

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

FERVO ENERGY CO.,
Petitioner,

v.

ORMAT TECHNOLOGIES INC.,
Patent Owner

Case: IPR 2024-00665
Patent 7,320,221

**PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 7,320,221**

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PETITIONER’S EXHIBIT LIST

Exhibit	Description
EX1001	U.S. Patent No. 7,320,221 (“221 Patent”)
EX1002	File History of U.S. Patent No. 7,320,221
EX1003	List of Challenged Claims
EX1004	Declaration of Robert Schaaf
EX1005	Curriculum Vitae of Robert Schaaf
EX1006	U.S. Patent No. 4,676,313 (“Rinaldi”)
EX1007	U.S. Patent No. 4,850,429 (“Mims”)
EX1008	Swenson, D.V. et al., “ <i>Modeling Flow in a Jointed Geothermal Reservoir</i> ”, Proceedings World Geothermal Congress, pp. 2553-2558. (May 1995). (“Swenson”)
EX1009	U.S. Patent No. 5,273,111 (“Brannan”)
EX1010	Kruger, P., “ <i>Stimulation of geothermal energy resources</i> ” (No. ERDA-37), Energy Research and Development Administration, Washington, DC (USA). Div. of Geothermal Energy (1975). (“Kruger”)
EX1011	Grassiani, M., “ <i>Advanced Power Plants for Use with Hot Dry Rock (HDR) and Enhanced Geothermal Technology</i> ”, Proceedings World Geothermal Congress, pp. 3719-3723 (2000). (“Grassiani”)
EX1012	Alkhasov, A.B., “ <i>Prospects of Horizontal Drilling when Constructing Geothermal Power Plants</i> ”, Proceedings, Twenty-

	Fourth Workshop on Geothermal Reservoir Engineering (1999). ("Alkhasov")
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I. INTRODUCTION

Pursuant to 35 U.S.C. §§ 311 and 312, Petitioner Fervo Energy Co., (“Fervo” or “Petitioner”) respectfully requests an *Inter Partes* review (“IPR”) of claims 1-38 (“Challenged Claims”) of U.S. Patent 7,320,221 (“the ’221 patent,” EX1001).

The Challenged Claims are directed to a method and apparatus for enhancing the extraction and utilization of geothermal energy for power production. As shown in this Petition, the claimed methods and apparatus were known in the art before the priority date of the ’221 patent. Specifically, this Petition and the cited evidence demonstrate that the Challenged Claims are unpatentable under (pre-AIA) 35 U.S.C. §103. Petitioner respectfully requests that these claims be held invalid and cancelled.

II. MANDATORY NOTICES

Pursuant to 37 C.F.R. §42.8(a)(1), Petitioner provides the following mandatory disclosures.

A. Real Party-in-Interest (37 C.F.R. §42.8(b)(1))

Pursuant to 37 C.F.R. §42.8(b)(1), Petitioner certifies that it is the real party-in-interest. No other party has directed, funded, or controlled Petitioner’s filing of this Petition, and this Petition was not filed at the behest of any other party.

B. Related Matters (37 C.F.R. §42.8(b)(2))

Ormat Technologies, Inc. (“Patent Owner” or “Ormat”) is the current assignee of record for the ’221 patent. As of the filing date of this Petition, Petitioner has

brought a suit for declaratory judgment against Patent Owner asserting non-infringement of the '221 patent in the following matter:

- *Fervo Energy Co. v. Ormat Technologies, Inc.*, Case No. 4:24-cv-00006 (S.D. Tex. Jan. 02, 2024).

Patent Owner has not yet answered those claims. Petitioner is not aware of any other litigation or any other board proceedings involving the '221 patent.

C. Lead and Back-up Counsel (37 C.F.R. §42.8(b)(3))

Lead Counsel	Back-up Counsel
Enes Ovcina, Reg. No. 75,938 Ahmad, Zavitsanos & Mensing, PLLC 1221 McKinney, Suite 2500 Houston, Texas 77010 eovcina@azalaw.com	Sujeeth Rajavolu, Reg. No. 82,112 Ahmad, Zavitsanos & Mensing, PLLC 1221 McKinney, Suite 2500 Houston, Texas 77010 srajavolu@azalaw.com

D. Service Information (37 C.F.R. §42.8(b)(4))

Petitioner consents to electronic service and respectfully requests that the Board address all correspondence to lead and back-up counsel, identified above. Petitioner also consents to electronic service by email at Fervo-Ormat@azalaw.com.

III. CERTIFICATION OF GROUNDS FOR STANDING

Petitioner certifies, pursuant to 37 C.F.R. §42.104(a), that the '221 patent is eligible for IPR and Petitioner is not barred or estopped from requesting an IPR challenging the patent claims on the grounds identified in this Petition. Petitioner is

not the owner of the '221 patent and has not filed a civil action challenging the validity of any claim of the '221 patent.

IV. STATEMENT OF PRECISE RELIEF REQUESTED

A. Claims for Which Review is Requested (37 C.F.R. §42.104(b)(1))

Petitioner requests *inter partes* review and cancellation of Challenged Claims of the '221 patent under 35 U.S.C. §311.

B. List of the Challenged Claims

Element	Claim Language
Claim 1	
Preamble 1	Method for recovering geothermal heat, which comprises enhancing the flow of geothermal fluid from at least one injection well to at least one production well, by the following steps:
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;
1b	Injecting water into said injection well, whereby the injected water is heated;
1c-1	Providing a second, horizontal, geothermal well in the ground, which is used as said production well,
1c-2	such that 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 and
1c-3	located at a shallower depth than said first, horizontal, injection, geothermal well;

1d	Recovering geothermal fluid from said production well;
1e	Generating a water density difference and a pressure difference between said first horizontal, injection well and said second horizontal, production well; and
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.
Claim 2	
2	Method according to claim 1, wherein the horizontal wells are provided by drilling along a geological layer.
Claim 3	
3	Method according to claim 1, 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.
Claim 4	
4	Method according to claim 1, further comprising extracting heat from the geothermal fluid recovered from the production well and using said heat for the production of energy.
Claim 5	
5	Method according to claim 1, wherein the water injected into the injection well is the geothermal fluid, recovered from the production well, depleted of heat by heat exchange.
Claim 6	

6	Method according to claim 1, further comprising monitoring the pressure difference.
Claim 7	
7	Method according to claim 1, wherein the first and second horizontal, geothermal wells are formed in a geological layer the suitability of which has been determined.
Claim 8	
8	Method according to claim 3, wherein the suitability of the geological layer is determined by geophysical surveys and by drilling slim holes in said layer.
Claim 9	
Preamble 9	Apparatus for enhancing the flow of geothermal fluid from at least one injection well to at least one production well, which comprises:
9a	A first, horizontal geothermal well, which is used as said injection well into which water is injected,
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; and
9c	Means for producing a water density difference and a pressure difference between said first horizontal, injection well and said second horizontal, production well,
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.
Claim 10	
10	Apparatus according to claim 9, further comprising instrumentation for monitoring the pressure difference.
Claim 11	
11	Apparatus according to claim 9, 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.
Claim 12	
12	Apparatus according to claim 9, wherein the first horizontal, geothermal well has a length up to 1.25 miles.
Claim 13	
13	Apparatus according to claim 9, wherein the second horizontal, geothermal well has a length up to 1.25 miles.
Claim 14	
14	Apparatus according to claim 9, wherein the horizontal distance between the first horizontal well and the second horizontal well is up to 2000 feet.
Claim 15	
15	Apparatus according to claim 9, wherein the vertical distance between the first horizontal well and the second horizontal well is up to 150 feet.
Claim 16	

16	Apparatus according to claim 9, 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.
Claim 17	
17	Apparatus according to claim 9, 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.
Claim 18	
18	Apparatus according to claim 17 including a binary power plant comprising an organic vapor turbine operating according to an organic Rankine cycle.
Claim 19	
19	Apparatus according to claim 18 wherein said binary power plant includes an air-cooled condenser.
Claim 20	
20	Apparatus according to claim 18 wherein the working fluid of said binary power plant is pentane or isopentane.
Claim 21	
21	Apparatus according to claim 18 wherein the working fluid of said binary power plant is butane or isobutane.
Claim 22	

22	Apparatus according to claim 17 wherein said power plant is a combined cycle geothermal power plant.
Claim 23	
23	Apparatus according to claim 9, further comprising a water injection pump for injecting heat-depleted geothermal fluid into the horizontal, injection well.
Claim 24	
24	Apparatus according to claim 9, further comprising a deep well pump connected to the horizontal production well for pumping hot geothermal fluid from the production well.
Claim 25	
25	Apparatus according to claim 9, wherein the horizontal, injection geothermal well comprises a perforated horizontal pipe.
Claim 26	
26	Apparatus according to claim 9, wherein the second horizontal, production geothermal well comprises a perforated horizontal pipe.
Claim 27	
27	Apparatus according to claim 25, wherein the perforated horizontal pipe is perforated on its lower surface.
Claim 28	
28	Apparatus according to claim 26, wherein the perforated horizontal pipe is perforated on its lower surface.
Claim 29	

29	Apparatus according to claim 9, wherein the production horizontal geothermal well is generally parallel to the injection horizontal, geothermal well.
Claim 30	
30	Apparatus according to claim 9, comprising a plurality of injection horizontal, geothermal wells for one production horizontal, geothermal well.
Claim 31	
31	Apparatus according to claim 9 comprising a plurality of horizontal injection wells and a plurality of horizontal production wells spaced horizontally and vertically.
Claim 32	
32	Apparatus according to claim 9 wherein all the water and make-up water is supplied from an external source.
Claim 33	
33	Apparatus according to claim 9 wherein part of the water circulating is from the reservoir and only make-up water is from an external source.
Claim 34	
Preamble 34	Method for assuring the flow of geothermal fluid from at least an injection well to at least a production well, which comprises the following steps:
34-I	Providing a first, horizontal, geothermal well, which is connected to said injection well;
34-II	Injecting water into said injection well;

34-III	Providing a second, horizontal, geothermal well, which is connected to said production well;
34-IV	Recovering geothermal fluid from said production well;
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; and
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.
Claim 35	
35	Method according to claim 1, wherein the geothermal fluid is one of water, steam and a combination thereof.
Claim 36	
36	Apparatus according to claim 9, wherein the geothermal fluid is one of water, steam and a combination thereof.
Claim 37	
37	Method according to claim 34, wherein the geothermal fluid is one of water, steam and a combination thereof.
Claim 38	
38	Apparatus according to claim 22 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.

