Appeal No. 2023-1217

IN THE
UNITED STATES COURT OF APPEALS
FOR THE FEDERAL CIRCUIT

US SYNTHETIC CORP.,
Appellant

v.

INTERNATIONAL TRADE COMMISSION,
Appellee

SF DIAMOND CO., LTD., SF DIAMOND USA, INC., ILJIN DIAMOND CO., LTD., ILJIN HOLDINGS CO., LTD., ILJIN USA INC., ILJIN EUROPE GMBH, ILJIN JAPAN CO., LTD., ILJIN CHINA CO., LTD., INTERNATIONAL DIAMOND SERVICES, INC., HENAN JINGRUI NEW MATERIAL TECHNOLOGY CO., CR GEMS SUPERABRASIVES CO., LTD., FUJIAN WANLONG SUPERHARD MATERIAL TECHNOLOGY CO., LTD.,
Intervenors

Appeal from the United States International Trade Commission in Investigation No. 337-TA-1236

NON-CONFIDENTIAL BRIEF OF APPELLANT US SYNTHETIC CORP.

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May 19, 2023

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U.S. Patent No. 10,508,502 ("the '502 patent"):

1. A polycrystalline diamond compact, comprising:

a polycrystalline diamond table, at least an unleached portion of the polycrystalline diamond table including:

a plurality of diamond grains bonded together via diamond-to-diamond bonding to define interstitial regions, the plurality of diamond grains exhibiting an average grain size of about 50 μm or less; and

a catalyst including cobalt, the catalyst occupying at least a portion of the interstitial regions;

wherein the unleached portion of the polycrystalline diamond table exhibits a coercivity of about 115 Oe to about 250 Oe;

wherein the unleached portion of the polycrystalline diamond table exhibits a specific permeability less than about 0.10 $G\cdot cm^3/g\cdot Oe$; and

a substrate bonded to the polycrystalline diamond table along an interfacial surface, the interfacial surface exhibiting a substantially planar topography;

wherein a lateral dimension of the polycrystalline diamond table is about 0.8 cm to about 1.9 cm.

2. The polycrystalline diamond compact of claim 1 wherein the unleached portion of the polycrystalline diamond table exhibits a specific magnetic saturation of about 15 $G\cdot cm^3/g$ or less.

11. The polycrystalline diamond compact of claim 1 wherein the lateral dimension of the polycrystalline diamond table is about 1.3 cm to about 1.9 cm.

15. A polycrystalline diamond compact, comprising:

a polycrystalline diamond table, at least an unleached portion of the polycrystalline diamond table including:

a plurality of diamond grains bonded together via diamond-to-diamond bonding to define defining interstitial regions, the plurality of diamond grains exhibiting an average grain size of about 50 μm or less; and

a catalyst including cobalt, the catalyst occupying at least a portion of the interstitial regions;

wherein the unleached portion of the polycrystalline diamond table exhibits:

a coercivity of about 115 Oe to about 250 Oe;

a specific magnetic saturation of about 10 $G \cdot cm^3/g$ to about 15 $G \cdot cm^3/g$; and

a thermal stability, as determined by a distance cut, prior to failure in a vertical lathe test, of about 1300 m to about 3950 m;

wherein a lateral dimension of the polycrystalline diamond table is about 0.8 cm or more.

21. The polycrystalline diamond compact of claim 15 wherein the unleached portion of the polycrystalline diamond table exhibits a specific permeability less than about 0.10 $G \cdot cm^3/g \cdot Oe$.

UNITED STATES COURT OF APPEALS
FOR THE FEDERAL CIRCUIT

CERTIFICATE OF INTEREST

Case Number: 2023-1217

Short Case Caption: US Synthetic Corp. v. ITC

Filing Party/Entity: US Synthetic Corp.

Instructions:

1. Complete each section of the form and select none or N/A if appropriate.
2. Please enter only one item per box; attach additional pages as needed, and check the box to indicate such pages are attached.
3. In answering Sections 2 and 3, be specific as to which represented entities the answers apply; lack of specificity may result in non-compliance.
4. Please do not duplicate entries within Section 5.
5. Counsel must file an amended Certificate of Interest within seven days after any information on this form changes. Fed. Cir. R. 47.4(c).

I certify the following information and any attached sheets are accurate and complete to the best of my knowledge.

Date: May 19, 2023 Signature: /s/ Daniel C. Cooley

Name: Daniel C. Cooley

1. **Represented Entities.** Fed. Cir. R. 47.4(a)(1).	2. **Real Party in Interest.** Fed. Cir. R. 47.4(a)(2).	3. **Parent Corporations and Stockholders.** Fed. Cir. R. 47.4(a)(3).
Provide the full names of all entities represented by undersigned counsel in this case.	Provide the full names of all real parties in interest for the entities. Do not list the real parties if they are the same as the entities. ☒ None/Not Applicable	Provide the full names of all parent corporations for the entities and all publicly held companies that own 10% or more stock in the entities. ☐ None/Not Applicable
US Synthetic Corporation		ChampionX Corporation

☐ Additional pages attached

4. Legal Representatives. List all law firms, partners, and associates that (a) appeared for the entities in the originating court or agency or (b) are expected to appear in this **court** for the entities. Do not include those who have already entered an appearance in this court. Fed. Cir. R. 47.4(a)(4).

