.

II. Understanding of Legal Framework

24. I am a technical expert and do not offer any legal opinions. However, counsel has informed me that the claim terms should be given their ordinary and customary meaning as understood by a person of ordinary skill in the art (“POSITA”) in question at the time of the invention as set forth by the *Phillips* standard. I have been informed that the *Phillips* standard dictates that claim construction begins with the claim language itself, further informed by the intrinsic evidence of the specification and the prosecution history.

25. Counsel has also informed me that a person cannot obtain a patent on an invention if his or her invention would have been obvious to a person of ordinary

skill in the art at the time the invention was made. A conclusion of obviousness may be founded upon more than a single item of prior art. In determining whether prior art references render a claim obvious, counsel has informed me that courts consider the following factors: (1) the scope and content of the prior art, (2) the differences between the prior art and the claims at issue, (3) the level of skill in the pertinent art, and (4) secondary considerations of nonobviousness. In addition, the obviousness inquiry should not be done in hindsight. Instead, the obviousness inquiry should be done through the eyes of one of skill in the relevant art at the time of the invention.

26. In considering whether certain prior art renders a particular patent claim obvious, counsel has informed me that this Board and U.S. courts allow a technical expert to consider the scope and content of the prior art, including the fact that one of skill in the art would regularly look to the disclosures in patents, trade publications, journal articles, industry standards, product literature and documentation, texts describing competitive technologies, requests for comment published by standard setting organizations, and materials from industry conferences.

27. I understand that the United States Supreme Court's most recent statement on the standard for determining whether a patent is obvious was stated in 2007 in the *KSR* decision. Specifically, I understand that the existence of an explicit teaching, suggestion, or motivation to combine known elements of the prior art is a

sufficient, but not a necessary, condition to a finding of obviousness. Thus, the teaching-suggestion-motivation test is not to be applied rigidly in an obviousness analysis.

28. I understand that for a patent claim to be obvious, the claim must be obvious to a person of ordinary skill in the art at the time of the invention. I understand that the factors to consider in determining the level of ordinary skill in the art include (1) the educational level and experience of people working in the field at the time the invention was made; (2) the types of problems faced in the art and the solutions found to those problems; and (3) the sophistication of the technology in the field.

29. I have been informed and understand that the Supreme Court has recognized several rationales for combining references or modifying a reference to show obviousness of claimed subject matter. Some of these rationales include the following: (a) combining prior art elements according to known methods to yield predictable results; (b) simple substitution of one known element for another to obtain predictable results; (c) use of a known technique to improve a similar device (method, or product) in the same way; (d) applying a known technique to a known device (method, or product) ready for improvement to yield predictable results; (e) choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success when there is a design need or market pressure to solve a

problem; (f) 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 (g) some teaching, suggestion, or motivation in the prior art that would have led a POSITA to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

30. I have also been informed that in order to rely on a prior art reference in an obviousness analysis, the prior art reference must be analogous to the claimed invention. I also understand that a prior art reference is shown to be analogous to the claimed invention if it is shown to be either (1) in the same field of endeavor as the claimed invention; or (2) reasonably pertinent to the problem faced by the inventor (even if it is not in the same field of endeavor as the claimed invention).

31. I understand that the field of endeavor is determined by looking at the claims and specification of the challenged patent.

32. I understand that for a prior art reference to be “reasonably pertinent” to the problem, it must have logically commended itself to an inventor’s attention in considering his or her problem. To do this, it is necessary to consider the problem faced by the inventor, as reflected—either explicitly or implicitly—in the patent’s specification.

33. I understand that even if a *prima facie* case of obviousness is established, the final determination of obviousness must also consider “secondary considerations” if presented. In most instances, the patentee raises these secondary considerations of non-obviousness. In that context, the patentee argues an invention would not have been obvious in view of these considerations, which include: (a) commercial success of a product due to the merits of the claimed invention; (b) a long-felt, but unsatisfied need for the invention; (c) failure of others to find the solution provided by the claimed invention; (d) deliberate copying of the invention by others; (e) unexpected results achieved by the invention; (f) praise of the invention by others skilled in the art; (g) lack of independent simultaneous invention within a comparatively short space of time; and (h) teaching away from the invention in the prior art. I further understand that secondary considerations evidence is only relevant if the offering party establishes a connection, or nexus, between the evidence and the claimed invention. The nexus cannot be based on prior art features. The establishment of a nexus is a question of fact.

III. Level of Ordinary Skill in the Art

34. I have been advised that there are multiple factors relevant to determining the level of ordinary skill in the pertinent art, including the educational level of active workers in the field at the time of the alleged invention, the

sophistication of the technology, the type of problems encountered in the art, and the prior art solutions to those problems.

35. The Challenged Claims pertain to a method of recovering geothermal heat. However, “Many of the techniques are derived from oil and gas industry.” (’221 patent at 4:23-24).

36. It is my opinion that a person having ordinary skill in the relevant art at the time of the alleged invention is a person with a Bachelor’s degree, Master’s degree, and/or Ph.D. in Chemical Engineering, Petroleum Engineering, Energy Resource Engineering, or the like OR at least five years of experience engineering, drilling, and constructing wells. I am directly familiar with the capabilities of such persons of ordinary skill in the art because I am such a person, and have also worked with such persons. In 2004, I had at least this level of skill in the art, having a Bachelor’s degree in Chemical Engineering and was an engineering and drilling manager who supervised drilling and completion of wells but less experience, could also have met the relevant standard for a POSITA.

IV. Claim Interpretation

37. I understand that claims during an IPR are interpreted under their plain meaning, which is the meaning understood by a POSITA after reading the entire patent. The analysis focuses on how the patentee used the claim terms in the claims, specification, and prosecution history of the patent. It is my understanding that

information external to the patent, such as dictionaries, expert testimony, and prior art, may be considered if ambiguities remain. Expert testimony may be useful in helping to explain the technology.

V. Summary of the '221 Patent

A. Description of the Alleged Invention

38. The '221 patent is purportedly directed to a method and apparatus for enhancing the flow of geothermal fluid between a deeper horizontal injection well and a shallower horizontal production well, substantially spaced from each other, to improve the flow of geothermal fluid that is used for power generation. *See* EX1001 at Abstract. To enhance the flow, a pressure difference is generated between injection and production wells and a water density difference is induced by the temperature difference. *See id.* “FIG. 3 is a schematic vertical cross section of the ground, illustrating an embodiment of the apparatus of the invention” (EX1001 at 5:27-28) depicting the flow of fluid from the deeper injection well (blue) to the shallower production well (orange)

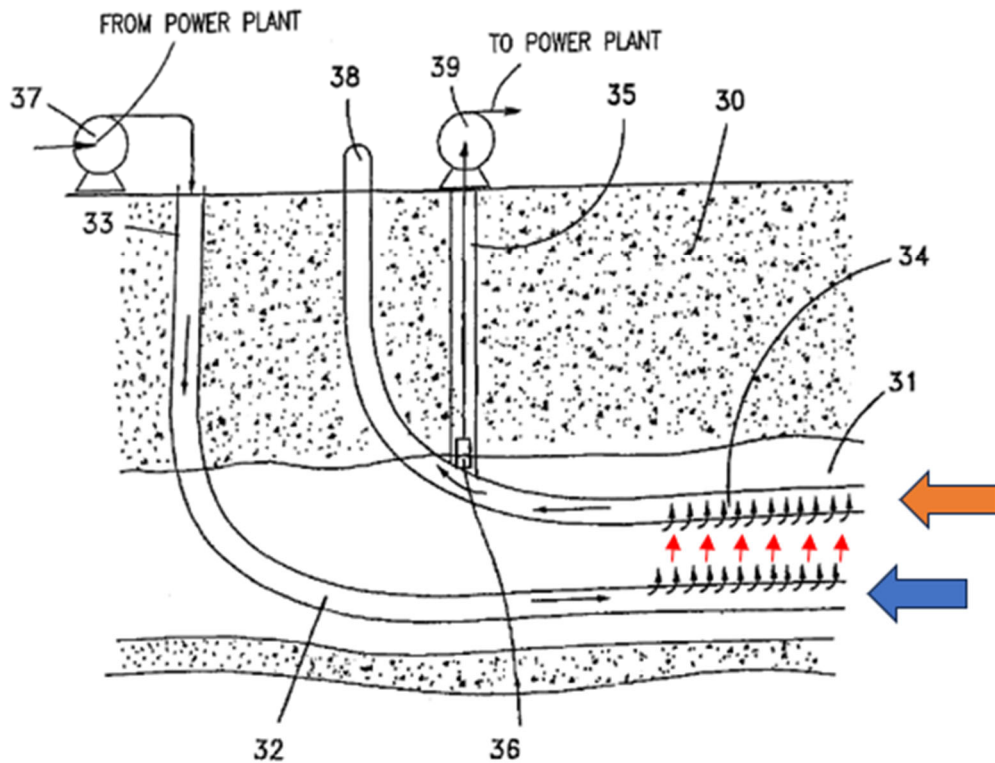


FIG. 3

39. Geothermal power plants are used to produce power from the extracted fluid. *See id.*

40. At the time that the application for the patent claims priority, which I understand is August 4, 2004, the industry was aware of this technology.

B. Prosecution History of the '221 Patent

41. During prosecution, the examiner made several rejections, including a final rejection, based on oil and gas extraction techniques described in the prior art. *See* EX1002 07-26-2006 Non-Final Rejection at 3 (“it’s well known to have an injection well [] being horizontally and vertically spaced apart from a production well[].”); *Id.* (“it’s well known to have an observation well having a differential

pressure sensor”); *Id.* (“it would have been obvious to a person having ordinary skill in the art to select different types of working fluid, distances, power plants ... for the purposes of achieving appropriate power output based on said selected fluids, distances, and power plants.”).

42. The examiner rejected Patent Owner’s argument that references from oil extraction cannot be applied in a geothermal context. *See* EX1002 11-28-2006 Final Rejection at 2. To overcome rejections, applicant amended the claim language to “further recite that the vertical distance separating the horizontal injection and production wells is dependent on the elevated temperature at the geological layer of the horizontal injection well.” EX1002 07-02-2007 Applicant Arguments/Remarks Made in an Amendment at 11. This separation based on the temperature, according to the applicant, differentiates the application from the prior art where the separation, according to the applicant, was based on the “fractured propagation length.” *Id.* at 13

VI. Documents Reviewed

43. In forming the opinions express in this Declaration, I have reviewed the following documents:

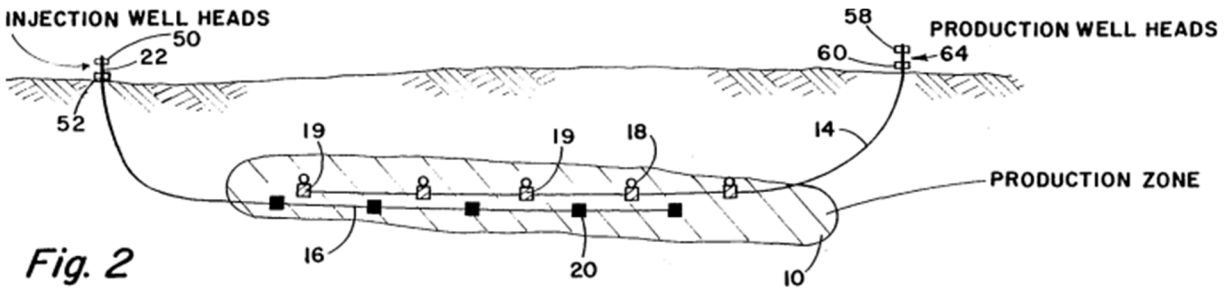
- a. EX1001, U.S. Patent No. 7,320,221 (“221 Patent”)
- b. EX1002, File History of U.S. Patent No. 7,320,221
- c. EX1003, List of Challenged Claims

- d. EX1006, U.S. Patent No. 4,676,313 (“Rinaldi”)
 - e. EX1007, U.S. Patent No. 4,850,429 (“Mims”)
 - f. EX1008, Swenson, D.V. et al., “*Modeling Flow in a Jointed Geothermal Reservoir*”, Proceedings World Geothermal Congress, pp. 2553-2558. (May 1995). (“Swenson”)
 - g. EX1009, U.S. Patent No. 5,273,111 (“Brannan”)
 - h. EX1010, Kruger, P., “*Stimulation of geothermal energy resources*” (No. ERDA-37), Energy Research and Development Administration, Washington, DC (USA). Div. of Geothermal Energy (1975). (“Kruger”)
 - i. EX1011, Grassiani, M., “*Advanced Power Plants for Use with Hot Dry Rock (HDR) and Enhanced Geothermal Technology*”, Proceedings World Geothermal Congress, pp. 3719-3723 (2000). (“Grassiani”)
 - j. EX1012, Alkhasov, A.B., “*Prospects of Horizontal Drilling when Constructing Geothermal Power Plants*”, Proceedings, Twenty-Fourth Workshop on Geothermal Reservoir Engineering (1999). (“Alkhasov”)
44. Where I have relied on these documents will be indicated by the text and citations below. Otherwise, I have relied on my education and experience.

VII. Summary of Prior Art

A. Rinaldi

45. Rinaldi, filed October 30, 1985, teaches fluid recovery techniques for oil extraction based on a deeper horizontal injection well and a shallower horizontal production well. *See, e.g.*, EX1006 at 1:8-9, Fig. 2:



46. As the '221 patent itself states, there was a history of adapting methods from the oil and gas industry for use in geothermal drilling: “[m]any of the techniques [in geothermal drilling] are derived from oil and gas industry.” EX1001 at 4:23-24; *see also id.* at 4:25-39 (“proposed horizontal wells of the present invention will be drilled by applying a technology which has been developed by the oil and gas industry.”). A POSITA with a goal of improving geothermal fluid recovery—a primary focus of the '221 patent—would have found it obvious to look to the oil and gas industry for fluid recovery techniques such as those disclosed in Rinaldi. *See id.* at 3:13-14 (“the invention particularly intends to improve [geothermal fluid] flow”).

47. Further, during prosecution, the examiner used references of oil and gas extraction techniques and dismissed the argument that these references cannot be applied in a geothermal context. *See* EX1002 11-28-2006 Final Rejection at 2 (“The Examiner disagrees because any well going into the ground are subjected to geothermal temperature. Mokrys’s wells are underground and therefore must inherently be subjected to geothermal temperature”).

48. As such, it is my opinion that a POSITA would have found it obvious and have been motivated to apply the fluid injection and recovery techniques of Rinaldi to geothermal wells to yield predictable, increased geothermal fluid extraction.

B. Swenson

49. Swenson, published in 1995, is titled “Modelling Flow in a Jointed Geothermal Reservoir” and the “paper describes a fully coupled fluid flow/rock deformation/heat transfer model of a jointed reservoir.” EX1008 at 2553. Swenson discloses several models with mathematical equations relating geothermal wells structure to fluid characteristics, including flow rate and heat transfer. *See id.* at 2553-54. Further, Swenson discloses implementing some of these models in a program called GEOCRACK that helps in “preprocessing, analysis, and postprocessing” of the geothermal fluid flow to help “engineer systems with extensive lifetimes and profitable thermal productivity by appropriate well spacing and limiting energy production rates.” *See id.* at 2558.

50. It is my opinion that a POSITA would recognize performing such analysis is an economic, efficient, and predictable way to improve fluid extraction in Rinaldi. As such, a POSITA would have found it obvious and have been motivated to use the modeling in Swenson for improving fluid extraction techniques in Rinaldi to increase flow extraction.

C. Grassiani

51. Grassiani, published in June 2000, is titled “Advanced Power Plants for Use with Hot Dry Rock (HDR) and Enhanced Geothermal Technology” and discusses efficient ways to use heat from the extracted geothermal fluid for power generation using power plants. *See, e.g.*, EX1011 at 3719. The ’221 patent itself discloses such use of extracted geothermal fluid for such power production. *See, e.g.*, EX1001 at Abstract. In fact, the very purpose of extracting geothermal fluid is for producing power. *Id.* As such, a POSITA would have been motivated to optimize the extraction of geothermal fluid using the techniques in Rinaldi and Brannan and combine those with the power production techniques in Grassiani to achieve predictable power generation from the extracted geothermal fluid.

D. Brannan

52. Brannan, filed on July 1, 1992, relates to “methods for recovering hydrocarbons from a subterranean formation” using “separate, discrete horizontal injection and production wells which are laterally and vertically spaced from each other.” EX1012 at 1:7-12. As explained above, Section VII.A, it is my opinion that a POSITA would have found it obvious and have been motivated to apply the fluid injection and recovery techniques of Brannan to geothermal wells to yield predictable, increased geothermal fluid extraction.