C. Statutory Grounds of Challenge (37 C.F.R. §42.104(b)(2))

Petitioner requests cancellation of Challenged Claims on the statutory grounds identified below because each and every element of those claims is explicitly or inherently disclosed by the below-identified prior art references:

Ground	Cited Prior Art References	Basis	Claim(s) Challenged
1	<i>Rinaldi</i> (EX1006) in view of the general knowledge of a POSITA	35 U.S.C. § 103	1-3, 6-11, 24-31, and 34-37
2	<i>Rinaldi</i> (EX1006) in view of <i>Swenson</i> (EX1008)	35 U.S.C. § 103	1-11 and 23-37
3	<i>Rinaldi</i> (EX1006) in view of <i>Grassiani</i> (EX1011) and further in view of <i>Brannan</i> (EX1009)	35 U.S.C. § 103	1-38
4	<i>Mims</i> (EX1007) in view of the general knowledge of a POSITA	35 U.S.C. § 103	1, 2, 6, 7, 9-11, 25-31, and 34-37
5	<i>Mims</i> (EX1007) in view of <i>Kruger</i> (EX1010) and further in view of <i>Swenson</i> (EX1008)	35 U.S.C. § 103	1, 2, 4-7, 9-11, and 25-37
6	<i>Mims</i> (EX1007) in view of <i>Grassiani</i> (EX1011) and further in view of <i>Brannan</i> (EX1009)	35 U.S.C. § 103	1-7, 9-23, 25-31, and 34-38
7	<i>Rinaldi</i> (EX1006) in view of <i>Swenson</i> (EX1008) and further in view of <i>Alkhasov</i> (EX1012)	35 U.S.C. § 103	1-11, 16, 17, and 23-37

D. Discretionary Denial Is Not Warranted

i. 35 U.S.C. §§314(a) or 325(d)

Petitioner respectfully submits that the Board should not exercise its discretion under 35 U.S.C. §§314(a) or 325(d) to deny this Petition. First, Grounds 1-7 are based on prior art references that were never considered during prosecution. Accordingly, the arguments presented herein do not overlap with arguments presented during prosecution. Accordingly, the first part of the *Advanced Bionics* framework is not satisfied.

To the extent the Board determines that an analysis under part two of *Advanced Bionics* is warranted, Petitioner submits that the grounds asserted herein demonstrate that the Examiner erred in his evaluation of the prior art. Accordingly, Petitioner submits that the evidence and facts presented in the Petition warrant reconsideration of the prior art, and respectfully requests the Board decline to exercise its discretion to deny institution under § 325(d).

ii. Discretionary Denial Is Not Warranted Under *Fintiv*

Apple Inc. v. Fintiv, Inc., IPR2020-00019, Paper 11 at 5-6 (PTAB Mar. 20, 2020) (precedential), and the Office's interim guidelines dated June 21, 2022 ("Guidance Memo") favor institution. Petitioner is plaintiff in the pending case captioned *Fervo Energy Co. v. Ormat Technologies, Inc.*, Case No. 4:24-cv-00006 (S.D. Tex. Jan. 02, 2024).

Factor 1 is at least neutral. The parties have not yet requested a stay, though Petitioner has informed the trial court of its intent to request one. Patent Owner has not yet asserted its claims for infringement or sought any preliminary relief. The early stage of the case increases the likelihood that a stay will be granted.

Factors 2 and 3 strongly favor institution. A trial date has not been set and the parties have not made substantial investments, as only the Complaint has been filed and Patent Owner has only sought dismissal and transfer to a different venue. Currently, the Initial Conference is scheduled for June 12, 2024.

Factor 4 is at least neutral. There are presently no claims for invalidity in the district court proceeding. There is no scheduling order setting the date for any invalidity contentions or deadlines for when the parties will meet and confer. As such, there is presently no overlap between this proceeding and the district court trial and any future overlap is speculative.

Factor 5 is neutral. Petitioner is plaintiff in the related district court proceeding.

Factor 6 favors institution. This Petition presents a compelling case on the merits. If the Board finds that factors 1-5 favor denial of institution, the compelling merits should still result in institution. Guidance Memo at 3-5; *CommScope Techs. LLC v. Dali Wireless, Inc.*, IPR2022-01242, Paper 23 at 3-5 (PTAB Feb. 27, 2023) (precedential).

V. SUMMARY OF THE '221 PATENT

The '221 patent was issued on January 22, 2008, from U.S. Patent Application No. 10/910,613, filed on August 4, 2004. The '221 patent does not claim priority to any earlier patent applications.

A. Description of the Alleged Invention

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)

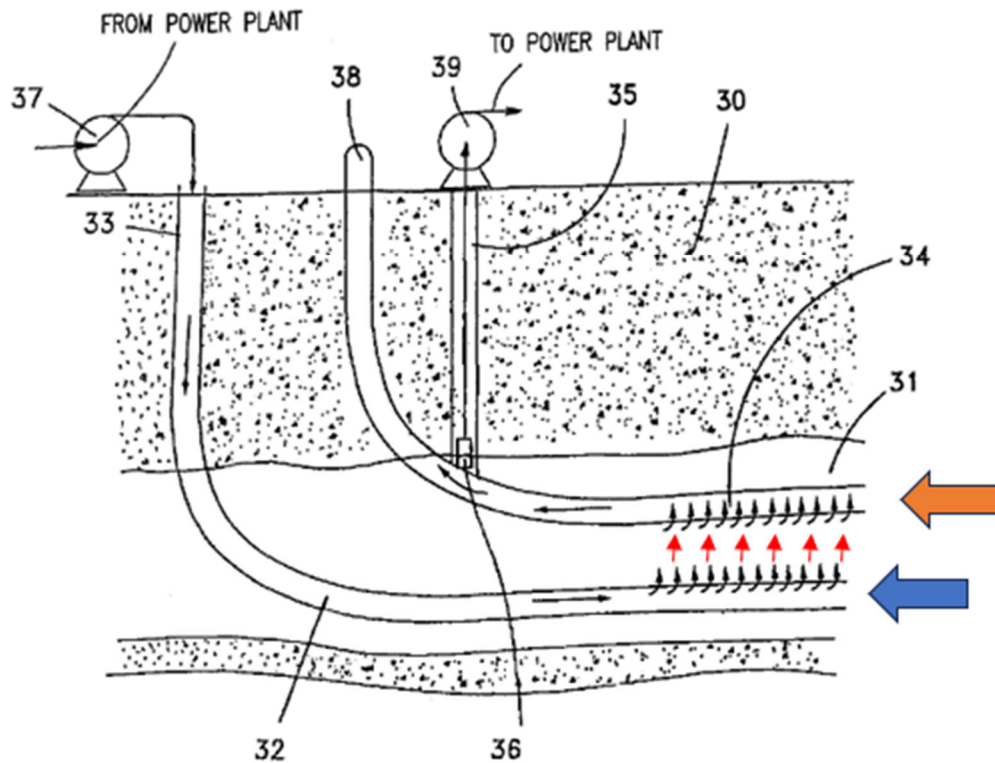


FIG. 3

Geothermal power plants are used to produce power from the extracted fluid.

See id.

B. Prosecution History of the '221 Patent

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.”).

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. CLAIM CONSTRUCTION

No terms need to be construed to resolve unpatentability. *Realtime Data, LLC v. Iancu*, 912 F.3d 1368, 1375 (Fed. Cir. 2019). The plain meaning should be applied to all claim terms. If Patent Owner seeks construction of any terms, Petitioner reserves the right to respond to Patent Owner’s proposed constructions.

VII. LEVEL OF ORDINARY SKILL IN THE ART

The level of ordinary skill in the art may be reflected by the prior art of record. *See Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001). The Challenged

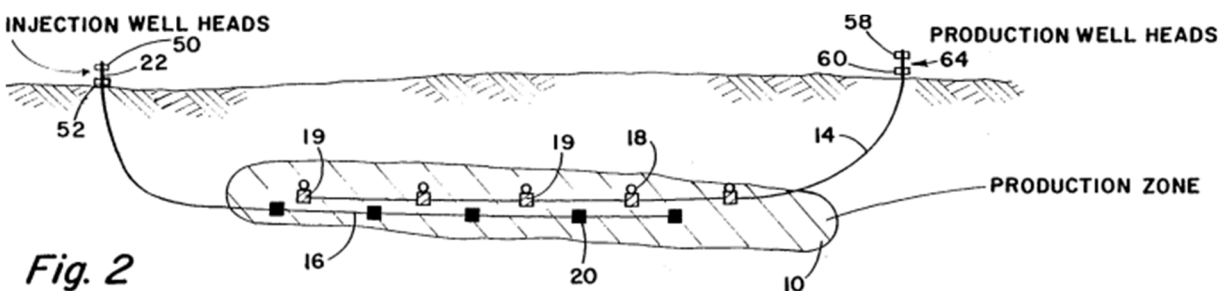
Claims pertain to a method of recovering geothermal heat. However, “[m]any of the techniques are derived from oil and gas industry.” EX1001 at 4:23-24. Accordingly, here, a person of ordinary skill in the art (“POSITA”) is a person with a Bachelor’s degree, Master’s degree, and/or Ph.D. in Chemical Engineering, Petroleum Engineering, Energy Resource Engineering, or the like, or at least five years of experience engineering, drilling, and constructing wells. Furthermore, a person with less formal education but more experience, or more formal education but less experience, could also have met the relevant standard for a POSITA. EX1004 at ¶ 34-36.

VIII. THE CHALLENGED CLAIMS ARE UNPATENTABLE

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

Overview of Rinaldi

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:



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”); EX1004 at ¶46.

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”).

As such, 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. EX1004 at ¶48.

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”

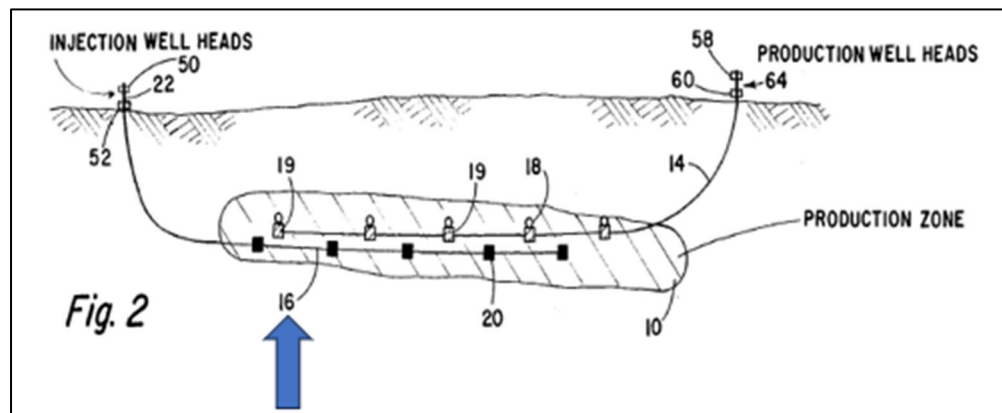
To the extent the preamble is limiting, Rinaldi teaches it. EX1004 at ¶58. Rinaldi discloses a “means for increasing fluid recovery from a well bore.” EX1006 at 1:8-9.

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.

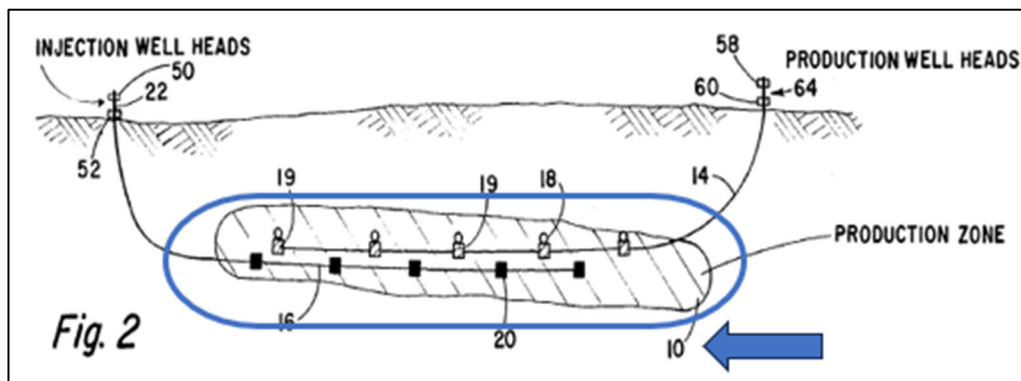
Element 1a: “providing a first, horizontal, geothermal well in the ground at a geological layer having an elevated temperature, which is used as said injection well”

Rinaldi teaches this element. EX1004 at ¶60. Rinaldi’s Figure 2 discloses drilling horizontal geothermal injection wells. *Id.* 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.



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



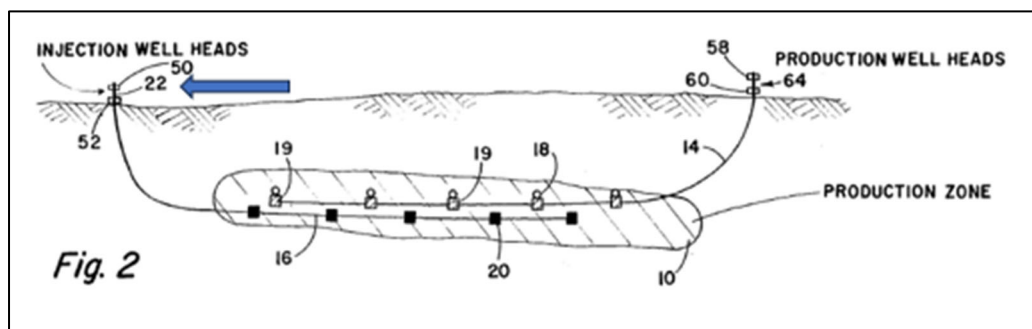
Id. at 3:19-20. The “reservoir boundary 12 and characteristics of the medium of the reservoir” are determined “by the usual geological and/or seismic techniques.” *Id.* at 3:21-23. A POSITA would have recognized that similar techniques would be employed in selection of a geological layer. EX1004 at ¶61. 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, EX1004 at ¶62) and “drilling at least one injection well bore into the formation.” *See* EX1006 Claim 1.

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

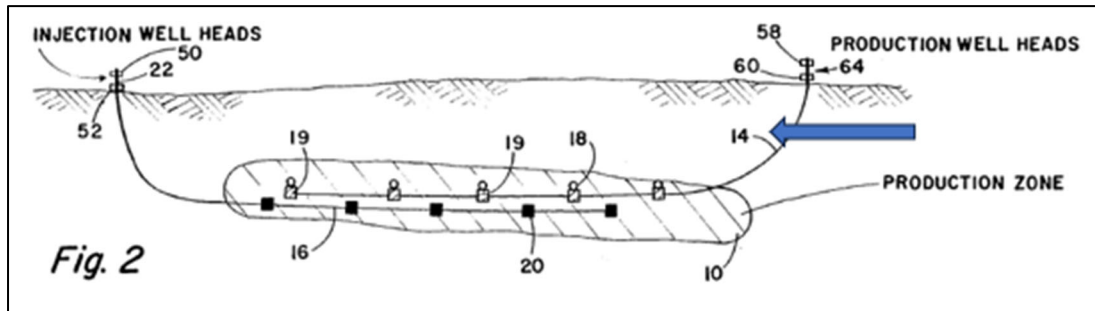
Rinaldi teaches this claim element. EX1004 at ¶64. Rinaldi discloses “[i]nitiat[ing] the flow of injection fluids through the injection well heads 22 of the injection well bores.”



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. EX1004 at ¶64; EX1006 at 5:35-36 (“knowledge of ... water flood operations”). Further, a POSITA would understand that the temperature of the formation below ground will necessarily heat the injected water. EX1004 at ¶64.

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

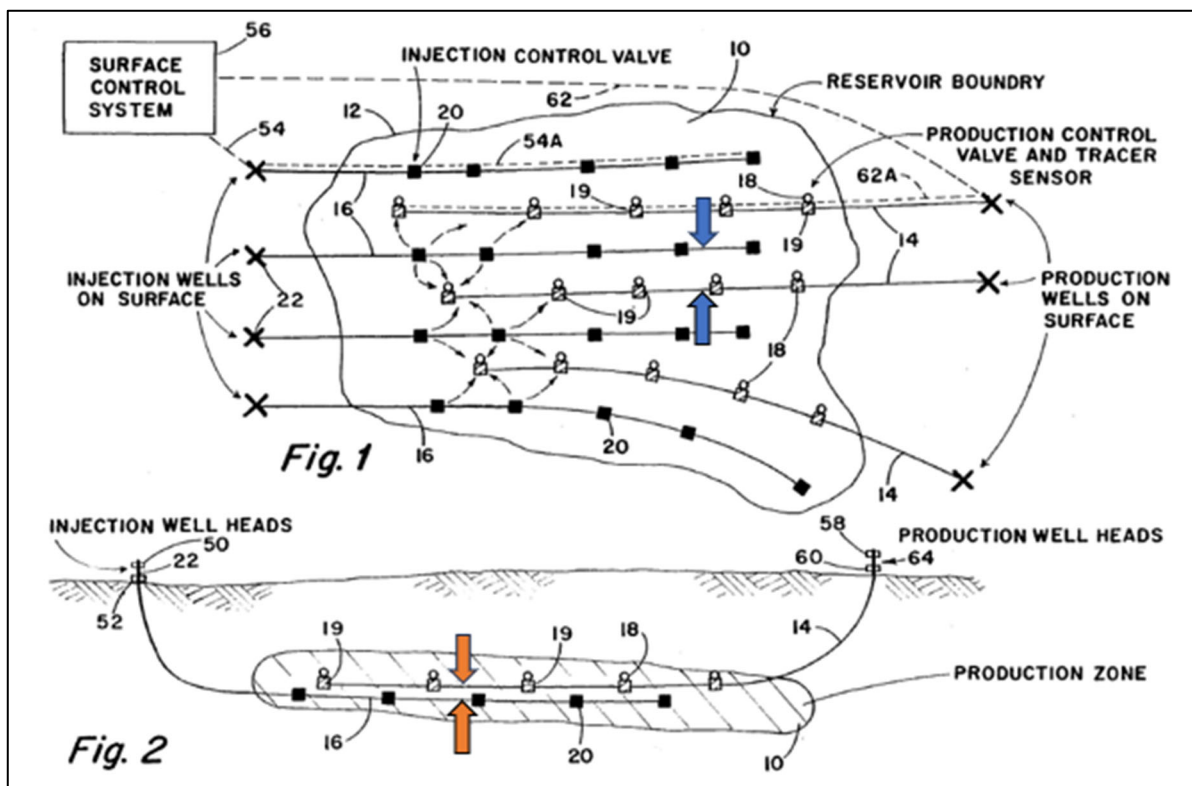
Rinaldi teaches this element. EX1004 at ¶66. Rinaldi discloses “drill[ing] a [...] substantially horizontal production well bore 14 into the reservoir” (EX1006 at 3:25-27):



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”

Rinaldi teaches this element. EX1004 at ¶67. 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. EX1004 at ¶67. Figures 1 and 2 show the production/injection wells horizontally (blue) and vertically (orange) spaced apart:



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. EX1004 at ¶68. 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.

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 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. EX1004 at ¶69.

Further, Rinaldi also teaches determining which wells to be activate based on the formation characteristics. EX1004 at ¶70. 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.

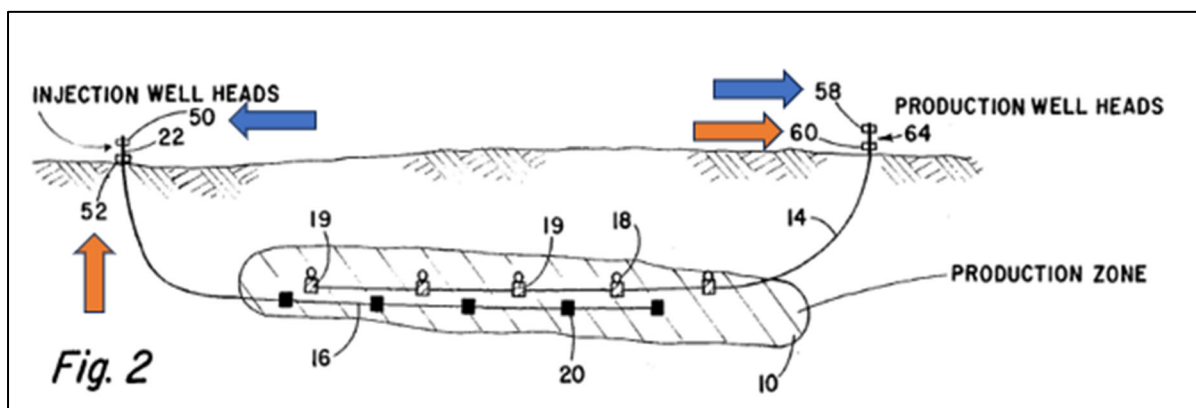
Element 1c-3: “said second, horizontal, production, geothermal well is ... located at a shallower depth than said first, horizontal, injection, geothermal well”

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

Rinaldi teaches this element. EX1004 at ¶73. 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.”).

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

Rinaldi teaches this element. EX1004 at ¶75. 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.



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.”).

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. EX1004 at ¶77. 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. *Id.* It is a basic property of physics that as the density of fluid (e.g., water) decreases, it tends to flow upwards. *Id.*

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”

Rinaldi teaches this element. EX1004 at ¶79. 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.”).

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.”).

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.