E. Mims

53. Mims, filed on December 21, 1987, teaches a method for “recovery of hydrocarbons from an underground formation by the use of horizontal injection and production wells.” EX1007 at 1:5-8. As explained above, Section VII.A, it is my opinion that a POSITA would have found it obvious and have been motivated to apply the fluid injection and recovery techniques of Mims to geothermal wells to yield predictable, increased geothermal fluid extraction.

F. Kruger

54. Kruger, published in 1975, is titled “Stimulation of Geothermal Energy Resources” and discusses stimulating geothermal production by “increas[ing] the efficiency through (1) modes of utilization, (2) technology for energy conversion, and (3) methods of extraction.” EX1010 at 4. Kruger discloses modes of utilization for increasing efficiency by considering the “characteristics of the geofluids, the gathering and steam water separation facilities, the turbine and generator equipment, the cooling cycle, the well productivity, spacing, and schedules, environmental impacts, and condensate disposal methods.” *Id.* It is my opinion that a POSITA would have found it obvious to combine these efficient utilization modes, including geofluid characteristics and well spacing, with the fluid extraction technique in Mims for efficient fluid recovery.

55. Further, Kruger discloses increasing the efficiency of extraction by using certain methods of heat extraction. *See, e.g.*, EX1040 at 8-10. It is my opinion that a POSITA would have found it obvious to use these methods of extraction to improve fluid recovery and would have been motivated to combine it with the fluid extraction technique in Mims to obtain higher heat extraction efficiency. Kruger discloses the concept of artificial circulation systems for geothermal energy extraction, as well as planning for the development of geothermal fields and heat exchange properties of such systems. *See, e.g.*, EX1010 at 19-20. A POSITA would have been motivated to improve the flow modelling in Swenson using the circulation systems in Kruger and obtain higher flow efficiency.

G. Alkhasov

56. Alkhasov, published in 1999, is titled “Prospects of Horizontal Drilling when Constructing Geothermal Power Plants” and discusses ways to improve output of a geothermal power plant by improving the flow rate and productivity of the wells using horizontal drilling. *See* EX1012 at p.1-2. It is my opinion that a POSITA would have found it obvious to use the recovered fluid for generating power and as such would have been motivated to combine the fluid extraction technique in Rinaldi with flow rate improvement techniques discussed in Alkhasov to obtain predictable results.

57. The '221 patent itself discloses using the extracted geothermal energy for power production. *See, e.g.*, EX1001 at Abstract. Further, a POSITA would have been motivated to combine the flow modelling in Swenson with flow rate improvement techniques discussed in Alkhasov to obtain higher energy production. *See* EX1008 at 2553 (noting the goal for long term energy production).

VIII. Invalidity Analysis

A. Ground 1: Claims 1-3, 6-11, 24-31, and 34-37 are obvious over Rinaldi in view of the general knowledge of a POSITA

Claim 1

Preamble 1: “method for recovering geothermal heat, which comprises the flow of geothermal fluid from at least one injection well to at least one production well”

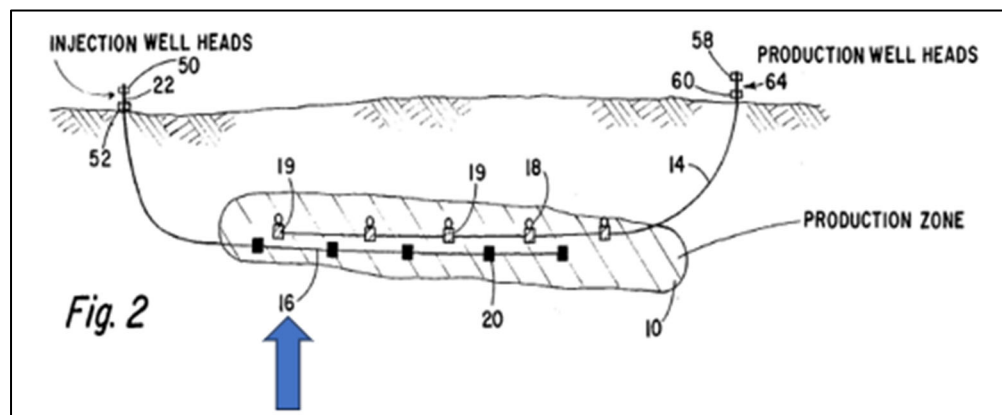
58. To the extent the preamble is limiting, Rinaldi teaches it. Rinaldi discloses a “means for increasing fluid recovery from a well bore.” EX1006 at 1:8-9. Rinaldi discloses “a method of enhancing oil and/or gas recovery by properly drilling injection and production wells into a reservoir.” EX1006 at Abstract. Further, the '221 patent concedes this technique was well known in the art: “[w]hile commercial production of geothermal fluids (e.g. for power production) out of a ‘classical’ steam or water dominated reservoirs is pretty well at hand, such production from Hot Dry Rock (HDR) (or Hot Fractured Rock HFR)) or even from reservoirs with low permeability or insufficient water recharge by Enhanced (or Engineered) Geothermal Systems (EGS) is essentially in the research and

development stage Nevertheless, research and development of such systems are being pursued intensively” EX1001 at 1:25-36.

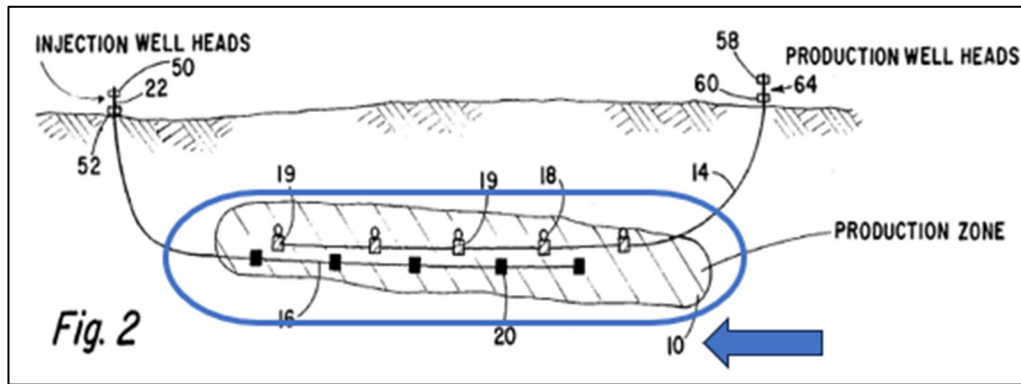
59. It is therefore my opinion that Rinaldi teaches this limitation.

Element 1a: “providing a first, horizontal, geothermal well in the ground at a geological layer having an elevated temperature, which is used as said injection well”

60. Rinaldi teaches this element. Rinaldi’s Figure 2 discloses drilling horizontal geothermal injection wells. *Id.* at XX. Rinaldi’s Figure 2 shows “placement of a first horizontal injection well bore 16 and drill[ing] the well bore 16 into the reservoir 10.” EX1006 at 3:41-43.



61. Rinaldi also shows a “a fluid reservoir 10 [blue] to be treated for enhanced oil and/or gas recovery”:



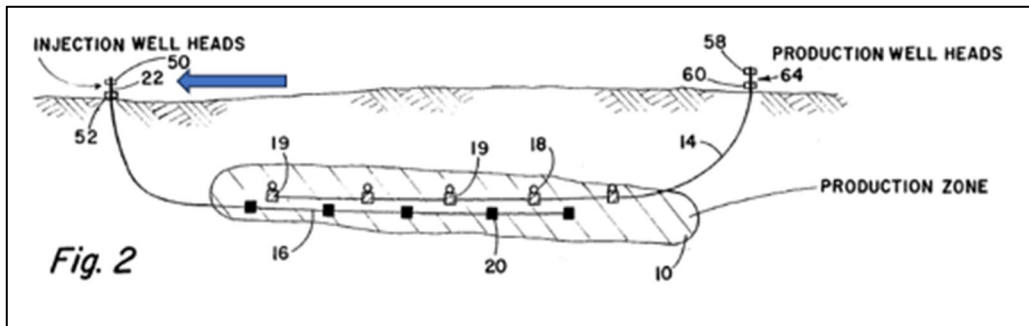
Id. at 3:19-20. The “reservoir boundary 12 and characteristics of the medium of the reservoir” are determined “by the usual geological and/or seismic techniques.” *Id.* at 3:21-23. It is my opinion that a POSITA would have recognized that similar techniques would be employed in selection of a geological layer.

62. Further, a POSITA would recognize that characteristics of a reservoir include the temperature of the formation, something that the ’221 patent also discloses. *See* EX1006 at 5:39-40 (“temperature and pressure characteristics must obviously be considered.”). Further, Rinaldi also claims these methods of “determining the formation boundary and characteristics” (*i.e.*, temperature) and “drilling at least one injection well bore into the formation.” *See* EX1006 Claim 1.

63. It is therefore my opinion that Rinaldi teaches this limitation.

Element 1b: “injecting water into said injection well, whereby the injection water is heated”

64. Rinaldi teaches this claim element. Rinaldi discloses “[i]nitiat[ing] the flow of injection fluids through the injection well heads 22 of the injection well bores.”

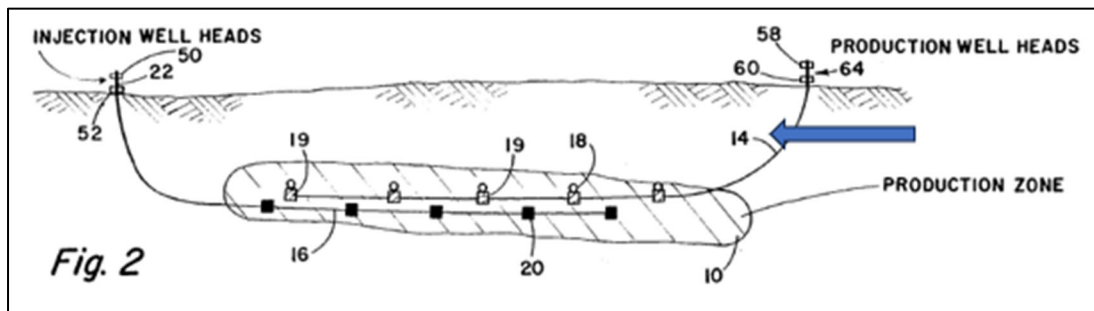


EX1006 at 4:17-18. Further, Rinaldi discloses the use of “proper or well known injection fluids.” EX1006 at 4:20-24. A POSITA would have recognized that water was one such well known injection fluid. Further, a POSITA would understand that the temperature of the formation below ground will necessarily heat the injected water.

65. It is therefore my opinion that Rinaldi teaches this limitation.

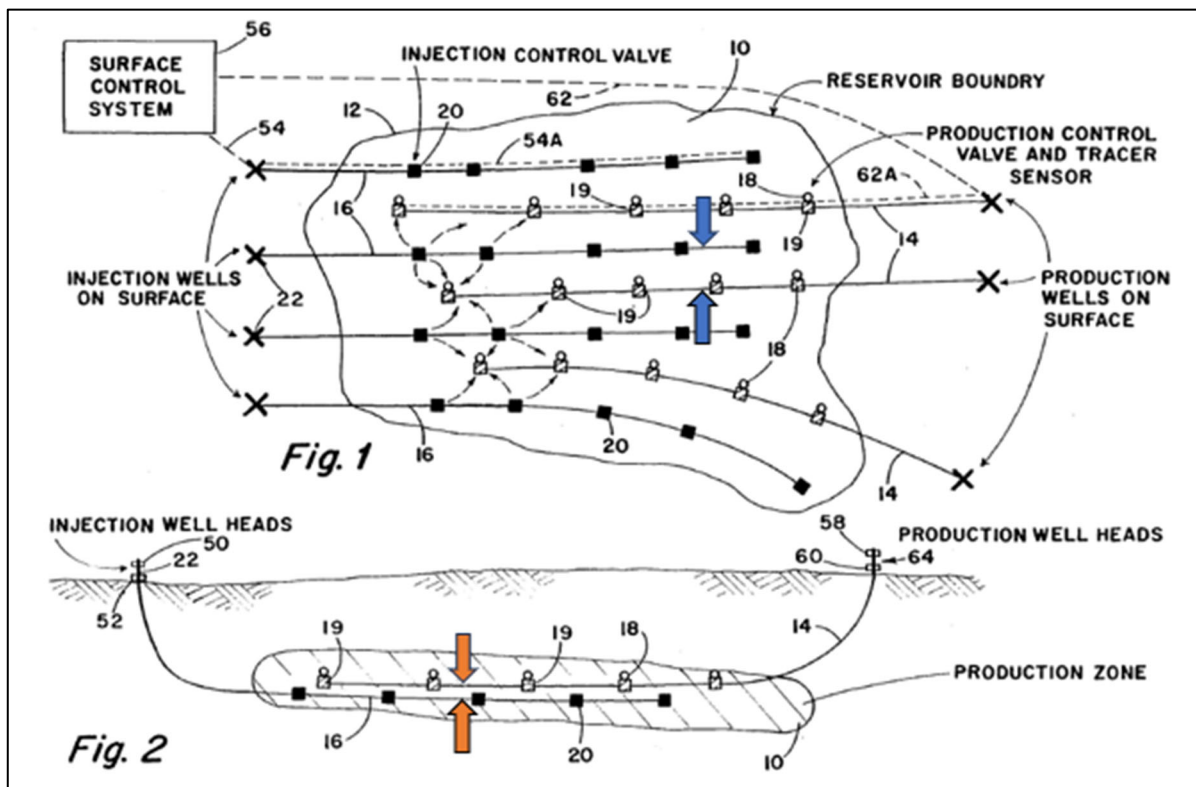
Element 1c-1: “[p]roviding a second, horizontal, geothermal well in the ground, which is used as said production well”

66. Rinaldi teaches this element. Rinaldi discloses “drill[ing] a [...] substantially horizontal production well bore 14 into the reservoir” (EX1006 at 3:25-27):



Element 1c-2: “said second, horizontal, production, geothermal well is substantially horizontally and vertically spaced from said first, horizontal, injection, geothermal well by a distance dependent on the elevated temperature”

67. Rinaldi teaches this element. Rinaldi claims methods comprising “drilling at least one production well bore into the formation spaced from said production well.” See EX1006 Claim 1. See also *id.* at Claim 13. Rinaldi discloses that the production well is substantially horizontally and vertically spaced from the injection well. Figures 1 and 2 show the production/injection wells horizontally (blue) and vertically (orange) spaced apart:



68. Rinaldi discloses a series of steps, including a “log and drill stem test” to be performed “until the reservoir 10 is economically and properly drilled with

spaced apart production and injection well bores.” EX1006 at 3:28-29; 3:47-49. A POSITA would recognize that the reservoir data obtained by the disclosed drill stem test would include temperature at the formation. This is confirmed by Rinaldi which, in the context of discussing “reservoir geological characteristics,” expressly states that things such as “temperature and pressure characteristics must obviously be considered.” *See* EX1006 at 5:34-40. Rinaldi discloses use of these measurable characteristics to “construct a computer model” that considers “geological data and structure characteristics,” such as temperature, to determine the placement of wells and drill spaced apart production and injection wells. *See id.* at 3:30-49.

69. Further, the ’221 patent itself notes prior art as disclosing well locations being dependent on the temperature for vertically drilled injection and production wells. *See* EX1001 at 1:39-52 (“In the prior art, geothermal energy recovery systems typical comprise production as well as injection wells ... drilled vertically or at an angle slightly deviated from the vertical The production location in said vertical geothermal wells are made at the depth where the temperature is sufficiently high.”). It is my opinion that it would have been obvious for a POSITA to employ the prior art technique of placing vertical wells based on the formation’s temperature to the horizontal wells and achieve predictable fluid flow.