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. EX1004 at ¶82. 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. *Id.* 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. *Id.*

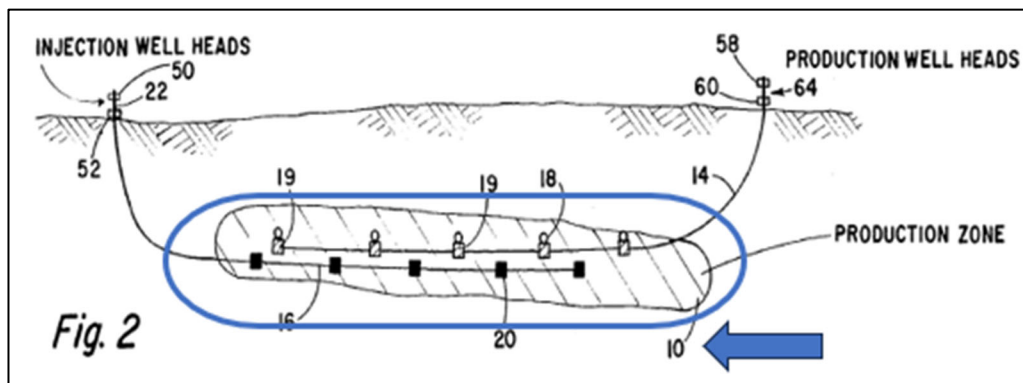
A POSITA would recognize that convection drives the upward movement of less dense geothermal fluid towards a second well (serving as the production well). EX1004 at ¶83. This process is primarily facilitated by the differential pressure between the injection and extraction points, alongside buoyancy effects resulting from temperature gradients. *Id.* 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. *See id.*

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

Claim 2 is dependent on Claim 1. Accordingly, Petitioner incorporates its arguments for Claim 1 herein. Rinaldi teaches this additional element. EX1004 at ¶85.

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

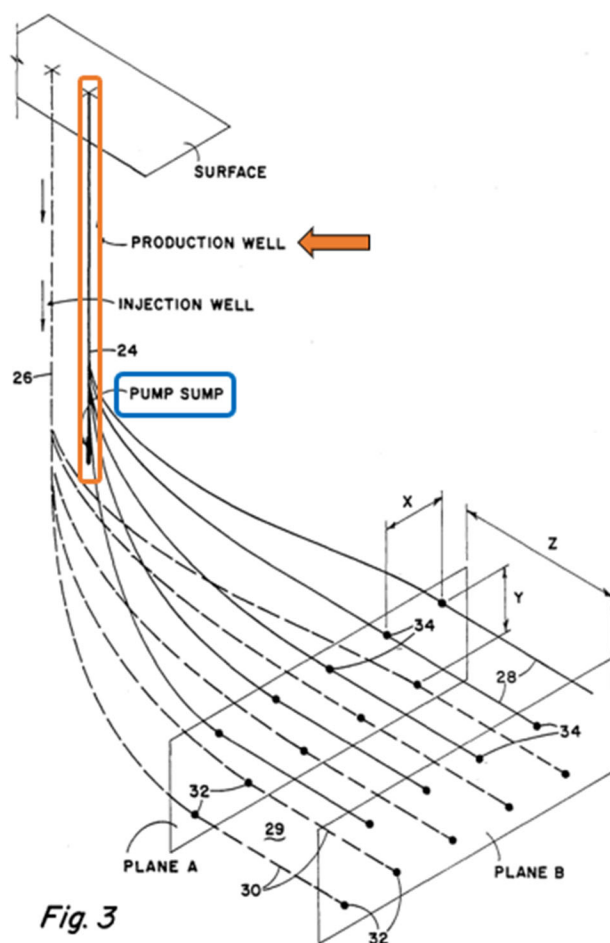


A POSITA would recognize that this pattern constitutes drilling along a geological layer and if not drilled this way, the purpose of heating the fluid through the geological layer will not be satisfied. EX1004 at ¶87.

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”

Claim 3 is dependent on Claim 1. Accordingly, Petitioner incorporates its arguments for Claim 1 herein. Rinaldi teaches this additional element. EX1004 at ¶90. 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. EX1004 at ¶90.

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



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. EX1004 at ¶92.

Claim 6: “monitoring the pressure difference”

Claim 6 is dependent on Claim 1. Accordingly, Petitioner incorporates its arguments for Claim 1 herein. Rinaldi teaches this additional element. EX1004 at ¶94. 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.

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

Claim 7 is dependent on Claim 1. Accordingly, Petitioner incorporates its arguments for Claim 1 herein. Rinaldi teaches this additional element. EX1004 at ¶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. EX1004 at ¶98.

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

Claim 8 is dependent on Claim 3. Accordingly, Petitioner incorporates its arguments for Claim 3 herein. Rinaldi teaches this additional element. EX1004 at ¶100. *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. EX1004 at ¶100.

Claim 9

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

To the extent the preamble is limiting, Rinaldi teaches this element. EX1004 at ¶102. *See* Preamble 1, Section VIII.A, which is incorporated herein by reference.

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

Rinaldi teaches this element. EX1004 at ¶104. *See* Elements 1a and 1b discussions, Section VIII.A, which are incorporated herein by reference.

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”

Rinaldi teaches this element. EX1004 at ¶106. *See* Elements 1c-1-3 and 1d discussions, Section VIII.A, which are incorporated herein by reference.

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

Rinaldi teaches this element. EX1004 at ¶108. *See* Element 1e discussion, Section VIII.A, which is incorporated herein by reference.

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”

Rinaldi teaches this element. EX1004 at ¶110. *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, 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. EX1004 at ¶110. 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. *Id.* 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. *Id.*

Claim 10: “instrumentation for monitoring the pressure difference”

Claim 10 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Rinaldi teaches this additional element. EX1004 at ¶112. *See* Claim 6 discussion, Section VIII.A, which is incorporated herein by reference.

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”

Claim 11 is dependent on Claim 9. Accordingly, Petitioner incorporates its 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. EX1004 at ¶114. Observation wells are used to monitor various parameters within a reservoir, such as pressure, temperature, and fluid movement. *Id.*

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

Claim 24 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Rinaldi teaches this additional element. EX1004 at ¶116. *See* Claim 3 discussion, Section VIII.A, which is incorporated herein by reference.

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

Claim 25 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Rinaldi teaches this additional element. EX1004 at ¶118. *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.

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

Claim 26 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Rinaldi teaches this additional element. EX1004 at ¶120. *See* Element 1c-1 and claim 25 discussions, Section VII.A, which are incorporated herein by reference. It would have been obvious for a POSITA to use perforated production well, similar to the perforated injection well disclosed in Rinaldi. EX1004 at ¶120.

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

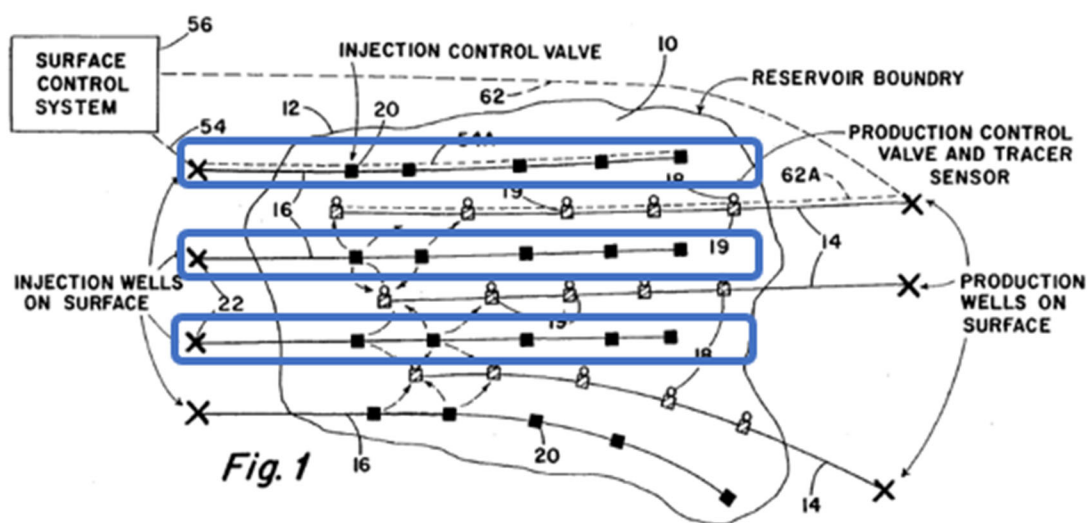
Claim 27 is dependent on Claim 25. Accordingly, Petitioner incorporates its arguments for Claim 25 herein. A POSITA would recognize that Rinaldi’s disclosure of a perforated horizontal pipe (EX1006 at 5:10-13) includes perforation on the lower surface. EX1004 at ¶122.

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

Claim 28 is dependent on Claim 26. Accordingly, Petitioner incorporates its 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. EX1004 at ¶124.

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

Claim 29 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Rinaldi teaches this additional element. EX1004 at ¶126. Figure 1 below discloses plurality of injection and production wells that are generally parallel to each other.



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

Claim 30 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Rinaldi teaches this additional element. EX1004 at ¶128. See claim 29 discussions, Section VII.A, which is incorporated herein by reference. See also EX1006 at 4:45-56.

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

Claim 31 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Rinaldi teaches this additional element, including the use of multiple horizontal injection and production wells. EX1004 at ¶130. *See* claim 30 discussions, Section VII.A, which is incorporated herein by reference.

Claim 34

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

To the extent the preamble is limiting, Rinaldi teaches this element. EX1004 at ¶132; *See* Preamble 1 discussion, Section VIII.A, which is incorporated herein.

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

Rinaldi teaches this element. EX1004 at ¶134. *See* Element 1a discussion, Section VIII.A, which is incorporated herein.

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

Rinaldi teaches this element. EX1004 at ¶136. *See* Element 1b discussion, Section VIII.A, which is incorporated herein.

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

Rinaldi teaches this element. EX1004 at ¶138. *See* Elements 1c-1–1c-3 discussions, Section VIII.A, which are incorporated herein.

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

Rinaldi teaches this element. EX1004 at ¶140. *See* Element 1d discussion, Section VIII.A, which is incorporated herein.

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”

Rinaldi teaches this element. EX1004 at ¶142. *See* Element 1e and claim 3 discussions, Section VIII.A, which are incorporated herein.

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”

Rinaldi teaches this element. EX1004 at ¶144. *See* Element 1f discussion, Section VIII.A, which is incorporated herein.

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

Claim 35 is dependent on Claim 1; Claim 36 is dependent on Claim 9; and Claim 37 is dependent on Claim 34. Accordingly, Petitioner incorporates its 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. EX1004 at ¶146.

Conclusion

For the reasons discussed above, 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.

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

Petitioner incorporates the overview and motivations to combine from Section VIII.A herein.

Overview of Swenson

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. A POSITA would recognize performing such analysis is an economic, efficient, and predictable way to improve fluid extraction in Rinaldi. EX1004 at ¶50. 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. *Id.*

Claim 1

Preamble 1

To the extent the preamble is limiting, Petitioner incorporates the discussion of Ground 1, Section VIII.A herein. Further, Swenson teaches this element. EX1004 at ¶149. 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

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

Element 1b

Rinaldi teaches element 1b of Claim 1. *See* Ground 1, Element 1b, Section VIII.A, which is incorporated herein. Additionally, Swenson teaches this element. EX1004 at ¶151. 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

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. EX1004 at ¶152. 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

Rinaldi teaches element 1e of Claim 1. *See* Ground 1, Element 1e, Section VIII.A, which is incorporated herein. Additionally, Swenson teaches this element. EX1004 at ¶153. 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	17.65MPa	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
	22.4 MPa	9.65 MPa	12.75 MPa	2.9 l/s

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

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

Rinaldi teaches element 1f of Claim 1. *See* Ground 1, Element 1f, Section VIII.A, which is incorporated herein. Additionally, Swenson teaches this element. EX1004 at ¶155. *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. EX1004 at ¶155.

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

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”

Claim 4 is dependent on Claim 1. Accordingly, Petitioner incorporates its arguments for Claim 1 herein. Swenson further teaches this additional element. EX1004 at ¶157. 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”

Claim 5 is dependent on Claim 1. Accordingly, Petitioner incorporates its arguments for Claim 1 herein. Swenson further teaches this additional element. EX1004 at ¶158. 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. EX1004 at ¶158.

Claim 6

Rinaldi teaches claim 6 as discussed in Ground 1. Accordingly, those arguments are incorporated herein. Additionally, Swenson teaches claim 6. EX1004 at ¶159. *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:

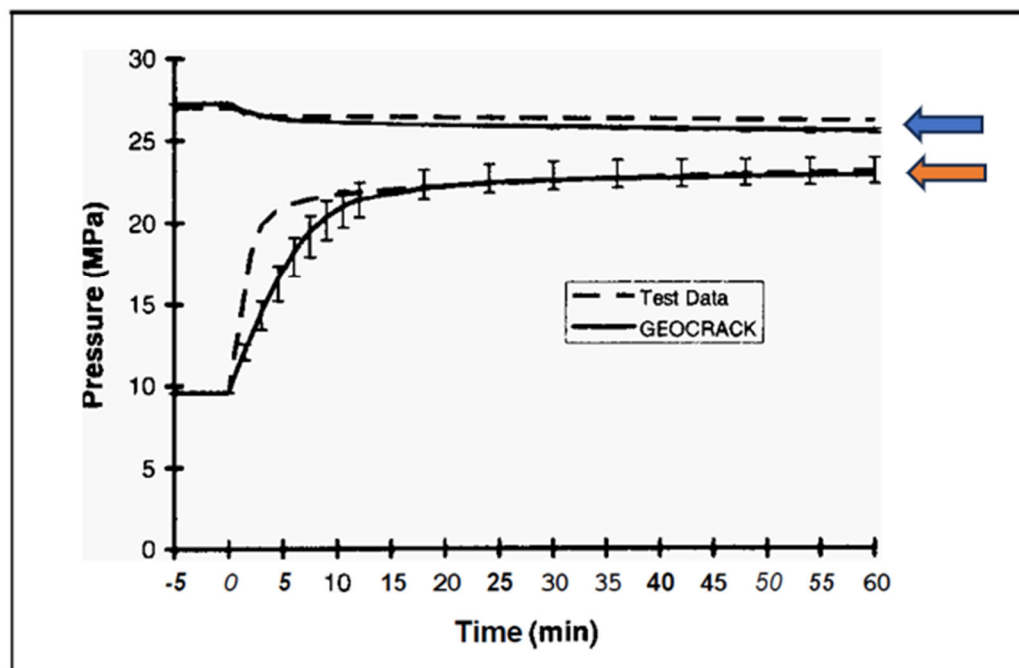


Figure 4: Transient well-head pressure during the cessation of production flow.

Claim 9

Preamble 9

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

Element 9a

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

Element 9b

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

Element 9c

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

Element 9d

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

Claim 10

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”

Claim 23 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Swenson further teaches this element. EX1004 at ¶166. Swenson discloses “pumping water down under pressure high enough to open natural joints in the rock” EX1008 at 2553. A POSITA would have recognized that pumps were well-known devices used to generate such high pressures. EX1004 at ¶167. 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. *Id.*

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

Claim 32 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Swenson further teaches this element. EX1004 at ¶168. 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. EX1004 at ¶168.

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

Claim 33 is dependent on Claim 9. Accordingly, Petitioner incorporates its 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. EX1004 at ¶169. *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

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

Element 34-I

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

Element 34-II

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

Element 34-III

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

Element 34-IV

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

Element 34-V

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

Element 34-VI

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

Claims 35-37

Claim 35 is dependent on Claim 1; Claim 36 is dependent on Claim 9; and Claim 37 is dependent on Claim 34. Accordingly, Petitioner incorporates its arguments for Claim 1, Claim 9, and Claim 34 herein. 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. EX1004 at ¶177.

Conclusion

For the reasons discussed, 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.

Petitioner incorporates the overview and motivations to combine from Section VIII.A herein.

Overview of Brannan

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.

Overview of Grassiani

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. EX1004 at ¶51

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

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

Claim 4 is dependent on Claim 1. Accordingly, Petitioner incorporates its arguments for Claim 1 herein. Grassiani teaches this additional element. EX1004 at ¶180. 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

Claim 5 is dependent on Claim 1. Accordingly, Petitioner incorporates its arguments for Claim 1 herein. Grassiani teaches this additional element. EX1004 at ¶181. 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.”

Claim 12 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Brannan teaches this additional element. EX1004 at ¶182. 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. EX1004 at ¶182. 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. *Id.*

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

Claim 13 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Brannan teaches this additional element. EX1004 at ¶183. *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. EX1004 at ¶183.

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

Claim 14 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Brannan teaches this additional element. EX1004 at ¶184. 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. EX1004 at ¶184.

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

Claim 15 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Brannan teaches this additional element. EX1004 at ¶185. 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. EX1004 at ¶185.

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”

Claim 16 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Grassiani teaches this additional element. EX1004 at ¶186. 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.

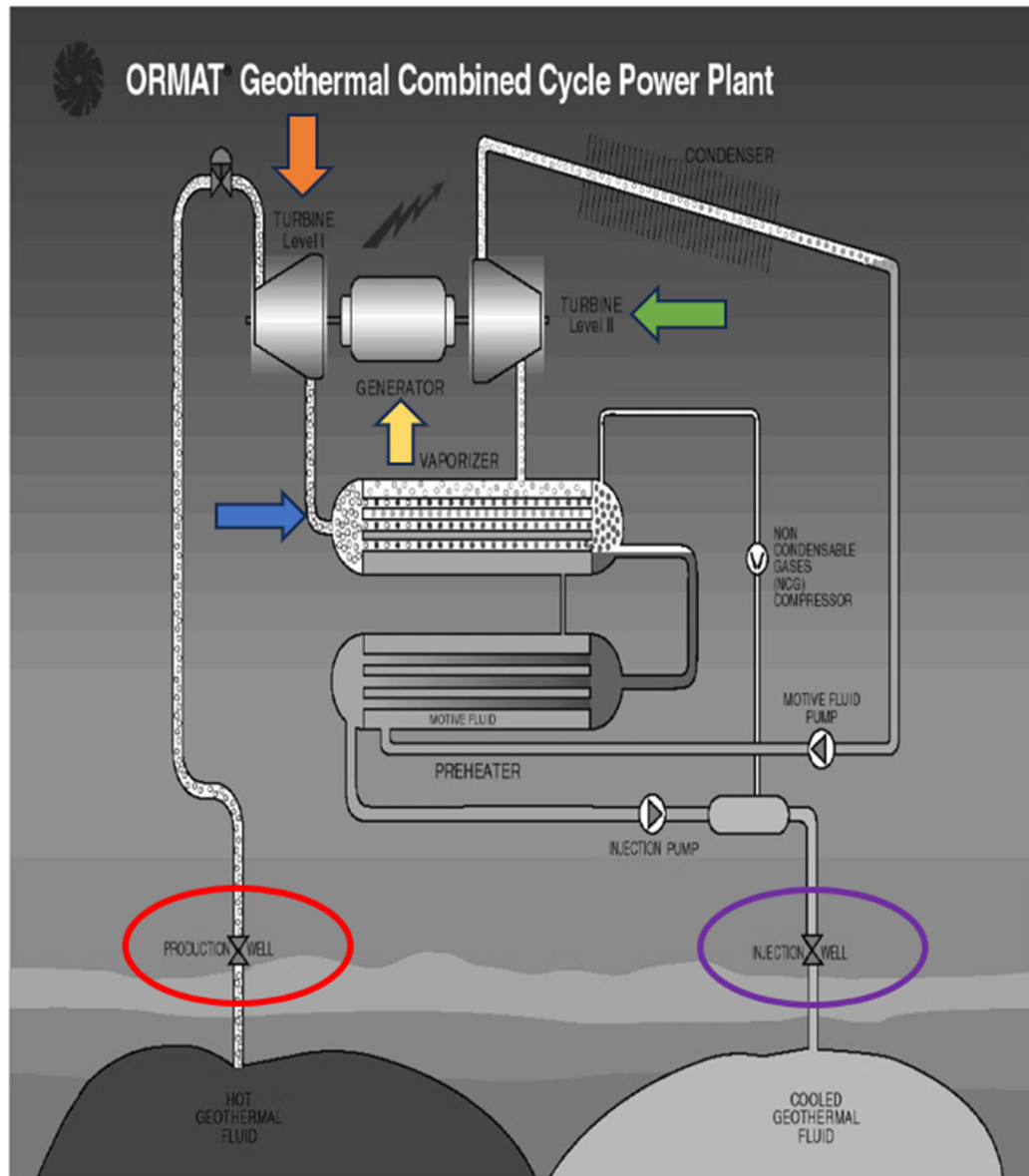


Figure 3. Process Diagram: ORMAT® Combined Cycle Unit

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”

Claim 17 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Grassiani teaches this additional element. EX1004 at ¶187. 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”

Claim 18 is dependent on Claim 17. Accordingly, Petitioner incorporates its arguments for Claim 17 herein. Grassiani teaches this additional element. EX1004 at ¶188. Grassiani discloses an organic vapor turbine operating according to an “Organic Rankine Cycle” for the level 2 turbine in its combined cycle power plant:

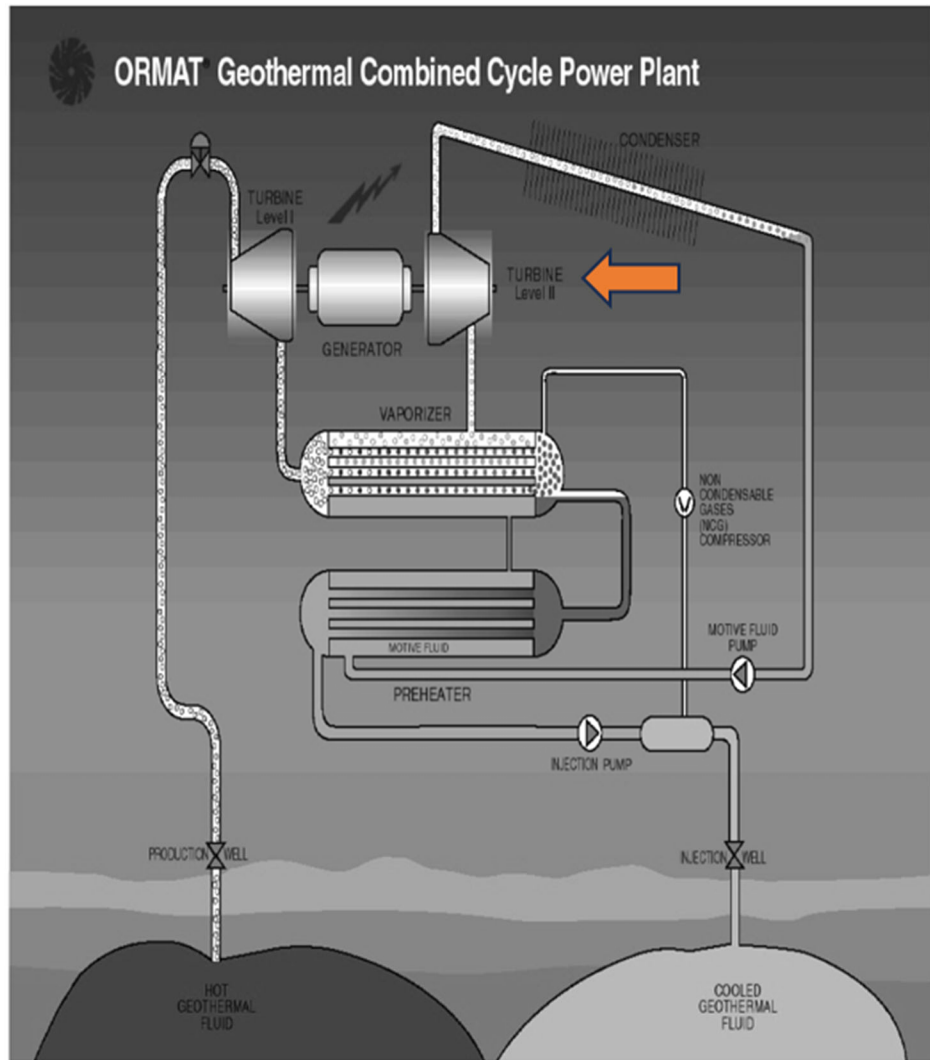


Figure 3. Process Diagram: ORMAT® Combined Cycle Unit

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

Claim 19 is dependent on Claim 18. Accordingly, Petitioner incorporates its arguments for Claim 18 herein. Grassiani teaches this additional element. EX1004 at ¶189. Grassiani discloses that “the spent motive fluid vapors ... are condensed in the finned tube air cooled condenser.” EX1011 at 3719.

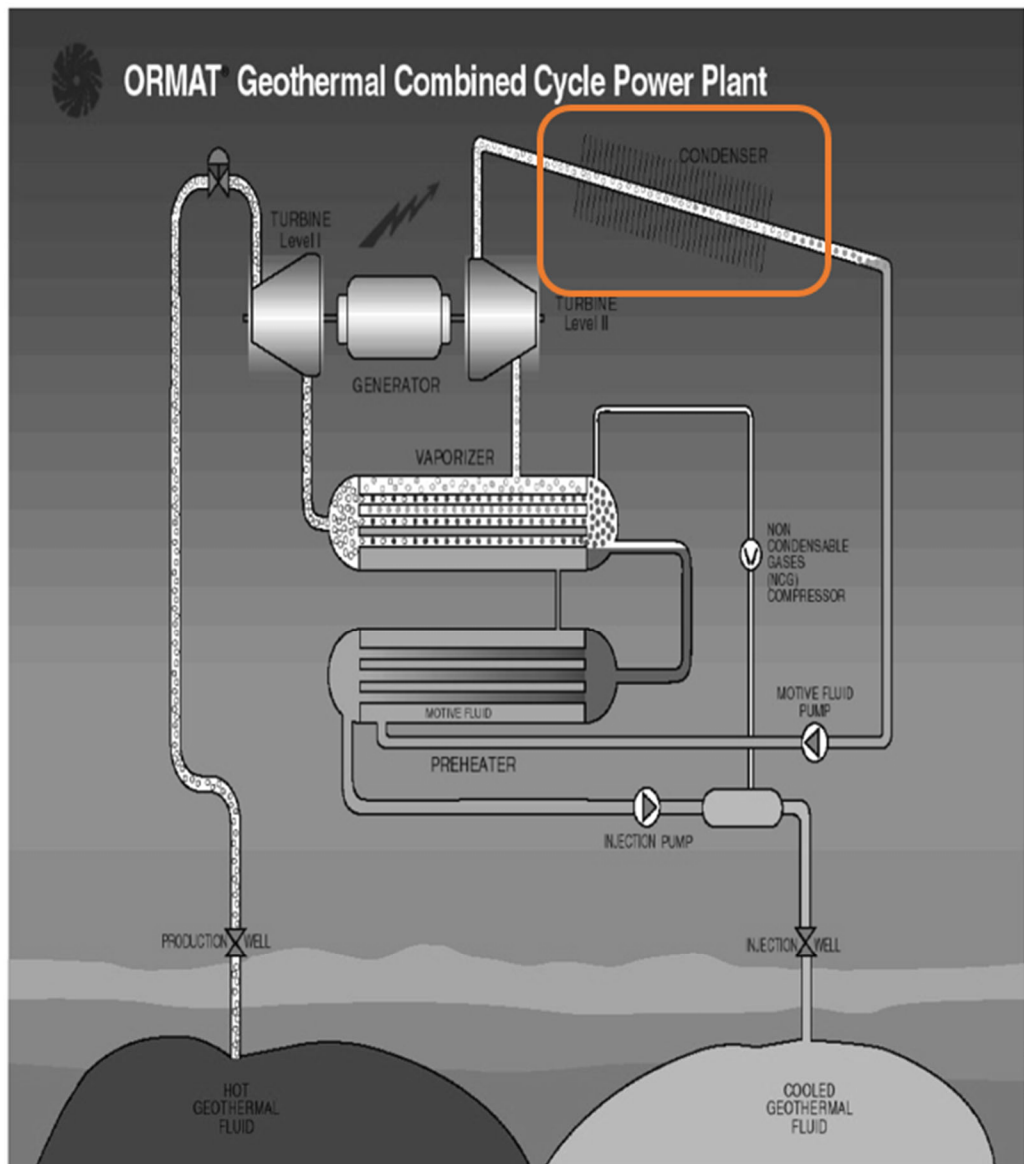


Figure 3. Process Diagram: ORMAT® Combined Cycle Unit

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

Claim 20 is dependent on Claim 18. Accordingly, Petitioner incorporates its arguments for Claim 18 herein. Grassiani teaches this additional element. EX1004 at ¶190. 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. EX1004 at ¶190.

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

Claim 21 is dependent on Claim 18. Accordingly, Petitioner incorporates its arguments for Claim 18 herein. Grassiani teaches this additional element. EX1004 at ¶191. 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. EX1004 at ¶191.

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

Claim 22 is dependent on Claim 17. Accordingly, Petitioner incorporates its arguments for Claim 17 herein. Grassiani teaches this additional element. EX1004 at ¶192. *See* Claim 16 discussion, Section VIII.C, which is incorporated herein by reference.

Claim 23

Claim 23 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Grassiani teaches this additional element. EX1004 at ¶193. Grassiani discloses an injection pump shown below:

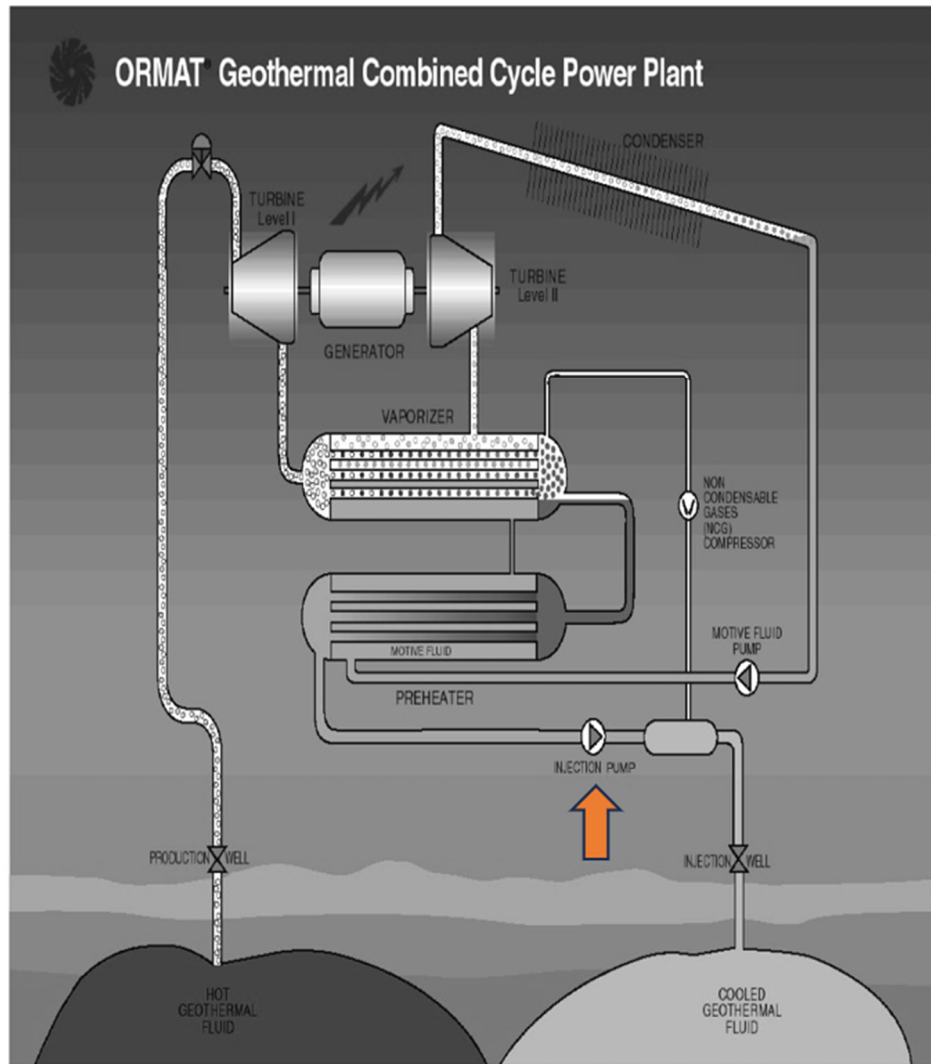


Figure 3. Process Diagram: ORMAT[®] Combined Cycle Unit

A POSITA would have recognized that an injection pump injects the heat depleted geothermal fluid from power plant back into the injection well. EX1004 at ¶194.

Claim 32

Claim 32 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Grassiani teaches this additional element. EX1004 at

¶195. 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. EX1004 at ¶195.