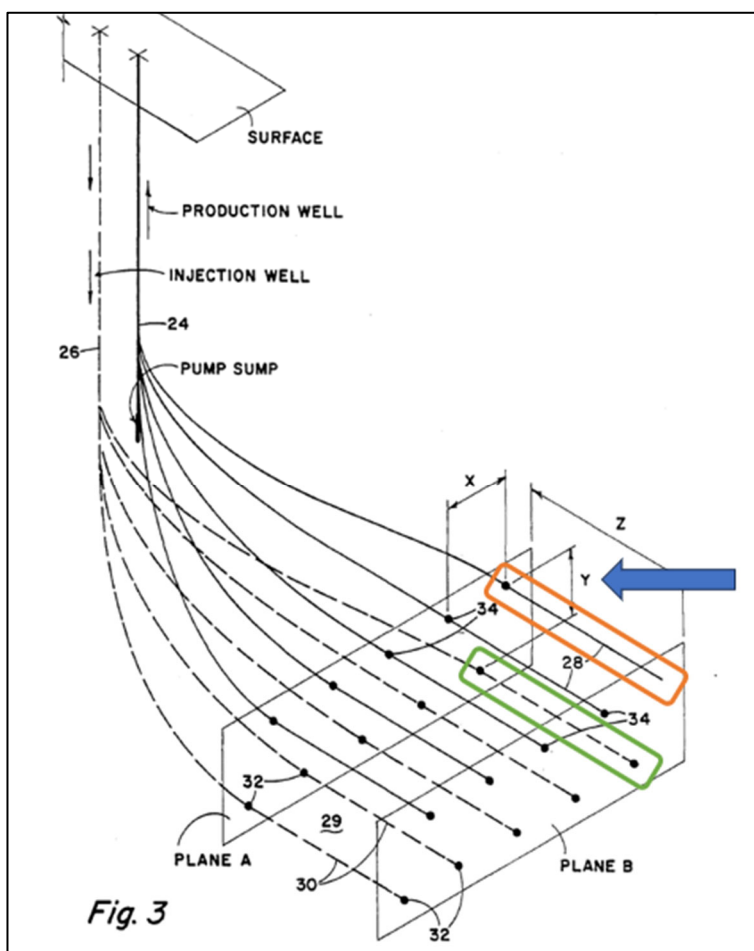
70. Further, Rinaldi also teaches determining which wells to be activate based on the formation characteristics. Rinaldi discloses a configuration of multiple

drilled injection and production wells (*see* EX1006 at 4:45-56) and states that the injection and production wells “may be provided with valves, nozzle or other suitable” injection/intake means for either the injection or retrieval of fluid. EX1006 at 4:62-5:3. Rinaldi then describes using a computer model that measures reservoir characteristics (e.g., temperature) to determine “the location and operational state of the control valves.” *Id.* at 3:36-37. It is my opinion that a POSITA would recognize that controlling which injection and production valves are open and closed necessarily has the effect of controlling the spacing between the active injection and production wells based on the measured reservoir characteristics.

71. It is therefore my opinion that Rinaldi teaches this limitation.

Element 1c-3: “said second, horizontal, production, geothermal well is ... located at a shallower depth than said first, horizontal, injection, geothermal well”

72. Rinaldi teaches this element. Rinaldi states that “the injection well bores [green] 30 are disposed at a lower elevation than the production well bores [orange] 28,” (EX1006 at 4:57-59):



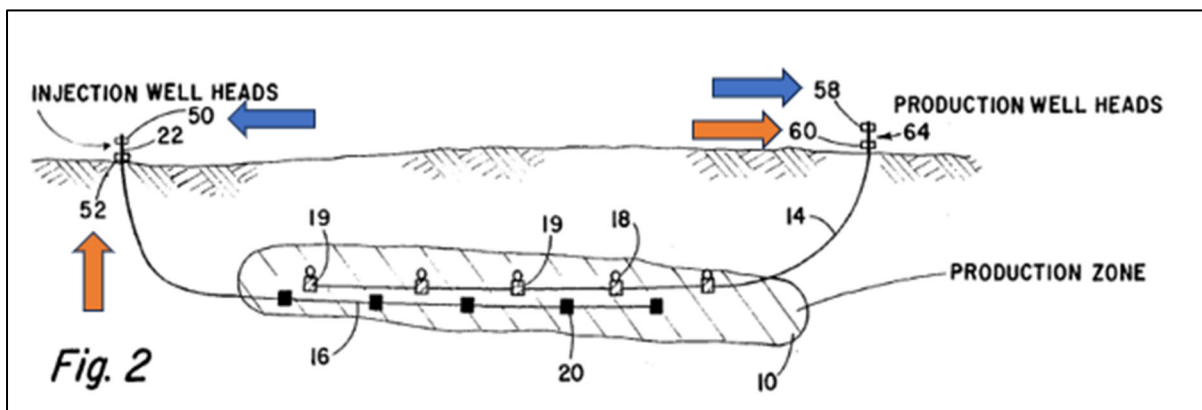
Element 1d: “recovering geothermal fluid from said production well”

73. Rinaldi teaches this element. For example, Rinaldi claims “removing produced fluid from said at least one production well bore.” EX1006, Claims 1,7. *See also id.* at 1:64-65 (“The fluids are then forced by a back pressure to flow towards the production wells.”).

74. It is therefore my opinion that Rinaldi teaches this limitation.

Element 1e: “generating a water density difference and a pressure difference between said first horizontal, injection well and said second horizontal, production well”

75. Rinaldi teaches this element. Rinaldi discloses generating the pressure difference, noting: “[s]pecific fluids at specified flow rates and pressures enter the injection wells at the surface and are forced into the reservoir via specifically set valve opening patterns. The fluids are then forced by a back pressure to flow toward the production wells.” EX1006 at 1:61-65. A computer evaluates the flow that “opens or closes the well valves and adjusts flow rates and pressures accordingly.” *Id.* at 2:19-21. These valves and pressure gauges are “employed to control the volume of fluid flow in the well.” *Id.* at 3:65-66; 4:3-4.



76. Rinaldi discloses generating the density difference, noting: “the oil bearing fluids contained within the subsurface formation 29 may be forced either upwardly or downwardly, as desired, dependent upon the density of the fluids used in the process ... lighter fluids will tend to flow up and over the heavier fluids, to the higher set of production wells 28.” *Id.* at 5:43-52. *See also id.* at 2:45-48 (“It is a

well known fact that fluids of different densities will stratify rapidly and sharply when forced through a medium as illustrated in FIG. 5.”); *Id.* at 5:29-33 (“lighter fluids will rise up and over heavier fluids, and more interestingly it is noted that the medium weight fluids will force themselves between fluids that are lighter and heavier.”).

77. Further, a POSITA would recognize that this claim limitation operates on the fundamental physics of fluid dynamics and thermodynamics, leveraging the principles of geothermal gradients and hydrothermal convection. A POSITA would have known that when water is injected into the subsurface through the injection well, the water heats up due to the geothermal heat and decreases in density. This temperature-induced density difference creates a natural convective flow, enhancing the movement of water through the geothermal reservoir. It is a basic property of physics that as the density of fluid (e.g., water) decreases, it tends to flow upwards.

78. It is therefore my opinion that Rinaldi teaches this limitation.

Element 1f: “inducing geothermal fluid into said second horizontal geothermal well from the geological layer because of buoyancy of the water and the pressure difference between the horizontal injection and horizontal production wells”

79. Rinaldi teaches this element. Rinaldi discloses inducing the flow of the fluid because of the density difference (creating buoyancy). *See, e.g.*, EX1006 at 5:43-52 (explained in element 1e); *see also id.* at 2:45-48 (“It is a well known fact

that fluids of different densities will stratify rapidly and sharply when forced through a medium as illustrated in FIG. 5.”).

80. Rinaldi discloses the effect of density difference: “if fluids of different densities and viscosities are injected into a reservoir using the valve and sensor system of this invention, it will be possible to move the injected fluids in a vertical manner and thereby assist in improving the reservoir sweep efficiency.” EX1006 at 2:45-59. *See also id.* at 5:29-39 (“the lighter fluid will rise up and over heavier fluids ... with the benefit being a greater sweep efficiency and thus higher oil and/or gas production.”).

81. Further, Rinaldi discloses the effect of pressure difference: “[s]pecific fluids at specified flow rates and pressures enter the injection wells at the surface and are forced into the reservoir via specifically set valve opening patterns. The fluids are then forced by a back pressure to flow toward the production wells.” *Id.* at 1:61-65. A computer “continually monitors and compares these pressures and flow rates, determines flow patterns, and opens or closes the reservoir valves as required. In this manner, both injected fluids and reservoir fluids are forced to flow in those patterns that produce optimum flow.” *Id.* at 2:21-26.

82. Indeed, a POSITA would recognize that the process of inducing geothermal fluid into a second horizontal geothermal well from a geological layer due to the buoyancy of water and the pressure difference between horizontal

injection and horizontal production wells is a known mechanism for extracting geothermal energy—just as it has been a known mechanism for extracting hydrocarbons for decades. This procedure relies on the principle that water, when heated by the earth’s natural geothermal heat within a geological layer, becomes less dense (more buoyant) compared to its surroundings. This buoyancy effect, combined with a pressure differential between an injection well (where water is introduced into the geothermal reservoir) and a production well (from which heated water is extracted), facilitates the movement of heated water towards the production well.

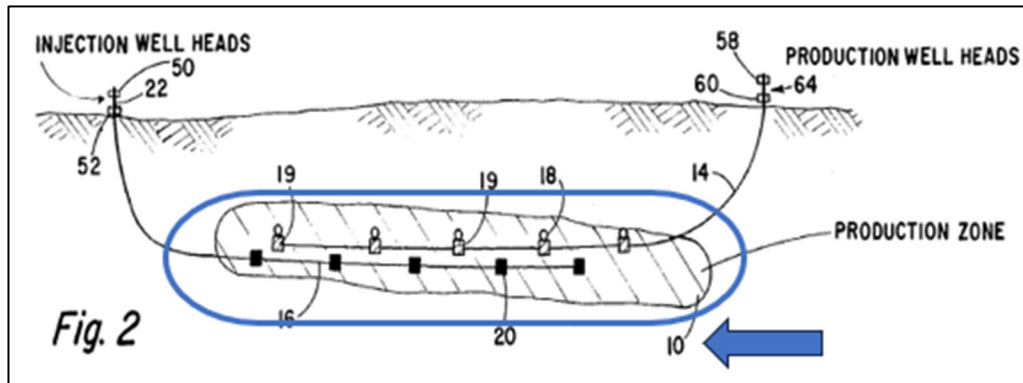
83. A POSITA would recognize that convection drives the upward movement of less dense geothermal fluid towards a second well (serving as the production well). This process is primarily facilitated by the differential pressure between the injection and extraction points, alongside buoyancy effects resulting from temperature gradients. The interaction between pressure differences and thermal buoyancy supports the efficient circulation of geothermal fluids, a principle fundamental to the design and operation of geothermal wells.

84. It is therefore my opinion that Rinaldi teaches this limitation.

Claim 2: “wherein the horizontal wells are provided by drilling along a geological layer”

85. Claim 2 is dependent on Claim 1. Accordingly, I incorporate my arguments for Claim 1 herein. Rinaldi teaches this additional element.

86. Figure 2 shows the injection and production wells “directionally drilled into a reservoir in a predetermined pattern.” EX1006 at 1:54-55:



87. A POSITA would recognize that this pattern constitutes drilling along a geological layer and if not drilled this way, the purpose of heating the fluid through the geological layer will not be satisfied.

88. It is therefore my opinion that Rinaldi teaches this claim.

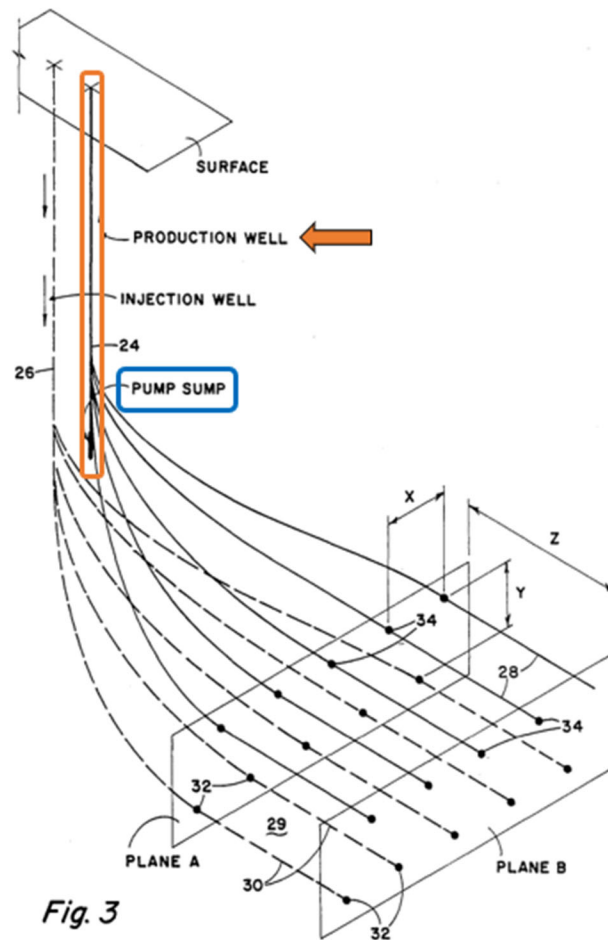
Claim 3: “increasing the pressure difference by pressurizing the water, injected in the horizontal, deeper injection well, above the hydrostatic pressure existing at the depth of the deeper injection geothermal well, and reducing the pressure in the horizontal, shallower production well using a fluid pump connected to said horizontal production well”

89. Claim 3 is dependent on Claim 1. Accordingly, I incorporate my arguments for Claim 1 herein. Rinaldi teaches this additional element.

90. Rinaldi teaches this element. Rinaldi discloses a model that defines the “best fluid flow rates and pressures into the reservoir so that optimum sweep efficiency and thus optimum fluid flow from the reservoir can be obtained.” EX1006 at 2:15-19. This model “determines flow patterns, and opens or closes the reservoir

valves as required. In this manner, both injected fluids and reservoir fluids are forced to flow in those patterns that produce optimum flow.” *Id.* at 2:22-26. A POSITA would recognize that these pressures are in addition to the hydrostatic pressures existing at the depth of the wells.

91. Further, Figure 3 shows a fluid pump connected to the horizontal production well:



92. A POSITA would recognize that fluids flow from high pressure areas to low pressure areas and for the geothermal fluid to be extracted through the

production well, its pressure has to be reduced by the pump to be lower than the surrounding pressures.

93. It is therefore my opinion that Rinaldi teaches this claim.

Claim 6: “monitoring the pressure difference”

94. Claim 6 is dependent on Claim 1. Accordingly, I incorporate my arguments for Claim 1 herein. Rinaldi teaches this additional element.

95. Rinaldi discloses a model that defines the “best fluid flow rates and pressures into the reservoir so that optimum sweep efficiency and thus optimum fluid flow from the reservoir can be obtained.” EX1006 at 2:15-19. Rinaldi discloses a “computer [that] continually monitors and compares these pressures and flow rates....” *Id.* at 2:21-22.

96. It is therefore my opinion that Rinaldi teaches this claim.

Claim 7: “wherein the first and second horizontal, geothermal wells are formed in a geological layer the suitability of which has been determined”

97. Claim 7 is dependent on Claim 1. Accordingly, I incorporate my arguments for Claim 1 herein. Rinaldi teaches this additional element.

98. Rinaldi discloses “[d]etermin[ing] the reservoir boundary 12 and characteristics of the medium of the reservoir by the usual geological and/or seismic techniques.” EX1006 at 3:21-23. *See also id.* at 3:28-29 (using a “drill stem test ... to obtain additional reservoir data”). As explained in the '221 patent (*see* EX1001 at

1:39-55), a POSITA would recognize that these geological techniques determine the suitability of a geological layer for drilling wells.

99. It is therefore my opinion that Rinaldi teaches this claim.

Claim 8: “wherein the suitability of the geological layer is determined by geophysical surveys and by drilling slim holes in said layer”

100. Claim 8 is dependent on Claim 3. Accordingly, I incorporate my arguments for Claim 3 herein. Rinaldi teaches this additional element. *See* discussion of Claim 7, which is incorporated herein by reference. Further, a POSITA would recognize that a drill stem test (*see, e.g.*, EX1006 at 3:28-29) consists of drilling slim holes in the geological layers to determine the suitability of the geological layer, including fluids present and the rate at which they can be produced.

101. It is therefore my opinion that Rinaldi teaches this claim.

Claim 9

Preamble 9: “apparatus for enhancing the flow of geothermal fluid from at least one injection well to at least one production well”

102. To the extent the preamble is limiting, Rinaldi teaches this element. *See* Preamble 1, Section VIII.A, which is incorporated herein by reference.

103. It is therefore my opinion that Rinaldi teaches this limitation.

Element 9a: “a first, horizontal geothermal well, which is used as said injection well into which water is injected”

104. Rinaldi teaches this element. *See* Elements 1a and 1b discussions, Section VIII.A, which are incorporated herein by reference.

105. It is therefore my opinion that Rinaldi teaches this limitation.

Element 9b: “a second horizontal, geothermal well, which is used as said production well from which geothermal fluid issues, wherein said second, horizontal, production, geothermal well is substantially horizontally and vertically spaced from said first, horizontal, injection, geothermal well and located at a shallower depth than said first, horizontal, injection, geothermal well”

106. Rinaldi teaches this element. *See* Elements 1c-1-3 and 1d discussions, Section VIII.A, which are incorporated herein by reference.

107. It is therefore my opinion that Rinaldi teaches this limitation.

Element 9c: “means for producing a water density difference and a pressure difference between said first horizontal, injection well and said horizontal, production well:”

108. Rinaldi teaches this element. *See* Element 1e discussion, Section VIII.A, which is incorporated herein by reference.

109. It is therefore my opinion that Rinaldi teaches this limitation.

Element 9d: “wherein the first horizontal, injection geothermal well has an open slotted outlet, from which injected water flows into the geological layer in which the well has been drilled, and the second horizontal, production geothermal well has an open slotted inlet, whereby geothermal fluid flows into it from the geological layer because of buoyancy of the water and the pressure difference between said horizontal injection and horizontal production wells”

110. Rinaldi teaches this element. *See* Elements 1b and 1f discussion, Section VIII.A, which are incorporated herein by reference. Further, Rinaldi discloses that the wells “may be provided with valves, nozzle or other suitable injection means” (EX1006 at 4:63-5:3) that were “well known.” By 2004, it is my opinion that a POSITA would understand that open slotted outlets are suitable

injection means well known in the art at the time to suit different reservoir conditions and production requirement. In the context of hydrocarbon extraction, slotted liners have been used for many decades to support the well structure and to filter out sand and other fine particles from the produced fluids. Similarly, in geothermal energy production, slotted liners or similar mechanisms are used to allow the flow of geothermal fluids into the well while preventing the entry of rock fragments or other debris that could clog the well or damage surface equipment.

111. It is therefore my opinion that Rinaldi teaches this limitation.

Claim 10: “instrumentation for monitoring the pressure difference”

112. Claim 10 is dependent on Claim 9. Accordingly, I incorporate my arguments for Claim 9 herein. Rinaldi teaches this additional element. *See* Claim 6 discussion, Section VIII.A, which is incorporated herein by reference.

113. It is therefore my opinion that Rinaldi teaches this claim.

Claim 11: “further comprising an observation well connected to the second horizontal, production geothermal well, and wherein the instrumentation comprising observation instrumentation present in said observation well”

114. Claim 11 is dependent on Claim 9. Accordingly, I incorporate my arguments for Claim 9 herein. A POSITA would recognize that by 2004, the use of observation wells was widely known and were an important part of reservoir management. Observation wells are used to monitor various parameters within a reservoir, such as pressure, temperature, and fluid movement.

115. It is therefore my opinion that Rinaldi teaches this claim.

Claim 24: “deep well pump connected to the horizontal production well for pumping hot geothermal fluid from the production well”

116. Claim 24 is dependent on Claim 9. Accordingly, I incorporate my arguments for Claim 9 herein. Rinaldi teaches this additional element. *See* Claim 3 discussion, Section VIII.A, which is incorporated herein by reference.

117. It is therefore my opinion that Rinaldi teaches this claim.

Claim 25: “wherein the horizontal, injection geothermal well comprises a perforated horizontal pipe”

118. Claim 25 is dependent on Claim 9. Accordingly, I incorporate my arguments for Claim 9 herein. Rinaldi teaches this additional element. *See* Element 1a discussion, Section VIII.A, which is incorporated herein by reference. Further, Rinaldi discloses that the horizontal injection well “is suitably perforated.” EX1006 at 5:10-13.

119. It is therefore my opinion that Rinaldi teaches this claim.

Claim 26: “the second horizontal, production geothermal well comprises a perforated horizontal pipe”

120. Claim 26 is dependent on Claim 9. Accordingly, I incorporate my arguments for Claim 9 herein. Rinaldi teaches this additional element. *See* Element 1c-1 and claim 25 discussions, Section VII.A, which are incorporated herein by reference. It is my opinion that it would have been obvious for a POSITA to use

perforated production well, similar to the perforated injection well disclosed in Rinaldi.

121. It is therefore my opinion that Rinaldi teaches this claim.

Claim 27: “wherein the perforated horizontal pipe is perforated on its lower surface”

122. Claim 27 is dependent on Claim 25. Accordingly, I incorporate my arguments for Claim 25 herein. It is my opinion that a POSITA would recognize that Rinaldi’s disclosure of a perforated horizontal pipe (EX1006 at 5:10-13) includes perforation on the lower surface.

123. It is therefore my opinion that Rinaldi teaches this claim.

Claim 28: “wherein the perforated horizontal pipe is perforated on its lower surface”

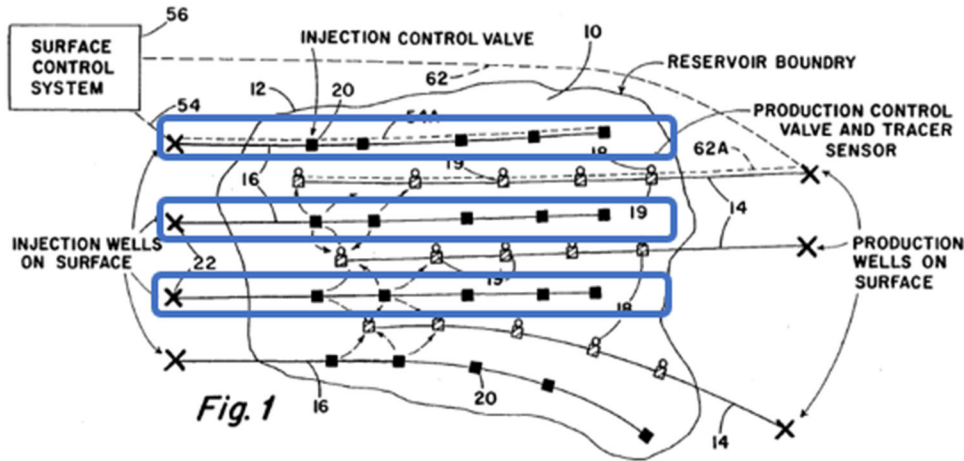
124. Claim 28 is dependent on Claim 26. Accordingly, I incorporate my arguments for Claim 26 herein. A POSITA would recognize that Rinaldi’s disclosure of a perforated horizontal pipe (EX1006 at 5:10-13) includes perforation on the lower surface.

125. It is therefore my opinion that Rinaldi teaches this claim.

Claim 29: “wherein the production horizontal geothermal well is generally parallel to the injection horizontal, geothermal well”

126. Claim 29 is dependent on Claim 9. Accordingly, I incorporate my arguments for Claim 9 herein. Rinaldi teaches this additional element. Figure 1

below discloses plurality of injection and production wells that are generally parallel to each other.



127. It is therefore my opinion that Rinaldi teaches this claim.

Claim 30: “a plurality of injection horizontal, geothermal wells for one production horizontal, geothermal well”

128. Claim 30 is dependent on Claim 9. Accordingly, I incorporate my arguments for Claim 9 herein. Rinaldi teaches this additional element. *See* claim 29 discussions, Section VII.A, which is incorporated herein by reference. *See also* EX1006 at 4:45-56.

129. It is therefore my opinion that Rinaldi teaches this claim

Claim 31: “a plurality of horizontal injection wells and a plurality of horizontal production wells spaced horizontally and vertically”

130. Claim 31 is dependent on Claim 9. Accordingly, I incorporate my arguments for Claim 9 herein. Rinaldi teaches this additional element, including the

use of multiple horizontal injection and production wells. *See* claim 30 discussions, Section VII.A, which is incorporated herein by reference.

131. It is therefore my opinion that Rinaldi teaches this claim.

Claim 34

Preamble 34: “method for assuring the flow of geothermal fluid from at least an injection well to at least a production well”

132. To the extent the preamble is limiting, Rinaldi teaches this element. *See* Preamble 1 discussion, Section VIII.A, which is incorporated herein.

133. It is therefore my opinion that Rinaldi teaches this limitation.

Element 34-I: “providing a first, horizontal, geothermal well, which is connected to said injection well”

134. Rinaldi teaches this element. *See* Element 1a discussion, Section VIII.A, which is incorporated herein.

135. It is therefore my opinion that Rinaldi teaches this limitation.

Element 34-II: “injecting water into said injection well”

136. Rinaldi teaches this element. *See* Element 1b discussion, Section VIII.A, which is incorporated herein.

137. It is therefore my opinion that Rinaldi teaches this limitation.

Element 34-III: “providing a second, horizontal, geothermal well, which is connected to said production well”

138. Rinaldi teaches this element. *See* Elements 1c-1–1c-3 discussions, Section VIII.A, which are incorporated herein.

139. It is therefore my opinion that Rinaldi teaches this limitation.

Element 34-IV: “recovering geothermal fluid from said production well”

140. Rinaldi teaches this element. *See* Element 1d discussion, Section VIII.A, which is incorporated herein.

141. It is therefore my opinion that Rinaldi teaches this limitation.

Element 34-V: “generating a water density difference and a pressure difference between said first horizontal well and said second horizontal well by providing a fluid pump connected to said second horizontal well”

142. Rinaldi teaches this element. *See* Element 1e and claim 3 discussions, Section VIII.A, which are incorporated herein.

143. It is therefore my opinion that Rinaldi teaches this limitation.

Element 34-VI: “inducing geothermal fluid into said second horizontal geothermal well from the geological layer because of buoyancy of the water and the pressure difference between the horizontal injection and horizontal production wells”

144. Rinaldi teaches this element. *See* Element 1f discussion, Section VIII.A, which is incorporated herein.

145. It is therefore my opinion that Rinaldi teaches this limitation.

Claims 35-37: “wherein the geothermal fluid is one of water, steam and a combination thereof”

146. Claim 35 is dependent on Claim 1; Claim 36 is dependent on Claim 9; and Claim 37 is dependent on Claim 34. Accordingly, I incorporate my arguments for Claim 1, Claim 9, and Claim 34 herein. A POSITA would understand that well known geothermal fluids include water, steam, and combinations thereof.

147. For the reasons discussed above, it is my opinion that all elements of claims 1-3, 6-11, 24-31, and 34-37 are obvious in view of the combination of Rinaldi and the general knowledge of a POSITA.

148. It is therefore my opinion that Rinaldi teaches these claims.

B. Ground 2: Claims 1-11 and 23-37 are obvious over Rinaldi in view of Swenson

Claim 1

Preamble 1

149. To the extent the preamble is limiting, I incorporate my discussion of Ground 1, Section VIII.A herein. Further, Swenson teaches this element. Swenson describes a “Hot Dry Rock (HDR) geothermal reservoir ... created by drilling a well into a body of hot crystalline rock, forming an artificial geothermal reservoir by pumping water down under pressures high enough to open natural joints in the rock, and subsequently drilling one or more production wells into the reservoir zone. During operation, fluid circulates around a closed loop, removing heat from the rock at depth and transporting it to the surface.” EX1008 at 2553.

Elements 1a and 1d

150. Rinaldi teaches elements 1a and 1d of Claim 1. *See* Elements 1a and 1d, Section VIII A, which are incorporated herein.

Element 1b

151. Rinaldi teaches element 1b of Claim 1. *See* Ground 1, Element 1b, Section VIII.A, which is incorporated herein. Additionally, Swenson teaches this element. According to Swenson, “water” is pumped “down under pressures high enough to open natural joints in the rock, and subsequently drilling one or more production wells into the reservoir zone.” EX1008 at 2553. This water gets heated as it “circulates around a closed loop, removing heat from the rock at depth and transporting it to the surface.” *Id.* at 2553.

Elements 1c-1–1c-3

152. Rinaldi teaches elements 1c-1–1c-3 of Claim 1. *See* Ground 1, Elements 1c-1–1c-3, Section VIII.A, which are incorporated herein. Additionally, Swenson teaches element 1c-2. Swenson states that “[m]odels, including GEOCRACK, show that longevity is dependent upon rock temperatures, flow path spacing, numbers of active flow paths, well spacing, and flow rates. Because well spacing and flow rates may be controlled to a much greater extent than the internal geometry of reservoir flow paths, GEOCRACK indicates that reservoir operators could engineer systems with extensive lifetimes and profitable thermal productivity by appropriate well spacing and limiting energy production rates.” EX1008 at 2558. *See also id.* at 2553 (describing use of the GEOCRACK model to address number and spacing of wells).

Element 1e

153. Rinaldi teaches element 1e of Claim 1. *See* Ground 1, Element 1e, Section VIII.A, which is incorporated herein. Additionally, Swenson teaches this element. Table 2 below shows the pressure difference generated between the injection and production wells:

	Injection Pressure	Production Pressure	Pressure Difference	Resultant Flow Rate
Fenton Hill	27.3 MPa	9.65 MPa	17.65 MPa	5.7 l/s
	27.3 MPa	12.4MPa	14.9MPa	5.7 l/s
	27.3 MPa	15.2MPa	12.1MPa	5.3 l/s
	22.4 MPa	9.65MPa	12.75 MPa	3.8 U/s
GEOCRACK	27.3 MPa	9.65MPa	17.65 MPa	5.7 U/s
	27.3 MPa	12.4MPa	14.9MPa	5.4 l/s
	27.3 MPa	15.2 MPa	12.1MPa	5.1 l/s
	22.4 MPa	9.65MPa	12.75 MPa	2.9 l/s

Table 2: Actual and modeled flows under different wellhead pressure conditions. (hydrostatic = 35.4 MPa)

154. Further, “[b]oth GEOCRACK and actual Fenton Hill data show that the level of outlet flow can be maintained even with a smaller driving pressure difference across the reservoir (Duteau and Brown, 1993).” EX1008 at 2556.

Element 1f

155. Rinaldi teaches element 1f of Claim 1. *See* Ground 1, Element 1f, Section VIII.A, which is incorporated herein. Additionally, Swenson teaches this element. *See* Element 1e discussion, Section VIII.B, which is incorporated herein.

Swenson discloses “outlet flow” through the production well maintained with “a small driving pressure difference.” EX1008 at 2556. Further, as “fluid circulates ... it removes the heat from the rock” EX1008 at 2553. A POSITA would recognize that as water gets heated, its density decreases, and it tends to flow upwards.

Claims 2, 3, 7, 8, 11, and 24-31

156. Rinaldi teaches claims 2, 3, 7, 8, 11, and 24-31 as discussed in Ground

1. Accordingly, those arguments are incorporated herein.

Claim 4: “extracting heat from the geothermal fluid recovered from the production well and using said heat for the production of energy”

157. Claim 4 is dependent on Claim 1. Accordingly, I incorporate my arguments for Claim 1 herein. Swenson further teaches this additional element. Swenson discloses a HDR system where the injected “fluid ... remov[es] heat from the rock at depth and transport[s] to the surface ... for steady, long-term energy production.” EX1008 at 2553.

Claim 5: “wherein the water injected into the injection well is the geothermal fluid, recovered from the production well, depleted of heat by heat exchange”

158. Claim 5 is dependent on Claim 1. Accordingly, I incorporate my arguments for Claim 1 herein. Swenson further teaches this additional element. Swenson discloses establishing a “closed loop circulation” by “removing heat from the rock at depth and transporting it to the surface for steady, long-term energy production.” EX1008 at 2553. A POSITA would recognize that for such a system to

form “closed loop” it must rely on re-injection of the extracted geothermal fluid through the injection well.

Claim 6

159. Rinaldi teaches claim 6 as discussed in Ground 1. Accordingly, those arguments are incorporated herein. Additionally, Swenson teaches claim 6. *See* Element 1e discussion, Section VIII.B, which is incorporated herein. Swenson discloses monitoring the “pressures at the injection (blue) and production wells (orange)” (EX1008 at 2555) when the valves are closed:

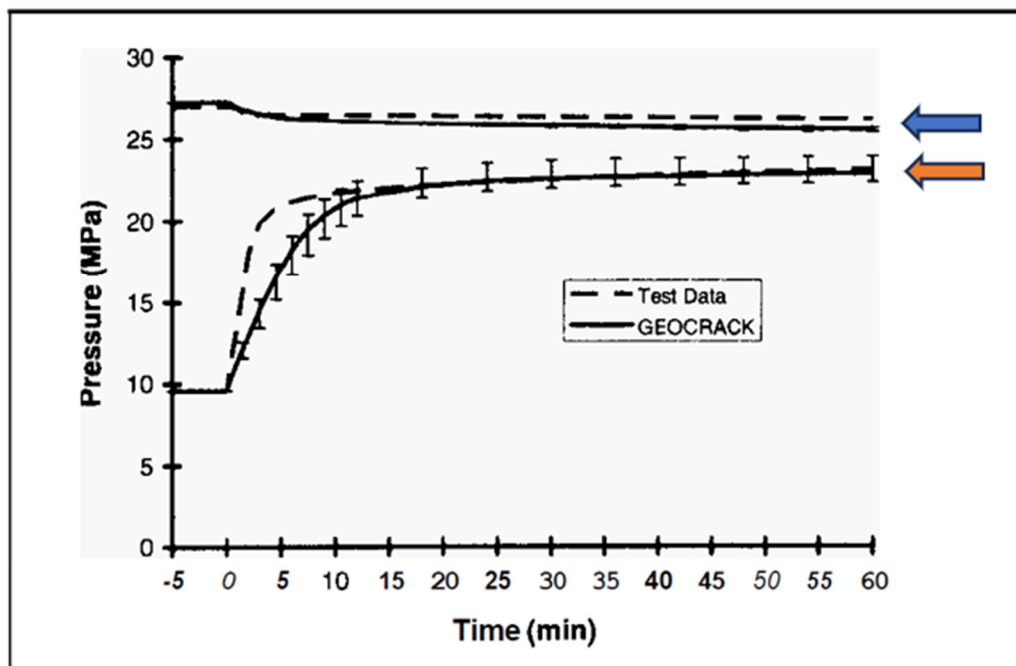


Figure 4: Transient well-head pressure during the cessation of production flow.