Claim 33

Claim 33 is dependent on Claim 9. Accordingly, Petitioner incorporates its 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. EX1004 at ¶196. *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”

Claim 38 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Grassiani teaches this additional element. EX1004 at ¶197. *See* Claim 16 discussion, Section VIII.C, which is incorporated herein by reference.

Conclusion

For the reasons discussed above, 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

Overview of Mims

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 VIII.A, a POSITA would have been motivated to apply oil recovery techniques to the geothermal wells. EX1004 at ¶53

Claim 1

Preamble

To the extent the preamble is limiting, Mims teaches it. EX1004 at ¶199. 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”).

Element 1a

Mims teaches this element. EX1004 at ¶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. 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. EX1004 at ¶202.

Element 1b

Mims teaches this element. EX1004 at ¶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.

A POSITA would understand that water was a well known injection fluid before the '221 patent priority date. EX1004 at ¶205. Indeed, 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).

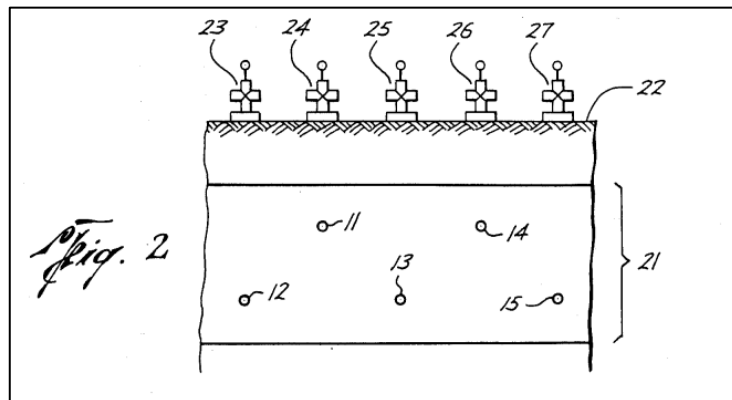
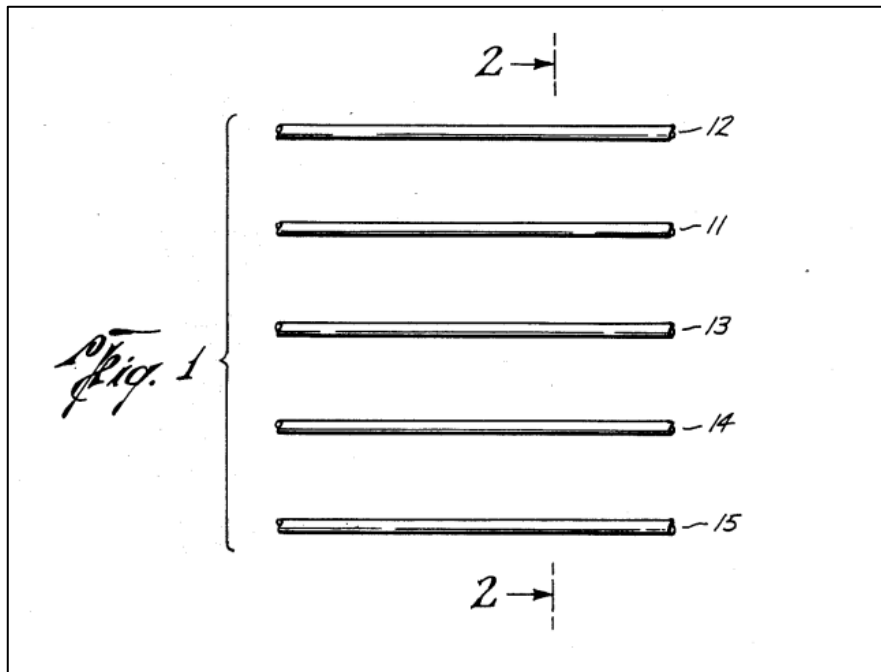
Further, a POSITA would recognize that the temperature of the formation, either for a Hot Dry Rock or for a geothermal reservoir, will necessarily heat the injected water. EX1004 at ¶207.

Element 1c-1

Mims teaches this element. EX1004 at ¶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”).

Element 1c-2

Mims teaches this element. EX1004 at ¶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. Figures 1 and 2 below show the wells vertically and horizontally spaced:



A POSITA would recognize that in such a configuration, the injection and production wells are substantially horizontally and vertically spaced from each other. EX1004 at ¶213. 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). EX1004 at ¶214.

Element 1c-3

Mims teaches this element. EX1004 at ¶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.

Element 1d

Mims teaches this element. EX1004 at ¶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....”).

Element 1e

In combination with Mims, a POSITA’s general knowledge at the time of the invention would have disclosed this element. EX1004 at ¶220; *see also* Mims at 3:61-68. 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 by reference.

Further, 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. EX1004 at ¶225. 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. *Id.*; EX1007 at 4:45–47 (noting “factors such as flow rate, temperatures, and pressures employed in a given operation”).

Element 1f

In combination with Mims, a POSITA's general knowledge at the time of the invention would have disclosed this element. EX1004 at ¶228. As discussed in Ground 1, Element 1f, the buoyancy and pressure difference are obvious and well understood features of geothermal circulation systems. EX1004 at ¶229.

Claim 2

Claim 2 is dependent on Claim 1. Accordingly, Petitioner incorporates its arguments for Claim 1 herein. Mims, in combination with the general knowledge of a POSITA teaches this additional element. EX1004 at ¶232. 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”).

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. EX1004 at ¶234.

Claim 6

Claim 6 is dependent on Claim 1. Accordingly, Petitioner incorporates its arguments for Claim 1 herein. Mims in combination with the general knowledge of a POSITA would render this element obvious. EX1004 at ¶237. Mims discloses the consideration of “pressures employed in a given operation.” Mims at 4:47. Pressures have to be measured in order to be considered as a factor in a given operation. EX1004 at ¶238. Further, monitoring pressure differences is a critical aspect of oil recovery and, likewise, geothermal energy production methods. *Id.* at ¶239. It helps optimize the extraction process and ensures the safety and efficiency of the wells. *Id.* 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. *Id.*

Claim 7

Claim 7 is dependent on Claim 1. Accordingly, Petitioner incorporates its arguments for Claim 1 herein. Mims in combination with the general knowledge of a POSITA would render this element obvious. EX1004 at ¶242. 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”).

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. EX1004 at ¶243. The assessment of geological layer suitability is an important step to determine whether to drill in the first instance. *Id.* at XX.

Claim 9

Preamble

To the extent the preamble is limiting, Mims teaches this element. EX1004 at ¶245. *See* Preamble 1 discussion, Section VIII.D, which is incorporated herein by reference.

Element 9a

Mims teaches this element. EX1004 at ¶245. *See* Elements 1a and 1b discussions, Section VIII.D, which are incorporated herein by reference.

Element 9b

Mims teaches this element. EX1004 at ¶245. *See* Elements 1c-1-3 and 1d discussions, Section VIII.D, which are incorporated herein by reference.

Element 9c

Mims teaches this element. EX1004 at ¶245. *See* Element 1e discussion, Section VIII.D, which is incorporated herein.

Element 9d

Mims teaches this element. EX1004 at ¶247-251. *See* Elements 1b and 1f discussions, Section VIII.D, which are incorporated herein. *See* Element 9d discussion, Section VIII.A for the POSITA knowledge on the open slots used for injection means, which is incorporated herein.

Claim 10

Claim 10 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Mims, along with the general knowledge of a POSITA, teaches this additional element. EX1004 at ¶252-256. *See also* Ground 4 arguments for Claim 6, Section VIII.D, which are incorporated herein.

Claim 11

Claim 11 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. A POSITA would recognize that by 2004, the use of observation wells was widely known. *See* Ground 1, Claim 11 discussion, Section VIII.A; *see also* EX1007 at 4:45-47 (describing factors to be observed).

Claim 25

Claim 25 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Mims, along with the general knowledge of a POSITA, teaches this additional element. EX1004 at ¶261. *See* Ground 4 discussion of Element 1a, Section VIII.D, which is incorporated herein. *See also* EX1007 at 4:45-47 (discussing perforation size). A POSITA would recognize the application of the well-known concept of perforating the injection well. EX1004 at ¶262.

Claim 26

Claim 26 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Mims, along with the general knowledge of a POSITA, teaches this additional element. EX1004 at ¶264-267. *See* Element 1c-1 discussion, Section VIII.D.1, which is incorporated herein by reference. *See also* EX1007 at 4:45-47 (discussing perforation size). A POSITA would recognize the application of the well-known concept of perforating the production well to connect it to the reservoir. EX1004 at ¶266.

Claim 27

Claim 27 is dependent on Claim 25. Accordingly, Petitioner incorporates its arguments for Claim 25 herein. Mims, along with the general knowledge of a POSITA, teaches this additional element. EX1004 at ¶268-270. A POSITA would recognize that Mims's disclosure of perforations (EX1007 at 4:45-47) includes perforation on the lower surface.

Claim 28

Claim 28 is dependent on Claim 26. Accordingly, Petitioner incorporates its arguments for Claim 26 herein. Mims, along with the general knowledge of a POSITA, teaches this additional element. EX1004 at ¶271-274. A POSITA would recognize that Mims's disclosure of perforations (EX1007 at 4:45-47) includes perforation on the lower surface.

Claim 29

Claim 29 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Mims teaches this additional element. EX1004 at ¶2275-276. *See* Elements 1a and 1c-1 discussions, Section VIII.D, which are incorporated herein.

Claim 30

Claim 30 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Mims teaches this additional element. EX1004 at ¶278-281. *See* Elements 1a and 1c-1 discussions, Section VIII.D, which are incorporated herein. *See also* EX1007 at 1:60-68 (describing a single (first) injection well with a plurality of (second and third) injection wells).

Claim 31

Claim 31 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Mims teaches this additional element. EX1004 at ¶282-284. 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).

Claim 34

Preamble

To the extent the preamble is limiting, Mims teaches this element. EX1004 at ¶285. *See* Preamble 1 discussion, Section VIII.D, which is incorporated herein by reference.

Element 34-I

Mims teaches this element. EX1004 at ¶285. *See* Element 1a discussion, Section VIII.D, which is incorporated herein by reference.

Element 34-II

Mims teaches this element. EX1004 at ¶285. *See* Element 1b discussion, Section VIII.D, which is incorporated herein by reference.

Element 34-III

Mims teaches this element. EX1004 at ¶285. *See* Elements 1c-1–1c-3 discussion, Section VIII.D, which are incorporated herein by reference.

Element 34-IV

Mims teaches this element. EX1004 at ¶285. *See* Element 1d discussion, Section VIII.D, which is incorporated herein by reference.

Element 34-V

Mims, along with the general knowledge of a POSITA, teaches this element. EX1004 at ¶287-290. *See* Element 1e discussion, Section VIII.D, which is incorporated herein by reference.