Claim 9

Preamble 9

160. *See* Preamble 1 discussion, Section VIII.B, which is incorporated herein.

Element 9a

161. *See* Elements 1a and 1b discussions, Section VIII.B, which are incorporated herein by reference.

Element 9b

162. *See* Elements 1c-1-3 and 1d discussions, Section VIII.B, which are incorporated herein by reference.

Element 9c

163. *See* Element 1e discussion, Section VIII.B, which is incorporated herein.

Element 9d

164. *See* Elements 1b and 1f discussions, Section VIII.B, which are incorporated herein.

Claim 10

165. *See* Claim 6 discussion, Section VIII.B, which is incorporated herein.

Claim 23: “comprising a water injection pump for injecting heat-depleted geothermal fluid into the horizontal, injection well”

166. Claim 23 is dependent on Claim 9. Accordingly, I incorporate my arguments for Claim 9 herein. Swenson further teaches this element. Swenson

discloses “pumping water down under pressure high enough to open natural joints in the rock” EX1008 at 2553.

167. It is my opinion that a POSITA would have recognized that pumps were well-known devices used to generate such high pressures. Further, a POSITA would recognize that after the geothermal fluid “remov[es] heat from the rock at depth and transport[s] it to the surface” (EX1008 at 2553), the fluid would be heat depleted.

Claim 32: “wherein all the water and make-up water is supplied from an external source”

168. Claim 32 is dependent on Claim 9. Accordingly, I incorporate my arguments for Claim 9 herein. Swenson further teaches this element. Swenson discloses a “Hot Dry Rock (HDR) geothermal reservoir ...that ...does not contain transportable water.” EX1008 at 2553. Such systems “require forming an artificial geothermal reservoir by pumping water” EX1008 at 2553. A POSITA would recognize that for such dry rock layers, water needs to be supplied from external sources to create artificial reservoirs.

Claim 33: “wherein part of the water circulating is from the reservoir and only make-up water is from an external source”

169. Claim 33 is dependent on Claim 9. Accordingly, I incorporate my arguments for Claim 9 herein. Swenson further teaches this element. It is well known in the art that for a Hot Dry Rock reservoir, an artificial reservoir needs to be formed while for a water dominated reservoir, there is an existing geothermal fluid at the

formation. *See also* EX1001 at 1:25-27 (“While commercial production of geothermal fluids (e.g. for power production) out of a ‘classical’ steam or water dominated reservoirs is pretty well at hand”).

Claim 34

Preamble

170. *See* Preamble 1 discussion, Section VIII.B, which is incorporated herein by reference.

Element 34-I

171. *See* Element 1a discussion, Section VIII.B, which is incorporated herein by reference.

Element 34-II

172. *See* Element 1b discussion, Section VIII.B, which is incorporated herein by reference.

Element 34-III

173. *See* Elements 1c-1–1c-3 discussions, Section VIII.B, which are incorporated herein by reference.

Element 34-IV

174. *See* Element 1d discussion, Section VIII.B, which is incorporated herein by reference.

Element 34-V

175. *See* Element 1e discussion, Section VIII B, which is incorporated herein by reference.

Element 34-VI

176. *See* Element 1f discussion, Section VIII B, which is incorporated herein by reference.

Claims 35-37

177. Claim 35 is dependent on Claim 1; Claim 36 is dependent on Claim 9; and Claim 37 is dependent on Claim 34. Accordingly, I incorporate my arguments for Claim 1, Claim 9, and Claim 34 herein. Swenson further discloses this element. Swenson discloses a “Hot Dry Rock (HDR) geothermal reservoir form[ed] by pumping water down under pressure high enough to open natural joints in the rock and transporting it to the surface.” EX1008 at 2553. A POSITA would understand that the geothermal fluid created by pumping water into the ground essentially contains water as one of its components.

178. For the reasons discussed, it is my opinion that all elements of claims 1-11, and 23-37 are obvious in view of Rinaldi over Swenson.

C. Ground 3: Claims 1-38 are obvious over Rinaldi in view of Grassiani and Brannan.

Claims 1-3, 6-11, 24-31, and 34-37

179. Rinaldi teaches claims 1-3, 6-11, 24-31, and 34-37 as discussed in Ground 1. Accordingly, those arguments are incorporated herein.

Claim 4

180. Claim 4 is dependent on Claim 1. Accordingly, I incorporate my arguments for Claim 1 herein. Grassiani teaches this additional element. Grassiani discloses the “geothermal fluid heat[ing] the organic motive fluid in the vaporizer” and this “vaporized motive fluid, typically iso-pentane, driv[ing] a turbine which is direct[ly] coupled to the generator.” EX1011 at 3719.

Claim 5

181. Claim 5 is dependent on Claim 1. Accordingly, I incorporate my arguments for Claim 1 herein. Grassiani teaches this additional element. Grassiani discloses that “[n]o geothermal ... fluid is consumed or lost in the plant, and 100% of the fluids are injected” back into the injection well. EX1011 at 3719.

Claim 12: “wherein the first horizontal, geothermal well has a length up to 1.25 miles.”

182. Claim 12 is dependent on Claim 9. Accordingly, I incorporate my arguments for Claim 9 herein. Brannan teaches this additional element. Brannan details a “[n]umerical model study using the THERM numerical simulator commercially available from Scientific Software Intercomp” that used a “500 meter

[~0.31 mile] horizontal well.” EX1009 at 11:28. Further, a POSITA would recognize that as the horizontal injection well length increases, its drainage area increases but so does frictional losses. As such, the optimal injection well length depends on several factors, including economics and it was a general knowledge within the industry to have a horizontal well length up to 1.25 miles.

Claim 13: “wherein the second horizontal, geothermal well has a length up to 1.25 miles”

183. Claim 13 is dependent on Claim 9. Accordingly, I incorporate my arguments for Claim 9 herein. Brannan teaches this additional element. *See* Claim 12 discussion, Section VIII.C, which is incorporated herein. A POSITA would recognize that as the horizontal production well length increases, its production area increases but so does frictional losses.

Claim 14: “wherein the horizontal distance between the first horizontal well and the second horizontal well is up to 2000 feet”

184. Claim 14 is dependent on Claim 9. Accordingly, I incorporate my arguments for Claim 9 herein. Brannan teaches this additional element. Brannan, while noting that “invention [is] not limited to any specific dimensions because absolute spacing distances depend upon the nature of the formation in which the wells are formed, states that an exemplary “horizontal spacing could be 162 meters [~531 feet].” EX1009 at 6:16-24. A POSITA would recognize that the spacing between wells depends on several factors, including the formation characteristics

and it was a common practice before 2004 to have horizontal spacing up to 2000 feet.

Claim 15: “wherein the vertical distance between the first horizontal well and the second horizontal well is up to 150 feet”

185. Claim 15 is dependent on Claim 9. Accordingly, I incorporate my arguments for Claim 9 herein. Brannan teaches this additional element. Brannan, while noting that “invention [is] not limited to any specific dimensions because absolute spacing distances depend upon the nature of the formation in which the wells are formed, states that an exemplary “vertical spacing ... could be 18 meters [~60 feet].” EX1009 at 6:16-24. A POSITA would recognize that the spacing between the wells depends on several factors, including the formation characteristics and it was a common practice before 2004 to have vertical spacing up to 150 feet.

Claim 16: “further comprising a power plant comprising an electricity generator and at least one turbine for driving said generator, conduit means for conveying geothermal fluid to said power plant whereby said geothermal fluid becoming heat-depleted, and conduit means for conveying heat-depleted geothermal fluid from said power plant to the horizontal, injection well”

186. Claim 16 is dependent on Claim 9. Accordingly, I incorporate my arguments for Claim 9 herein. Grassiani teaches this additional element. Grassiani discloses a geothermal combined cycle power plant where the steam extracted using the production well (red) drives the turbine at Level 1 (orange) that is then condensed in the vaporizer (blue) and vaporize the working fluid with the resulting vapors driving the turbine at Level 2 (green) that is coupled to a generator (yellow) for

producing power and injecting this heat depleted fluid back to the injection well
(purple). See EX1011 at 3719-20.

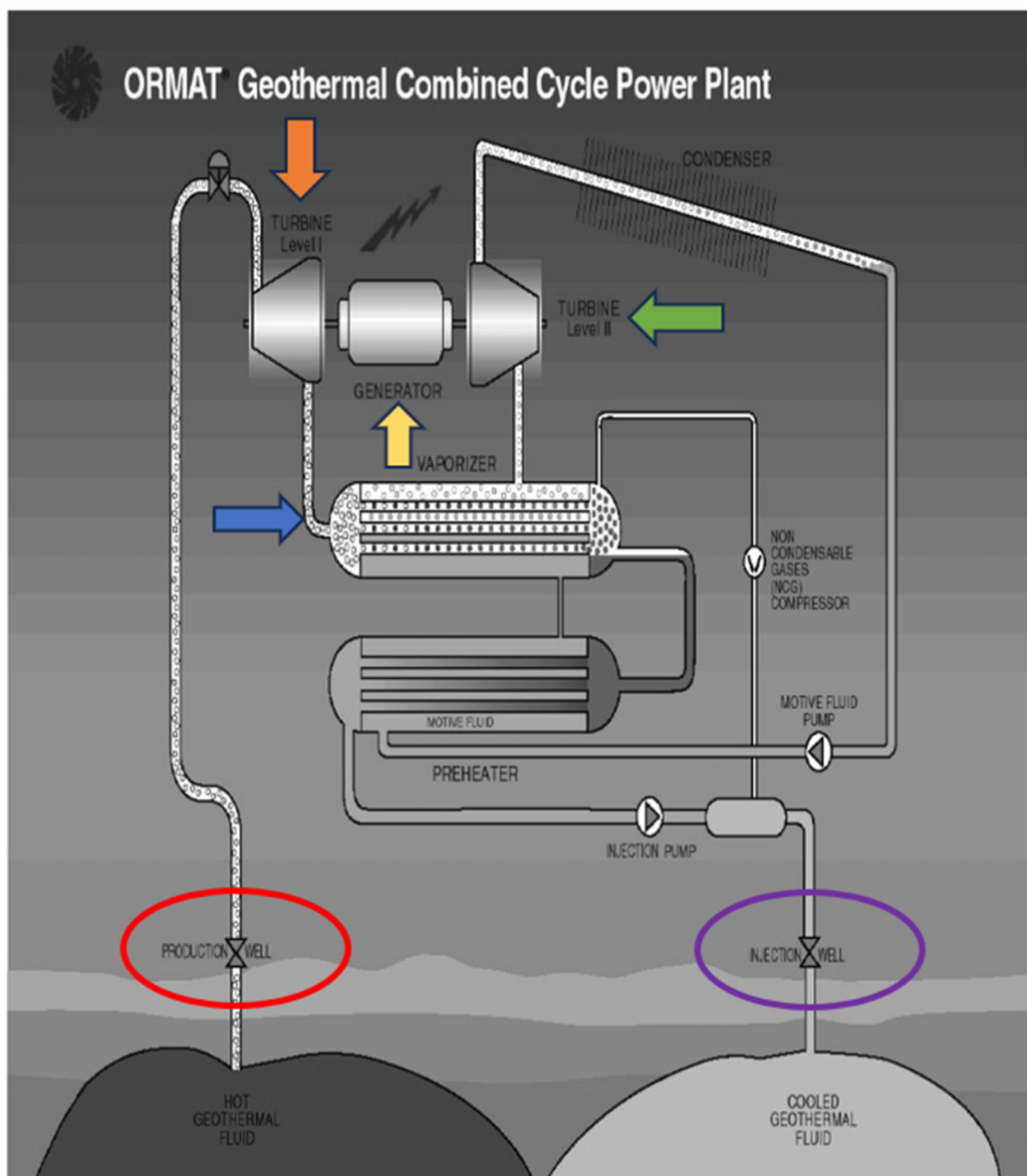


Figure 3. Process Diagram: ORMAT® Combined Cycle Unit

Claim 17: “further comprising a heat exchanger, conduit means for conveying geothermal fluid to a heat exchanger whereby to heat is transferred to a working fluid for producing power in a power plant”

187. Claim 17 is dependent on Claim 9. Accordingly, I incorporate my arguments for Claim 9 herein. Grassiani teaches this additional element. Grassiani discloses a “tube and shell heat exchanger” vaporizer where the “geothermal fluid flowing in the tubes” heats the organic “motive fluid in the shell side.” EX1011 at 3719.

Claim 18: “including a binary power plant comprising an organic vapor turbine operating according to an organic Rankine cycle”

188. Claim 18 is dependent on Claim 17. Accordingly, I incorporate my arguments for Claim 17 herein. Grassiani teaches this additional element. Grassiani discloses an organic vapor turbine operating according to an “Organic Rankine Cycle” for the level 2 turbine in its combined cycle power plant:

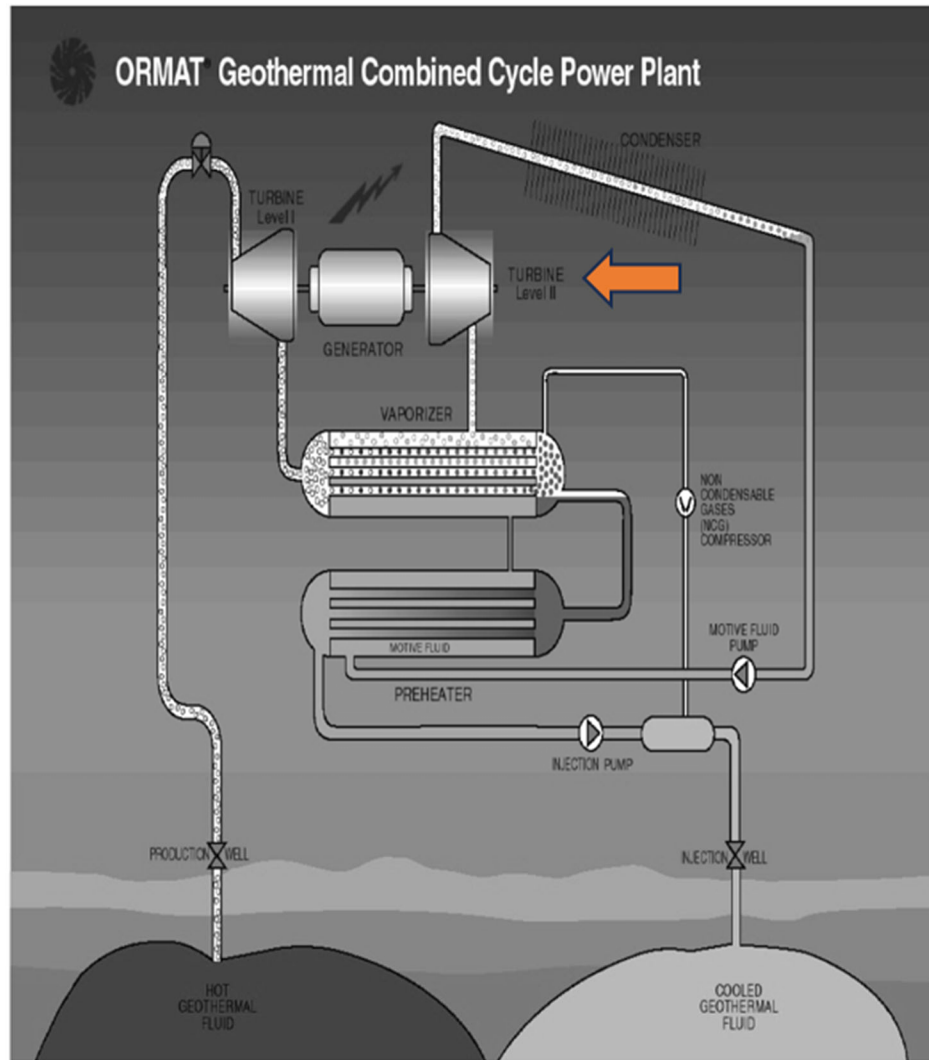


Figure 3. Process Diagram: ORMAT® Combined Cycle Unit

Claim 19: “wherein said binary power plant includes an air-cooled condenser”

189. Claim 19 is dependent on Claim 18. Accordingly, I incorporate my arguments for Claim 18 herein. Grassiani teaches this additional element. Grassiani discloses that “the spent motive fluid vapors ... are condensed in the finned tube air cooled condenser.” EX1011 at 3719.

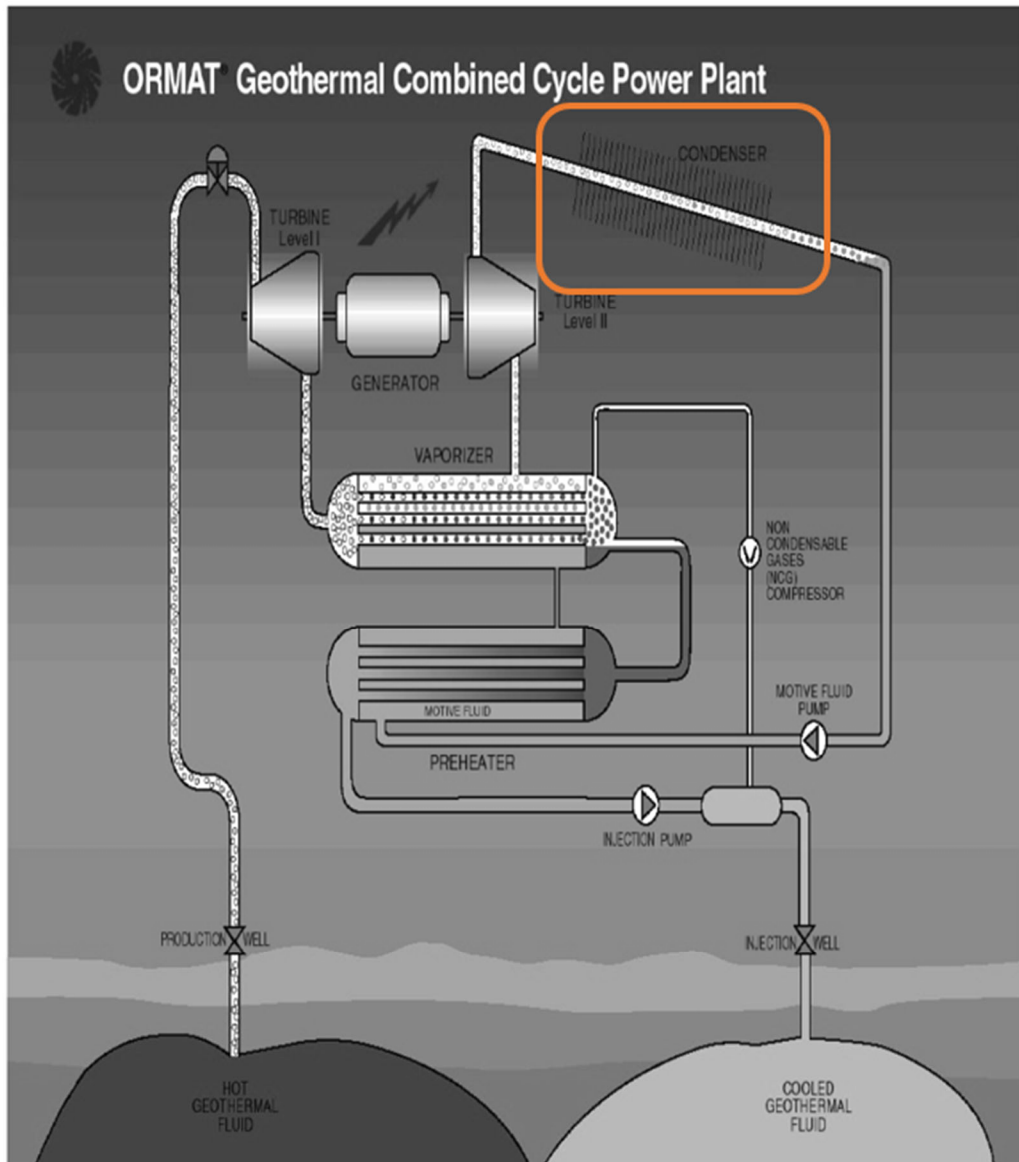


Figure 3. Process Diagram: ORMAT[®] Combined Cycle Unit

Claim 20: “wherein the working fluid of said binary power plant is pentane or isopentane”

190. Claim 20 is dependent on Claim 18. Accordingly, I incorporate my arguments for Claim 18 herein. Grassiani teaches this additional element. Grassiani notes that the working fluid, i.e., “the vaporized motive fluid [] typically [is] iso-

pentane.” EX1011 at 3719. A POSITA would recognize that pentane, isopentane (methylbutane), butane, and isobutane are some of the typical working fluids used in binary power plants.

Claim 21: “wherein the working fluid of said binary power plant is butane or isobutane”

191. Claim 21 is dependent on Claim 18. Accordingly, I incorporate my arguments for Claim 18 herein. Grassiani teaches this additional element. Grassiani notes that the working fluid, i.e., “the vaporized motive fluid [] typically [is] isopentane.” EX1011 at 3719. A POSITA would recognize that pentane, isopentane (methylbutane), butane, and isobutane are some of the typical working fluids used in binary power plants.

Claim 22: “wherein said power plant is a combined cycle geothermal power plant”

192. Claim 22 is dependent on Claim 17. Accordingly, I incorporate my arguments for Claim 17 herein. Grassiani teaches this additional element. *See* Claim 16 discussion, Section VIII.C, which is incorporated herein by reference.

Claim 23

193. Claim 23 is dependent on Claim 9. Accordingly, I incorporate my arguments for Claim 9 herein. Grassiani teaches this additional element. Grassiani discloses an injection pump shown below:

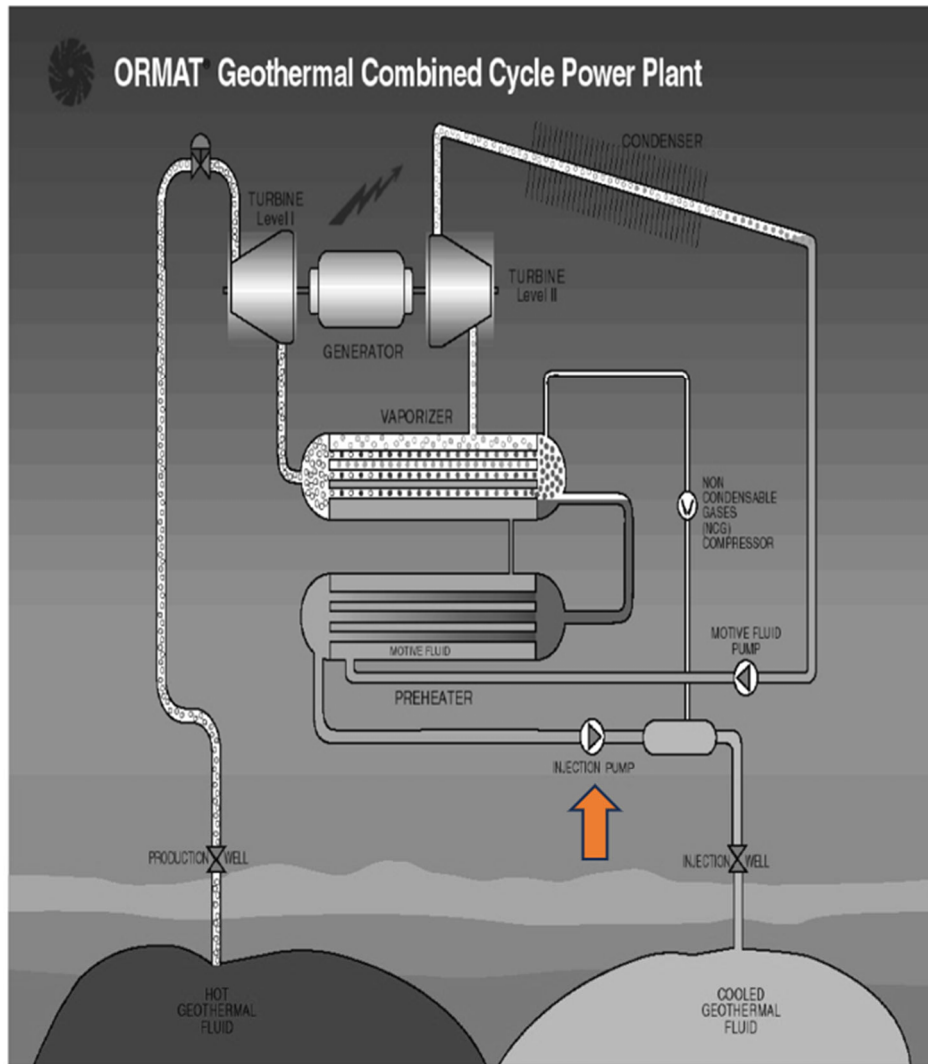


Figure 3. Process Diagram: ORMAT[®] Combined Cycle Unit

194. A POSITA would have recognized that an injection pump injects the heat depleted geothermal fluid from power plant back into the injection well.

Claim 32

195. Claim 32 is dependent on Claim 9. Accordingly, I incorporate my arguments for Claim 9 herein. Grassiani teaches this additional element. Grassiani discloses a Hot Dry Rock systems that “lack natural water.” EX1011 at 3719. A

POSITA would have recognized that such systems require all the water to be injected from an external source to create an artificial reservoir.

Claim 33

196. Claim 33 is dependent on Claim 9. Accordingly, I incorporate my arguments for Claim 9 herein. It is well known in the art that for a Hot Dry Rock reservoir, an artificial reservoir needs to be formed while for a water dominated reservoir, there is an existing geothermal fluid at the formation. *See also* EX1001 at 1:25-27 (“While commercial production of geothermal fluids (e.g. for power production) out of a ‘classical’ steam or water dominated reservoirs is pretty well at hand”).

Claim 38: “wherein said combined cycle geothermal power plant includes a steam turbine for expanding geothermal steam from said geothermal fluid and producing electricity, a vaporizer to which the expanded steam is Supplied to condense and vaporize the working fluid, which working fluid is supplied to a turbine where it expands thereby driving an electric generator for producing electric power”

197. Claim 38 is dependent on Claim 9. Accordingly, I incorporate my arguments for Claim 9 herein. Grassiani teaches this additional element. *See* Claim 16 discussion, Section VIII.C, which is incorporated herein by reference.

198. For the reasons discussed above, it is my opinion that all elements of claims 1-38 are obvious in view of the combination of Rinaldi, Grassiani, and Brannan.

D. Ground 4: Claims 1, 2, 6, 7, 9-11, 25-31, and 34-37 are obvious over Mims in view of the General Knowledge of a POSITA

Claim 1

Preamble

199. To the extent the preamble is limiting, Mims discloses that the invention relates to “recovering hydrocarbons from an underground hydrocarbon formation which comprises drilling and completing at least three substantially parallel horizontal wells A recovery fluid is injected into the formation through the second and third wells and hydrocarbons and other fluids are recovered through the first well.” EX1007 at Abstract. *See also id.* at Fig. 2 (showing injection and production wells); *id.* at 1:6-11 (discussing arrangement of “horizontal production and injection wells”).

200. It is therefore my opinion that Mims discloses this limitation.

Element 1a

201. Mims discloses “three substantially parallel horizontal wells the second and third wells are placed relatively near the bottom of the interval on each side of the first well. A recovery fluid is injected into the formation through the second and third wells.” EX1007 at 1:65-2:3. *See also id.* at 1:9-10 (“the invention employs horizontal [] injection wells”); *see also* EX1007 at Claims 1 and 2.

202. It is my opinion that a POSITA would have recognized that a geological layer, either for a Hot Dry Rock or for a geothermal reservoir, is at an elevated temperature.

203. It is therefore my opinion that Mims teaches this limitation.

Element 1b

204. Mims teaches that “the second and third wells [injection wells] are placed relatively near the bottom of the interval on each side of the first well. A recovery fluid [e.g., water] is injected into the formation through the second and third wells.” EX1007 at 1:65-2:3; *see also* EX1007 at Claims 1 and 2.

205. It is my opinion that a POSITA would understand that water was a well-known injection fluid before the '221 patent priority date.

206. According to Mims, “[a]ny recovery fluid known in the art of enhanced oil recovery may be employed in the invention process,” and identifies as particular examples “water, water with a viscosity increasing polymer, [and] steam.” EX1007 at 3:61-68 (emphasis added).

207. It is my opinion that a POSITA would recognize that the temperature of the formation, either for a Hot Dry Rock or for a geothermal reservoir, will necessarily heat the injected water.

208. It is therefore my opinion that Mims teaches this limitation.

Element 1c-1

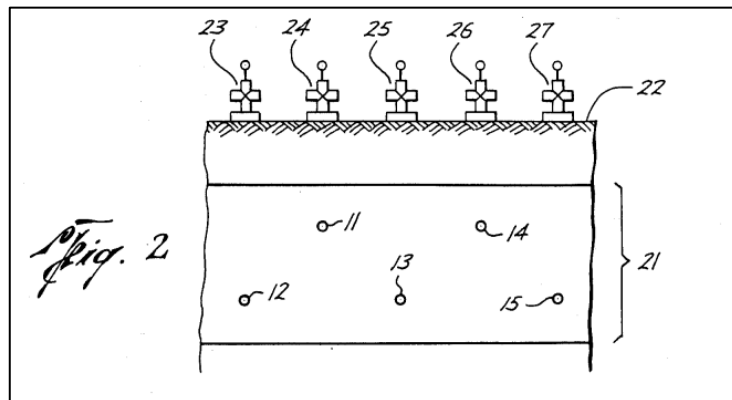
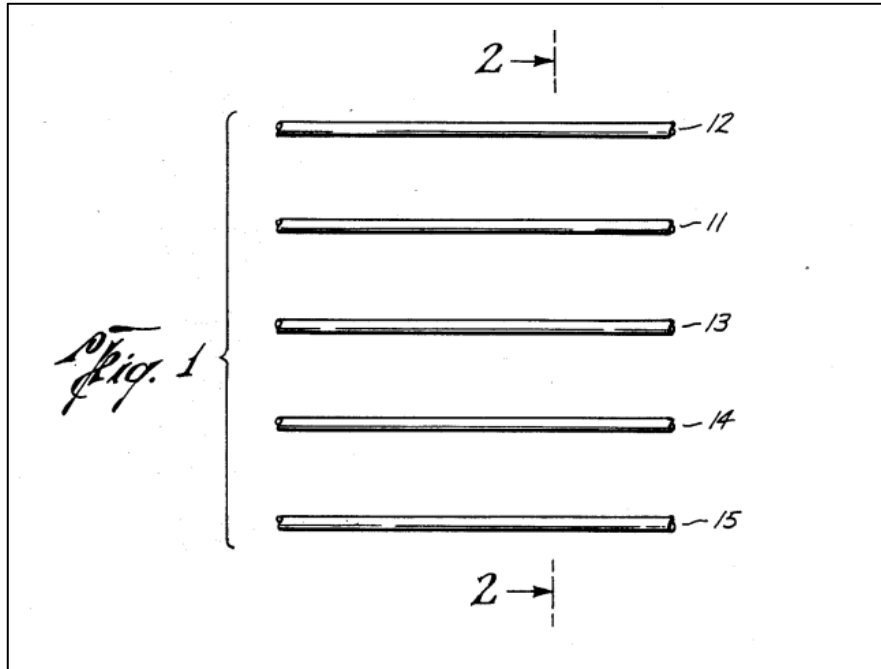
209. Mims discloses that the production well is horizontal. EX1007 at 2:40-50 (“In its most basic embodiment, at least three substantially parallel horizontal wells, a first well, a second well, and a third well”); *id.* at 1:65-2:3 (“[t]he first well [production well] is placed relatively near the top of a hydrocarbon interval”).

210. It is therefore my opinion that Mims teaches this limitation.

Element 1c-2

211. According to Mims, “[o]ptimum well spacing may vary considerably from formation to formation and may depend upon many factors known to those skilled in the art ... determined by conventional drilling criteria, the characteristics of the specific formation, the economics of a given situation and the well known art of drilling horizontal wells.” EX1007 at 4:31-39.

212. Figures 1 and 2 below show the wells vertically and horizontally spaced:



213. It is my opinion that a POSITA would recognize that in such a configuration, the injection and production wells are substantially horizontally and vertically spaced from each other.

214. It is also my opinion that a POSITA would further understand that Mims teaches well spacing dependent upon many factors known to those skilled in the art, including the characteristics of the formation, which at the time of the earliest

priority date of the '221 patent would have included temperature. EX1007 at 4:27–47.

215. It is therefore my opinion that Mims teaches this limitation.

Element 1c-3

216. Mims teaches that “[t]he first well [production well] is placed relatively near the top of a hydrocarbon interval and the second and third wells [injection wells] are placed relatively near the bottom of the interval on each side of the first well.” EX1007 at 1:65-2:3; *id.* at 2:40-50 (same); EX1007 at claims 1 and 2.

217. It is therefore my opinion that Mims teaches this limitation.

Element 1d

218. Mims discloses that fluid is recovered via the production well. EX1007 at 2:2-3 (“fluids are recovered through the first well”); *see also* Mims at claims 1 and 2 (“...producing hydrocarbons and other fluids through the first and fourth wells....”).