Element 34-VI

Mims, along with the general knowledge of a POSITA, teaches this element. EX1004 at ¶291-293. *See* Element 1f discussion, Section VIII.D, which is incorporated herein by reference.

Claims 35-37

Claim 35 is dependent on Claim 1; Claim 36 is dependent on Claim 9; and Claim 37 is dependent on Claim 34. Accordingly, Petitioner incorporates its Ground 4 arguments for Claim 1, Claim 9, and Claim 34 herein. Mims teaches this additional element. EX1004 at ¶295. *See* Element 1b discussion, Section VIII.D, which is incorporated herein by reference.

Conclusion

For the reasons discussed, all elements of claims 1, 2, 6, 7, 9-11, and 25-31, 34-37 are rendered obvious in view of the combination of Mims and the general knowledge of a POSITA.

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

Petitioner incorporates the overview and motivations to combine from Section VIII.D and Section VIII.B herein.

Overview of Kruger

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.* 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. EX1004 at ¶54.

Further, Kruger discloses increasing the efficiency of extraction by using certain methods of heat extraction. *See, e.g.*, EX1040 at 8-10. 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. EX1004 at ¶55. 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. EX1004 at ¶55.

Claim 1

Preamble

To the extent the preamble is limiting, Mims teaches the preamble as set forth in Ground 4, Section VIII.D, which is incorporated herein. Further, both Swenson and Kruger teach this element. EX1004 at ¶298. 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.

Element 1a

Mims teaches element 1a of Claim 1 as set forth in Ground 4, Section VIII.D, which is incorporated herein. Additionally, Kruger teaches the use of an injection well for recovery of geothermal energy. EX1004 at ¶300-303; *see* EX1010 at 11-12. 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. EX1004 at ¶302.

Element 1b

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. EX1004 at ¶304. 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.

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. 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. EX1004 at ¶308.

Element 1c-1

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

Element 1c-2

Mims teaches element 1c-2 of Claim 1 as set forth in Ground 4, Section VIII.D, which is incorporated herein. Swenson also teaches this element. EX1004 at ¶311-313. 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 1c-3

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

Element 1d:

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

Element 1e:

Mims teaches element 1e of Claim 1 as set forth in Ground 4, Section VIII.D, which is incorporated herein. Additionally, Swenson teaches this element. EX1004 at ¶320. 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)

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.

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. 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. EX1004 at ¶323. 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 by reference.

Element 1f:

Element 1f is obvious to a POSITA in view of Mims as set forth in Ground 4, Section VIII.D, which is incorporated herein. Further, *see* Element 1e discussion, Section VIII.E, 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. As discussed in Ground 1, Element 1f, the buoyancy and pressure difference are obvious and well understood features of geothermal circulation systems. EX1004 at ¶326.

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. EX1004 at ¶327. A POSITA would understand these disclosures describe the extraction of geothermal energy using buoyant circulation of pressurized water, as described in element 1f. EX1004 at ¶328.

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

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 Ground 4 are incorporated herein.

Claim 4

Claim 4 is dependent on Claim 1. Accordingly, Petitioner incorporates its arguments for Claim 1 herein. Swenson further teaches this additional element. EX1004 at ¶332. 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. 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.

Claim 5

Claim 5 is dependent on Claim 1. Accordingly, Petitioner incorporates its arguments for Claim 1 herein. Swenson further teaches this additional element. EX1004 at ¶336-339. 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 system to form a “closed loop” it must rely on re-injection of the extracted geothermal fluid through the injection well. EX1004 at ¶338.

Claim 32

Claim 32 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Swenson further teaches this additional element. EX1004 at ¶340-343. 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. A POSITA would recognize that for such dry rock layers, water needs to be supplied from external sources. EX1004 at ¶342.

Claim 33

Claim 33 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Kruger further teaches this additional element. EX1004 at ¶344-347. 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. 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. EX1004 at ¶346. 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. *Id.*

Conclusion

For the reasons discussed above, all elements of claims 1, 2, 4-7, 9-11, and 25-37 are rendered obvious in view of the combination of Mims, Kruger and Swenson.

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

Petitioner incorporates the overview and motivations to combine from Section VIII.D and Section VIII.C herein.

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

Mims teaches claims 1, 2, 6, 7, 9-11, 25-31, and 34-37 as discussed in Ground 4. Accordingly, those arguments are incorporated herein.

Claim 3

Claim 3 is dependent on Claim 1. Accordingly, Petitioner incorporates its arguments for Claim 1 herein. Grassiani teaches this additional element. EX1004 at ¶350. Grassiani discloses “injection wellhead pressures are expected to be in the range of 100kg/cm² during operating flow conditions.” EX1011 at 3719. A POSITA would recognize that any applied pressure adds to the already existing hydrostatic pressure at the depth of the horizontal deeper injection wells. EX1004 at ¶352.

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

Claims 4-5, 12-23, and 38

Petitioner incorporates its Ground 3 arguments for Claims 4-5, 12-23, and 38 herein.

Conclusion

For the reasons discussed above, all elements of claims 1-7, 9-23, 25-31, and 34-38 are obvious in view of the combination of Mims, Grassiani, and Brannan.

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

Petitioner incorporates the overview and motivations to combine from Section VIII.A and Section VIII.B herein.

Overview of Alkhasov

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.

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. EX1004 at ¶56. 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); EX1004 at ¶57.

Claim 1

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

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

Elements 1c-1–1c-3

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. EX1004 at ¶360.

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. EX1004 at ¶361. 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. EX1004 at ¶362. 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. *Id.*

Claims 2-11 and 23-37

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

Claim 16 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Alkhasov further teaches this additional element. EX1004 at ¶364. 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):

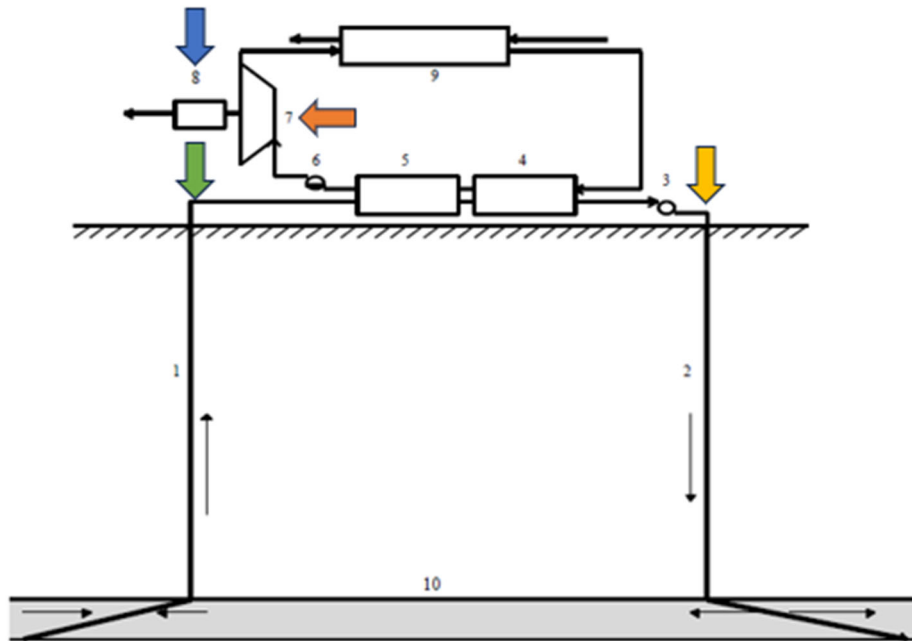


Fig.1 Technological scheme of GPP with horizontal wells. 1 - producing well; 2- injection well; 3- pump house of GCS; 4- heat-exchanger; 5- evaporator; 6- pump of secondary contour; 7- turbine; 8- generator; 9- condensator; 10- aquifer.

Claim 17

Claim 17 is dependent on Claim 9. Accordingly, Petitioner incorporates its arguments for Claim 9 herein. Alkhasov further teaches this additional element. EX1004 at ¶365. 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. *Id.*

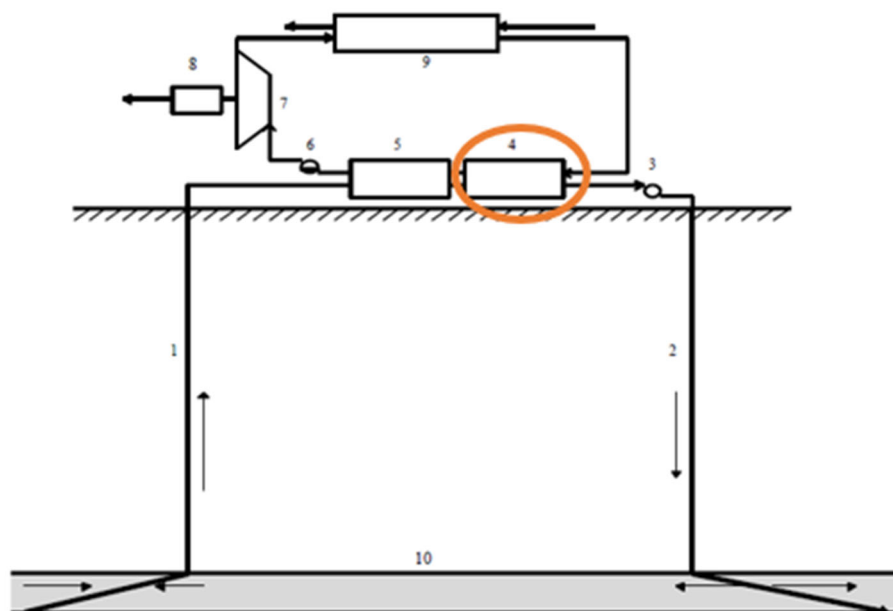


Fig.1 Technological scheme of GPP with horizontal wells. 1 - producing well; 2- injection well; 3- pump house of GCS; 4- heat-exchanger; 5- evaporator; 6- pump of secondary contour; 7- turbine; 8- generator; 9- condensator; 10- aquifer.

Conclusion

For the reasons discussed above, 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

For the reasons set forth above, Petitioner has established a reasonable likelihood that the Challenged Claims are unpatentable. Accordingly, Petitioner

respectfully requests institution of inter partes review and cancellation of the Challenged Claims.

Dated: March 8, 2024

Respectfully submitted,

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CERTIFICATE OF COMPLIANCE

Pursuant to 37 C.F.R. § 42.24(d), the undersigned certifies that this Response complies with the type-volume limitation of 37 C.F.R. § 42.24(b). The word count application of the word processing program used to prepare this Response indicates that the Response contains 13,952 words.

Dated: March 8, 2024

Respectfully submitted,

/s/ Sujeeth Rajavolu

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CERTIFICATE OF SERVICE

The undersigned certifies that the foregoing Petition to Institute an *Inter Partes* Review for U.S. Patent No. 7,320,221 under 35 U.S.C. § 312 and accompanying EXHIBITS were served on the following litigation counsel for Patent Owner via E-Mail and Federal Express on March 8, 2024:

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