219. It is therefore my opinion that Mims teaches this limitation.

Element 1e

220. It is my opinion that Mims, in combination with a POSITA’s general knowledge at the time of the invention, would have disclosed “[g]enerating a water density difference and a pressure difference between said first horizontal, injection well and said second horizontal, production well.” *See generally*, EX1007 at 3:61-68.

221. The concept of generating a water density difference between a horizontal injection well and horizontal production well is obvious and a well-studied, basic physical principle.

222. As discussed above, it is my opinion that a POSITA would recognize that this claim limitation operates on the fundamental physics of fluid dynamics and thermodynamics, leveraging the principles of geothermal gradients and hydrothermal convection.

223. It is also my opinion that a POSITA would have known that when water is injected into the subsurface through the injection well, the water heats up due to the geothermal heat and decreases in density. This temperature-induced density difference creates a natural convective flow, enhancing the movement of water through the geothermal reservoir.

224. It is also my opinion that it is a basic property of physics that as the density of fluid (e.g., water) decreases, it tends to flow upwards.

225. It is my opinion that a POSITA would have known injecting water at a controlled rate increases the pressure in the reservoir, further driving the heated water towards the production well. This pressure difference is crucial for overcoming the natural hydrostatic and lithostatic pressures within the earth's crust, facilitating the upward movement of heated water and steam.

226. Mims discloses “factors such as flow rate, temperatures, and pressures employed in a given operation” EX1007 at 4:45–47.

227. It is therefore my opinion that Mims, along with the general knowledge of a POSITA, teaches this claim.

Element 1f

228. It is my opinion that Mims, in combination with a POSITA’s general knowledge at the time of the invention, would have disclosed this element.

229. As discussed above in Section VIII.A, the buoyancy and pressure difference are obvious and well understood features of geothermal circulation systems.

230. It is therefore my opinion that Mims, along with the general knowledge of POSITA, teaches this claim.

Claim 2

231. Claim 2 is dependent on Claim 1, and further adds the limitation “wherein the horizontal wells are provided by drilling along a geological layer”.

232. It is my opinion that Mims, in combination with the general knowledge of a POSITA, teaches this additional element.

233. Mims discloses “the recovery of hydrocarbons from an underground formation by the use of horizontal injection and production wells.” EX1007 1:5-10. Mims also describes “drilling and completing at least three substantially parallel

horizontal wells to form a substantially triangular well pattern within a hydrocarbon formation.” EX1007 at Abstract; *see also id.* at 1:12-24; *id.* at 2:43-47 (describing placement of wells within a “hydrocarbon interval”).

234. It is my opinion that a POSITA would recognize that in Mims, which describes wells drilled horizontally within a hydrocarbon formation or along the same hydrocarbon interval as drilling along a geological layer and if not drilled this way, the purpose of heating the fluid through the geological layer will not be satisfied.

235. It is therefore my opinion that Mims, along with the general knowledge of a POSITA, teaches this claim.

Claim 6

236. Claim 6 is dependent on Claim 1, and further adds the limitation “comprising monitoring the pressure difference.”

237. It is my opinion that Mims, in combination with the general knowledge of a POSITA, would render this claim obvious. Mims discloses the consideration of “pressures employed in a given operation.” EX1007 at 4:47.

238. Pressures have to be measured in order to be considered as a factor in a given operation.

239. Further, monitoring pressure differences is a critical aspect of oil recovery and, likewise, geothermal energy production methods. It helps optimize the

extraction process and ensures the safety and efficiency of the wells. Further, managing pressure within a reservoir is crucial for effective hydrocarbon recovery, as it directly influences the flow of oil and gas towards production wells. Proper pressure management ensures the optimal displacement of hydrocarbons, enhancing the efficiency of recovery processes such as water flooding, gas injection, or thermal methods.

240. It is therefore my opinion that Mims teaches this claim.

Claim 7

241. Claim 7 is dependent on Claim 1 and further adds the limitation “wherein the first and second horizontal, geothermal wells are formed in a geological layer the suitability of which has been determined.”

242. It is my opinion that Mims, in combination with the general knowledge of a POSITA, would render this claim obvious. Mims describes “drilling and completing at least three substantially parallel horizontal wells to form a substantially triangular well pattern within a hydrocarbon formation.” EX1007 at Abstract; *see also id.* at 1:12-24; *id.* at 2:43-47 (describing placement of wells within a “hydrocarbon interval”).

243. A POSITA would have recognized that choosing a hydrocarbon formation or hydrocarbon interval for horizontal drilling involves determining the

suitability of the geological layer for drilling. The assessment of geological layer suitability is an important step to determine whether to drill in the first instance.

244. It is therefore my opinion that Mims teaches this claim.

Claim 9

245. Independent Claim 9 and independent claim 1 contain similar claim limitations. *Compare* EX1001 cl. 1 to cl. 9. Accordingly, Section VIII.D discusses the disclosure of claim 9, preamble to claim 9, element c, are incorporated for claim 9a-9c analysis.

246. It is therefore my opinion that Mims teaches these claim limitations.

Element 9d

247. In addition to the Mims disclosures discussed in Section VIII.D, it is my opinion that a POSITA's knowledge on the open slots used for injection means would render this claim limitation obvious.

248. It is my opinion that by 2004, a POSITA would understand that open slotted outlets are suitable injection means well known in the art at the time to suit different reservoir conditions and production requirement.

249. It is my opinion that a POSITA would understand that in the context of hydrocarbon extraction, slotted liners have been used for many decades to support the well structure and to filter out sand and other fine particles from the produced fluids.

250. Further, it is my opinion that a POSITA would understand, in geothermal energy production, slotted liners or similar mechanisms are used to allow the flow of geothermal fluids into the well while preventing the entry of rock fragments or other debris that could clog the well or damage surface equipment.

251. It is therefore my opinion that Mims teaches this claim limitation.

Claim 10

252. Claim 10 is dependent on Claim 9 and further adds the limitation “further comprising instrumentation for monitoring the pressure difference.” Accordingly, my opinions for Claim 9 are incorporated herein.

253. It is also my opinion that Mims, along with the general knowledge of a POSITA, teaches this additional element.

254. Mims discloses the consideration of “pressures employed in a given operation.” EX1007 at 4:47.

255. It is my opinion that pressures have to be measured in order to be considered as a factor in a given operation. Further, monitoring pressure differences is a critical aspect of oil recovery and, likewise, geothermal energy production methods. It helps optimize the extraction process and ensures the safety and efficiency of the wells. Further, managing pressure within a reservoir is crucial for effective hydrocarbon recovery, as it directly influences the flow of oil and gas towards production wells. Proper pressure management ensures the optimal

displacement of hydrocarbons, enhancing the efficiency of recovery processes such as water flooding, gas injection, or thermal methods.

256. It is therefore my opinion that Mims teaches this claim.

Claim 11

257. Claim 11 is dependent on Claim 9 and further adds the limitation “further comprising an observation well connected to the second horizontal, production geothermal well, and wherein the instrumentation comprising observation instrumentation present in said observation well.” Accordingly, my opinions for Claim 9 are incorporated herein.

258. It is my opinion that a POSITA would recognize that by 2004, the use of observation wells was widely known. *See* Section VIII.D; *see also* EX1007 at 4:45-47 (describing factors to be observed).

259. It is therefore my opinion that Mims teaches this claim.

Claim 25

260. Claim 25 is dependent on Claim 9 and further adds the limitation “wherein the horizontal, injection geothermal well comprises a perforated horizontal pipe.” Accordingly, my opinions for Claim 9 are incorporated herein.

261. It is my opinion that Mims, along with the general knowledge of a POSITA, teaches this additional element. *See* Section VIII.D; *See also* EX1007 at

4:45-47 (“Perforation size will be a function of other factors such as flow rate, temperatures and pressures employed in a given operation”).

262. It is my opinion that a POSITA would recognize the application of the well-known concept of perforating the injection well.

263. It is therefore my opinion that Mims teaches this claim.

Claim 26

264. Claim 26 is dependent on Claim 9 and further adds the limitation “wherein the second horizontal, production geothermal well comprises a perforated horizontal pipe.” Accordingly, my opinions for Claim 9 are incorporated herein.

265. It is my opinion that Mims, along with the general knowledge of a POSITA, teaches this additional element. Section VIII.D; *See also* EX1007 at 4:45-47 (“Perforation size will be a function of other factors such as flow rate, temperatures and pressures employed in a given operation”).

266. It is my opinion that a POSITA would recognize the application of the well-known concept of perforating the injection well.

267. It is therefore my opinion that Mims teaches this claim.

Claim 27

268. Claim 27 is dependent on Claim 25 and further adds the limitation “wherein the perforated horizontal pipe is perforated on its lower surface.” Accordingly, my opinions for Claim 25 are incorporated herein.

269. It is my opinion that Mims, along with the general knowledge of a POSITA, teaches this additional element. A POSITA would recognize that Mims's disclosure of perforations (EX1007 at 4:45-47) includes perforation on the lower surface.

270. It is therefore my opinion that Mims teaches this claim.

Claim 28

271. Claim 28 is dependent on Claim 26 and further adds the limitation "wherein the perforated horizontal pipe is perforated on its lower surface." Accordingly, my opinions for Claim 26 are incorporated herein.

272. It is my opinion that Mims, along with the general knowledge of a POSITA, teaches this additional element.

273. A POSITA would recognize that Mims's disclosure of perforations (EX1007 at 4:45-47) includes perforation on the lower surface.

274. It is therefore my opinion that Mims teaches this claim.

Claim 29

275. Claim 29 is dependent on Claim 9 and further adds the limitation "wherein the production horizontal geothermal well is generally parallel to the injection horizontal, geothermal well." Accordingly, my opinions for Claim 9 are incorporated herein.

276. Mims teaches this additional element. EX1007 at 2:40-50 (“In its most basic embodiment, at least three substantially parallel horizontal wells, a first well, a second well, and a third well”). *See also id.* at 1:9-10 (“the invention employs horizontal [] injection wells”); *see also* EX1007 at Claims 1 and 2.

277. It is therefore my opinion that Mims teaches this claim.

Claim 30

278. Claim 30 is dependent on Claim 9 and further adds the limitation “comprising a plurality of injection horizontal, geothermal wells for one production horizontal, geothermal well.” Accordingly, my opinions for Claim 9 are incorporated herein.

279. Mims teaches this additional element. Mims discloses “three substantially parallel horizontal wells the second and third wells are placed relatively near the bottom of the interval on each side of the first well. A recovery fluid is injected into the formation through the second and third wells.” EX1007 at 1:65-2:3. *See also id.* at 1:9-10 (“the invention employs horizontal [] injection wells”); *see also* EX1007 at Claims 1 and 2.

280. Mims also teaches “...at least three substantially parallel horizontal wells, a first well, a second well, and a third well”) EX1007 at 2:40-50; *See also* EX1007 at 1:60-68 (describing a single (first) injection well with a plurality of (second and third) injection wells).

281. It is therefore my opinion that Mims teaches this claim.

Claim 31

282. Claim 31 is dependent on Claim 9 and further adds the limitation “comprising a plurality of horizontal injection wells and a plurality of horizontal production wells spaced horizontally and vertically.” Accordingly, my opinions for Claim 9 are incorporated herein.

283. Mims teaches this additional element. For example, Mims discloses a plurality of injection and production wells across a formation. EX1007 at 4:11-19; *id.* at 4:20-27 (disclosing fourth and fifth wells in the configuration).

284. It is therefore my opinion that Mims teaches this claim.

Claim 34

285. Independent Claim 34 and independent claim 1 contain similar claim limitations. *Compare* EX1001 cl. 1 to cl. 34. Accordingly, paragraphs ____ discuss the disclosure of claim 1, preamble to claim 1, element e, are incorporated for claim 34-I to 34-IV analysis.

286. It is therefore my opinion that Mims teaches these claim limitations.

Element 34-V

287. It is my opinion that Mims, along with the general knowledge of a POSITA, teaches this element.

288. It is my opinion that a POSITA would have known injecting water at a controlled rate increases the pressure in the reservoir, further driving the heated water towards the production well. This pressure difference is crucial for overcoming the natural hydrostatic and lithostatic pressures within the earth's crust, facilitating the upward movement of heated water and steam.

289. Mims teaches certain factors to consider. EX1007 at 4:45–47 (noting “factors such as flow rate, temperatures, and pressures employed in a given operation”).

290. It is therefore my opinion that Mims teaches this claim limitation.

Element 34-VI

291. It is my opinion that Mims, along with the general knowledge of a POSITA, teaches this element.

292. As discussed in Section VIII.A, the buoyancy and pressure difference are obvious and well understood features of geothermal circulation systems.

293. It is therefore my opinion that Mims teaches this claim limitation.

Claims 35-37

294. Claim 35 is dependent on Claim 1; Claim 36 is dependent on Claim 9; and Claim 37 is dependent on Claim 34. Accordingly, my opinions for Claim 1, Claim 9, and Claim 34 herein.

295. Moreover, Mims teaches the “wherein the geothermal fluid is one of water, steam and a combination thereof” element. EX1007 at 3:61-68 (“[a]ny recovery fluid known in the art of enhanced oil recovery may be employed in the invention process,” and identifies as particular examples “water, water with a viscosity increasing polymer, [and] steam.”).

296. It is therefore my opinion that Mims teaches these claims.

E. Ground 5: Claims 1, 2, 4-7, 9-11, and 25-37 are obvious over Mims in view of Kruger and in further view of Swenson

Claim 1

Preamble

297. To the extent the preamble is limiting, Mims teaches the preamble as set forth in Ground 4, Section VIII.D, which is incorporated herein.

298. Further, both Swenson and Kruger teach this element. Swenson describes a “Hot Dry Rock (HDR) geothermal reservoir ... created by drilling a well into a body of hot crystalline rock, forming an artificial geothermal reservoir by pumping water down under pressures high enough to open natural joints in the rock, and subsequently drilling one or more production wells into the reservoir zone. During operation, fluid circulates around a closed loop, removing heat from the rock at depth and transporting it to the surface.” EX1008 at 2553.

299. It is therefore my opinion that Mims, in view of Swenson and Kruger teaches this limitation.

Element 1a

300. Mims teaches element 1a of Claim 1 as set forth in Ground 4, Section VIII.D, which is incorporated herein.

301. Additionally, Kruger teaches the use of an injection well for recovery of geothermal energy. *see* EX1010 at 11-12.

302. It is my opinion that a POSITA would understand that Mims, when read in conjunction with the technique described in Kruger, would allow a POSITA to utilize horizontal wells to achieve the desired results.

303. It is therefore my opinion that Mims in view of Kruger teaches this limitation.

Element 1b

304. Mims teaches element 1b of Claim 1 as set forth in Ground 4, Section VIII.D, which is incorporated herein. Swenson further teaches this additional element.

305. According to Swenson, “water” is pumped “down under pressures high enough to open natural joints in the rock, and subsequently drilling one or more production wells into the reservoir zone.” EX1008 at 2553. This water gets heated as it “circulates around a closed loop, removing heat from the rock at depth and transporting it to the surface.” *Id.* at 2553.

306. Additionally, Kruger discloses “cold water [being] forced into the fracture zone through the deeper well. Pumping is discontinued when natural convection in the cycle is achieved.” EX1010 at 11-12.

307. It is my opinion that a POSITA would understand that Kruger is describing the same basic principles of fluid dynamics and thermodynamics as set forth in this claim element, benefitting from on the concepts of geothermal gradients and hydrothermal convection, which heats the water injected downhole.

308. It is therefore my opinion that Mims in view of Kruger teaches this limitation.

Element 1c-1

309. Mims teaches element 1c-1 of Claim 1 as set forth in Ground 4, Section VIII.D, which is incorporated herein.

310. It is therefore my opinion that Mims teaches this limitation.

Element 1c-2

311. Mims teaches element 1c-2 of Claim 1 as set forth in Ground 4, Section VIII.D, which is incorporated herein.

312. Swenson states that “[m]odels, including GEOCRACK, show that longevity is dependent upon rock temperatures, flow path spacing, numbers of active flow paths, well spacing, and flow rates. Because well spacing and flow rates may be controlled to a much greater extent than the internal geometry of reservoir flow

paths, GEOCRACK indicates that reservoir operators could engineer systems with extensive lifetimes and profitable thermal productivity by appropriate well spacing and limiting energy production rates.” EX1008 at 2558. *See also id.* at 2553 (describing use of the GEOCRACK model to address number and spacing of wells).

313. It is therefore my opinion that Mims, in view of Swenson, teaches this limitation.

Element 1c-3

314. Mims teaches element 1c-3 of Claim 1 as set forth in Ground 4, Section VIII.D, which is incorporated herein.

315. It is therefore my opinion that Mims teaches this limitation.

Element 1d:

316. Mims teaches element 1d of Claim 1 as set forth in Ground 4, Section VIII.D, which is incorporated herein.

317. Moreover, both Swenson and Kruger disclose the recovery of geothermal fluid from production wells. *See* EX1008 at 2553, 2554, 2558; *see* EX1010 at 4, 11-12, 20-21.

318. It is therefore my opinion that Mims, in view of Swenson and in further view of Kruger, teaches this limitation.

Element 1e:

319. Mims teaches element 1e of Claim 1 as set forth in Ground 4, Section VIII.D, which is incorporated herein.

320. Additionally, Table 2 of Swenson shows the pressure difference generated between the injection and production wells:

	Injection Pressure	Production Pressure	Pressure Difference	Resultant Flow Rate
Fenton Hill	27.3 MPa	9.65 MPa	17.65 MPa	5.7 l/s
	27.3 MPa	12.4MPa	14.9MPa	5.7 l/s
	27.3 MPa	15.2MPa	12.1MPa	5.3 l/s
	22.4 MPa	9.65MPa	12.75 MPa	3.8 U/s
GEOCRACK	27.3 MPa	9.65MPa	17.65MPa	5.7 U/s
	27.3 MPa	12.4MPa	14.9MPa	5.4 l/s
	27.3 MPa	15.2 MPa	12.1MPa	5.1 l/s
	22.4MPa	9.65MPa	12.75MPa	2.9 l/s

Table 2: Actual and modeled flows under different wellhead pressure conditions. (hydrostatic = 35.4MPa)

321. Further, “[b]oth GEOCRACK and actual Fenton Hill data show that the level of outlet flow can be maintained even with a smaller driving pressure difference across the reservoir (Duteau and Brown, 1993).” EX1008 at 2556.

322. Kruger also teaches that “cold water is forced into the fracture zone through the deeper well,” and that “[p]umping is discontinued when natural convection in the cycle is achieved.” EX1010 at 11-12.

323. It is my opinion that a POSITA would understand that this discloses generating a water density difference and a pressure difference between an injection well and a production well in the context of geothermal energy extraction. The concept of generating a water density difference between a horizontal injection well

and horizontal production well is obvious and a well-studied, basic physical principle. *See* Element 1e discussion, Section VIII.A, for POSITA's general knowledge, which is incorporated herein.

324. It is therefore my opinion that Mims, in view of Kruger and in further view of Swenson, teaches this limitation.

Element 1f:

325. In my opinion, Element 1f is obvious to a POSITA in view of Mims as set forth in Ground 4, Section VIII.D, which is incorporated herein. *See* Element 1e discussion, Section VIII.E, which is incorporated herein.

326. Swenson discloses "outlet flow" through the production well maintained with "a small driving pressure difference." EX1008 at 2556. Further, as "fluid circulates ... it removes the heat from the rock" EX1008 at 2553. As discussed in Section VIII.A, Ground 1, Element 1f, the buoyancy and pressure difference are obvious and well understood features of geothermal circulation systems.

327. Finally, Kruger discloses the development of a model "to estimate the fluid mechanics and heat exchange properties of the system." EX1010 at 20-21. This model, as disclosed in Kruger, identifies "that adequate heat extraction will be possible even at relatively high flow rate solely through buoyant circulation of pressurized water." *Id.* "[B]uoyant circulation of pressurized water" discloses the

concept of utilizing buoyancy and pressure differences to drive fluid movement within a geothermal system.

328. It is my opinion that a POSITA would understand these disclosures describe the extraction of geothermal energy using buoyant circulation of pressurized water, as described in element 1f. *See* Sections VIII.A and VIII.D.

329. It is therefore my opinion that Mims, in view of Kruger, and in further view of Swenson, teaches this limitation.

Claims 2, 6, 7, 9-11, 25-31, and 34-37

330. As discussed above, all the elements of Claims 2, 6, 7, 9-11, 25-31, and 34-37 are obvious to a POSITA in view of Mims. Accordingly, those arguments from Section VIII.D, Ground 4 are incorporated herein.

331. It is therefore my opinion that Mims teaches all of these claims and their respective limitations.

Claim 4

332. Claim 4 is dependent on Claim 1 and further adds the limitation “further comprising extracting heat from the geothermal fluid recovered from the production well and using said heat for the production of energy.” Accordingly, my opinions for Claim 1 are incorporated herein.

333. Swenson discloses a HDR system where the injected “fluid ... remov[es] heat from the rock at depth and transport[s] to the surface ... for steady, long-term energy production.” EX1008 at 2553.

334. Additionally, Kruger discloses that the “[e]xtraction of the heat in rock formation may be achieved by flashing the geothermal liquid to steam within the formation...” EX1010 at 8.

335. It is therefore my opinion that Mims, in view of Kruger, in further view of Swenson, teaches this claim.

Claim 5

336. Claim 5 is dependent on Claim 1 and further adds the limitation “wherein the water injected into the injection well is the geothermal fluid, recovered from the production well, depleted of heat by heat exchange.” Accordingly, my opinions for Claim 1 are incorporated herein.

337. Swenson discloses establishing a “closed loop circulation” by “removing heat from the rock at depth and transporting it to the surface for steady, long-term energy production.” EX1008 at 2553.

338. It is my opinion that a POSITA would recognize that for such system to form a “closed loop” it must rely on re-injection of the extracted geothermal fluid through the injection well.

339. It is therefore my opinion that Mims, in view of Swenson, teaches this claim.

Claim 32

340. Claim 32 is dependent on Claim 9 and further adds the limitation “wherein all the water and make-up water is supplied from an external source.” Accordingly, my opinions for Claim 9 are incorporated herein.

341. Swenson discloses a “Hot Dry Rock (HDR) geothermal reservoir ...that ...does not contain transportable water.” EX1008 at 2553. Such systems “require forming an artificial geothermal reservoir by pumping water” *Id.* at 2553.

342. It is my opinion that a POSITA would recognize that for such dry rock layers, water needs to be supplied from external sources.

343. It is therefore my opinion that Mims, in view of Swenson, teaches this claim.

Claim 33

344. Claim 33 is dependent on Claim 9 and further adds the limitation “wherein part of the water circulating is from the reservoir and only make-up water is from an external source.” Accordingly, my opinions for Claim 9 are incorporated herein.

345. Kruger discloses that when considering projects “to establish an artificial circulation system for heat extraction from deposits of hot rock,” certain parameters, such as “the availability of makeup water” must be considered. EX1010 at 20.

346. It is my opinion that a POSITA would recognize that part of the water circulating in a natural convection system such as that described in Kruger (EX1010 at 11-12) is from the reservoir and, if no make-up water is available within the system, it must come from an external source. The practice of using water directly from the geothermal reservoir for energy production, supplemented by make-up water to replace losses, is a common approach in geothermal operations to maintain system balance and efficiency.

347. It is therefore my opinion that Mims, in view of Kruger, teaches this claim.

F. Ground 6: Claims 1-7, 9-23, 25-31, and 34-38 are obvious over Mims in view of Grassiani and Brannan

Claims 1, 2, 6, 7, 9-11, 25-31, and 34-37

348. Mims teaches claims 1, 2, 6, 7, 9-11, 25-31, and 34-37 as discussed in Section VIII.D, Ground 4. Accordingly, my opinions from Section VIII.D, Ground 4 are incorporated herein.

349. It is therefore my opinion that Mims teaches these claims.

Claim 3

350. Claim 3 is dependent on Claim 1 and further adds the limitation “comprising increasing the pressure difference by pressurizing the water, injected in the horizontal, deeper injection well, above the hydrostatic pressure existing at the depth of the horizontal deeper injection geothermal well, and reducing the pressure in the horizontal, shallower production well using a fluid pump connected to said horizontal production well.” Accordingly, my opinions for Claim 1 are incorporated herein.

351. Grassiani discloses “injection wellhead pressures are expected to be in the range of 100kg/cm² during operating flow conditions.” EX1011 at 3719.

352. It is my opinion that a POSITA would recognize that any applied pressure adds to the already existing hydrostatic pressure at the depth of the horizontal deeper injection wells.

353. Further, Grassiani discloses a power plant in China that had “down-hole pumps” for its “two production wells.” *See* EX1011 at 3720.

354. It is therefore my opinion that Mims, in view of Grassiani, teaches this claim.

Claims 4-5, 12-23, and 38

355. My opinions from Section VIII.C, Ground 3 for Claims 4-5, 12-23, and 38 are incorporated herein.

356. Further, Brannan details a “[n]umerical model study using the THERM numerical simulator commercially available from Scientific Software Intercomp” that used a “500 meter [~0.31 mile] horizontal well.” EX1009 at 11:28.

357. Additionally, it is my opinion that a POSITA would recognize that as the horizontal injection well length increases, its drainage area increases but so does frictional losses. As such, the optimal injection well length depends on several factors, including economics and it was a general knowledge within the industry to have a horizontal well length up to 1.25 miles.

358. It is therefore my opinion that Mims, in view of Grassiani and in further view of Brennan, teaches these claims.

G. Ground 7: Ground 7: Claims 1-11, 16, 17, and 23-37 are obvious over Rinaldi in view of Swenson and in further view of Alkhasov

Claim 1

Preamble 1, Elements 1a, 1b, 1d, 1e, and 1f

359. These elements are obvious over Rinaldi in view of Swenson. *See* Ground 1, Claim 1, Section VIII.A. Accordingly, those arguments are incorporated as if set forth herein.

Elements 1c-1–1c-3

360. These elements are obvious over Rinaldi in view of Swenson. *See* Elements 1c-1–1c-3, Sections VIII.A and VIII.B. Alkhasov further teaches that the

production well is spaced from the injection well by a distance dependent on the elevated temperature.

361. According to Alkhasov, the output of the well, P , is dependent on the water density ρ_a in the production well.

$$P = \Delta P_i + \Delta P_a + \Delta P_{ie} + \Delta P_o + (\rho_a - \rho_i)gH$$

Where ΔP_i , ΔP_a , ΔP_{ie} are correspondingly hydraulic losses of pressure in injection, [production] wells and surface pipelines; ΔP_o is filtrational losses of pressure in formation; ρ_a is the density of thermal water in producti[on] well; H is the depth of well, m.

EX1012 at p.3. Further, it also instructs on various geothermal pressure and temperature differentials that determine the placement and length of the wells.

362. A POSITA would recognize that density depends on temperature and as such the density of the water in the wells would be dependent on the downhole temperature. Further, if the output rate is insufficient to generate sufficient power, a POSITA would recognize that the placement of the production and injection wells needs to be modified to meet the desired output rate.

Claims 2-11 and 23-37

363. Rinaldi in view of Swenson teach claims 2-11 and 23-37 as discussed in Ground 2. Accordingly, those arguments are incorporated as if set forth herein.

Claim 16

364. Claim 16 is dependent on Claim 9. Accordingly, I incorporate my arguments for Claim 9 herein. Alkhasov further teaches this additional element.

Figure 1 discloses the geothermal power plant model comprising of generator (8), turbine (7), connection to the horizontal production well (1) for extracting the geothermal fluid and conveying it to the power plant and connection to the injection well (2) for injecting the fluid from the power plant back into the well (EX1012 at p.2):

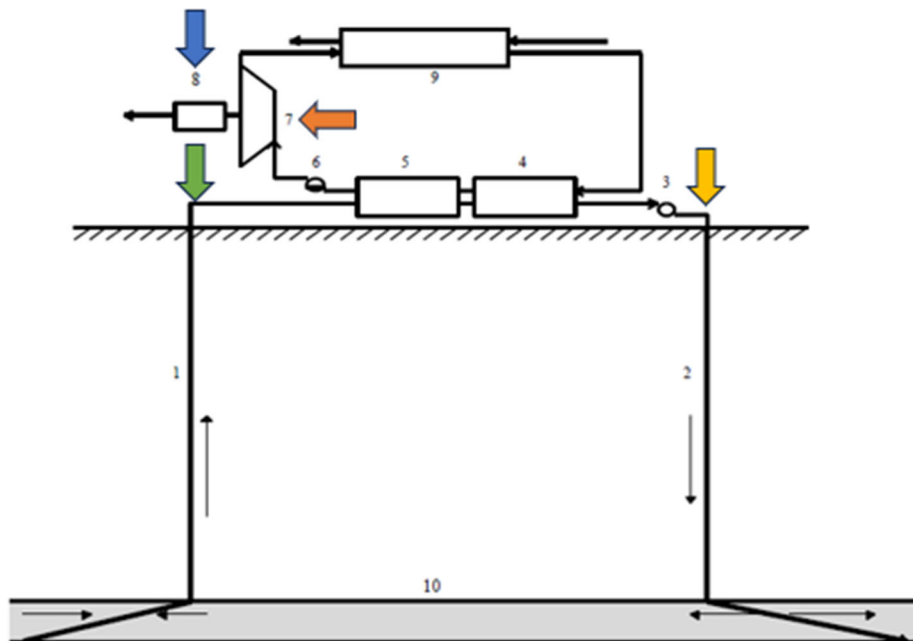


Fig.1 Technological scheme of GPP with horizontal wells. 1 - producing well; 2- injection well; 3- pump house of GCS; 4- heat-exchanger; 5- evaporator; 6- pump of secondary contour; 7- turbine; 8- generator; 9- condensator; 10- aquifer.

Claim 17

365. Claim 17 is dependent on Claim 9. Accordingly, I incorporate my arguments for Claim 9 herein. Alkhasov further teaches this additional element. Figure 1 discloses a heat-exchanger (4) as shown. EX1012 at p.2. A POSITA would recognize that the basic functionality of a heat exchanger in a power plant is to convey heat from one fluid (geothermal fluid) to the other (working fluid/motive fluid) for producing power.

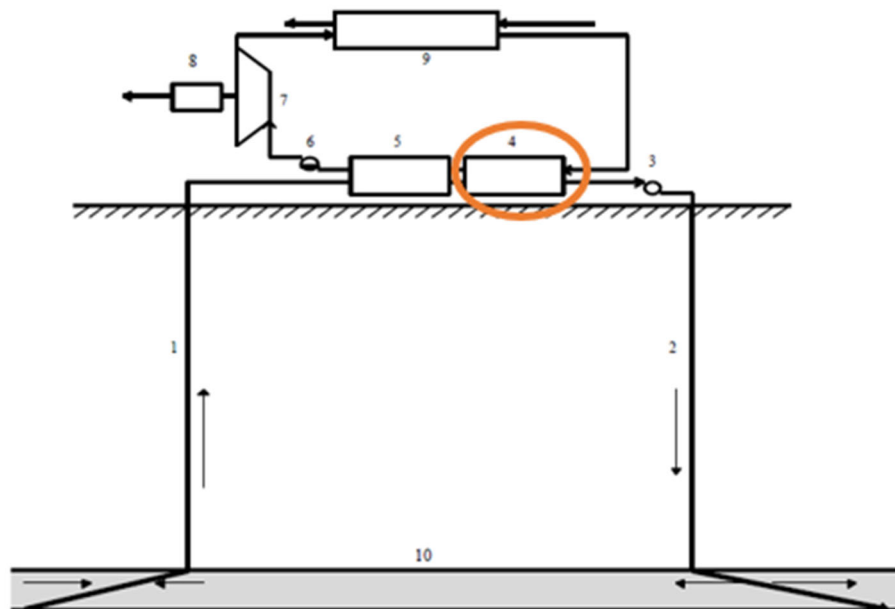


Fig.1 Technological scheme of GPP with horizontal wells. 1 - producing well; 2- injection well; 3- pump house of GCS; 4- heat-exchanger; 5- evaporator; 6- pump of secondary contour; 7- turbine; 8- generator; 9- condensator; 10- aquifer.

366. For the reasons discussed above, it is my opinion that all elements of claims 1-11, 16, 17, and 23-37 are rendered obvious in view of the combination of Rinaldi over Swenson and Alkhasov.

IX. Conclusion

367. As explained above, it is my opinion that each of claims 1-38 of the '221 patent are obvious in view of the prior art.

368. The findings and opinions set forth in this declaration are based on my work and examinations to date. I may continue my examinations. I may also receive additional documentation and other factual evidence over the course of this proceeding that will allow me to supplement and/or refine my opinions. I reserve the right to add to, alter, or delete my opinions and my declaration upon discovery of any such additional information. I reserve the right to make such changes as may be deemed necessary.

369. I understand that Petitioner is not requesting claim construction of any patent claim. However, if Patent Owner seeks construction of any terms, I reserve the right to consider and opine on Patent Owner's proposed constructions.

X. Acknowledgement and Signature

I declare under the penalty of perjury that the foregoing is true and correct.

Executed on this date of March 6, 2024.

A handwritten signature in black ink, appearing to read "Robert Schaaf", written in a cursive style.

ROBERT SCHAAF