☐ None/Not Applicable ☐ Additional pages attached

Kelly S. Horn Finnegan, Henderson, Farabow, Garrett & Dunner, LLP	Yicong (Eve) Du Finnegan, Henderson, Farabow, Garrett & Dunner, LLP	Smith R. Brittingham, IV Finnegan, Henderson, Farabow, Garrett & Dunner, LLP
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Sonja Salhsten Finnegan, Henderson, Farabow, Garrett & Dunner, LLP	Ruohan (Jack) Li Finnegan, Henderson, Farabow, Garrett & Dunner, LLP (no longer with the firm)	

5. Related Cases. Other than the originating case(s) for this case, are there related or prior cases that meet the criteria under Fed. Cir. R. 47.5(a)?

☒ Yes (file separate notice; see below) ☐ No ☐ N/A (amicus/movant)

If yes, concurrently file a separate Notice of Related Case Information that complies with Fed. Cir. R. 47.5(b). **Please do not duplicate information.** This separate Notice must only be filed with the first Certificate of Interest or, subsequently, if information changes during the pendency of the appeal. Fed. Cir. R. 47.5(b).

6. Organizational Victims and Bankruptcy Cases. Provide any information required under Fed. R. App. P. 26.1(b) (organizational victims in criminal cases) and 26.1(c) (bankruptcy case debtors and trustees). Fed. Cir. R. 47.4(a)(6).

☒ None/Not Applicable ☐ Additional pages attached

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The public version of the addendum to U.S. Synthetic Corporation's opening brief redacts confidential information of U.S. Synthetic Corporation and Respondents, including technical details about products and business information. No material has been redacted from the text of the opening brief.

TABLE OF AUTHORITIES

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Cases

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STATEMENT OF RELATED CASES

Counsel for US Synthetic Corporation ("USS") hereby certifies that no other appeal from the same proceeding in the United States International Trade Commission ("ITC") is or was previously before this Court or another appellate court, whether under the same or similar title.

The Court's decision in this appeal may affect or be affected by *US Synthetic Corporation v. CR Gems Superabrasives Co., Ltd.*, No. 4:20-cv-03962 (S.D. Tex.); *US Synthetic Corporation v. Shenzhen Haimingrun Superhard Materials Co., Ltd.*, No. 4:20-cv-03966 (S.D. Tex.); *US Synthetic Corporation v. Iljin Diamond Co., Ltd. et al.*, No. 4:20-cv-03968 (S.D. Tex.); *US Synthetic Corporation v. Henan Jingrui New Materials Technology Co., Ltd.*, No. 4:20-cv-03970 (S.D. Tex.); *US Synthetic Corporation v. Zhuhai Juxin Technology*, No. 4:20-cv-03971 (S.D. Tex.); *US Synthetic Corporation v. Zhengzhou New Asia Superhard Materials Composite Co., Ltd. et al.*, No. 4:20-cv-03973 (S.D. Tex.); *US Synthetic Corporation v. SF Diamond Co. Ltd. et al.*, No. 4:20-cv-03974 (S.D. Tex.); and *US Synthetic Corporation v. Fujian Wanlong Superhard Material Technology Co., Ltd.*, No. 4:20-cv-03975 (S.D. Tex.).

I. STATEMENT OF JURISDICTION

The ITC had jurisdiction pursuant to 19 U.S.C. § 1337. The Commission issued its Final Determination on October 3, 2022. USS's notice of appeal from the Commission's determination finding no Section 337 violation was timely filed on November 28, 2022. This Court has jurisdiction pursuant to 28 U.S.C. § 1295(a)(6).

II. STATEMENT OF THE ISSUES

1. Did the International Trade Commission ("Commission") err when it found that claims 1, 2, 11, 15, and 21 of U.S. Patent No. 10,508,502 ("the '502 patent") are directed to an abstract idea and therefore ineligible under 35 U.S.C. § 101?

III. INTRODUCTION

USS appeals the Commission's decision finding claims of the '502 patent invalid under 35 U.S.C. § 101 as being directed to a patent-ineligible abstract idea. The claims held unpatentably abstract by the Commission are directed to a *composition of matter*: a polycrystalline diamond compact ("PDC") [1] used in drilling applications. USS believes—and no case raised by the parties in the proceedings is contrary—that this is the first time a composition of matter has been deemed an ineligible abstract idea.

Compositions of matter are expressly among the categories Congress enumerated as patentable in the Patent Act of 1793, persisting unchanged to the present day, 35 U.S.C. § 101 ("any new and useful process, machine, manufacture, or composition of matter"). The Commission recognized that USS's claims to man-made PDCs were statutory compositions of matter, but nevertheless held that they were ineligible for patenting under the judge-made exception for mere abstract ideas.

[1] "PDC" refers to a "**p**olycrystalline **d**iamond **c**ompact," which is a compact of *both* polycrystalline diamond *and* a substrate often made of tungsten carbide. "PCD," on the other hand, refers specifically to the **p**oly**c**rystalline **d**iamond that is sintered to the top of the substrate. The PCD is often referred to as a "PCD table" or a "diamond table."

The Supreme Court and Federal Circuit jurisprudence defining ineligible-subject matter have traditionally found claims "abstract" when they are directed to mathematical equations, business methods, or generic ideas implemented on computers. Here, however, the claims are directed to tangible PDCs—described, in part, by objective measurements of their physical properties. The Commission's ineligibility decision was unprecedented in finding that by including these measurements to define the characteristics of the diamond microstructure, the PDC claims were rendered abstract by virtue of identifying "results" or "side effects." The Commission went further, finding that the claimed PDC measurements were nonstructural and thus abstract because "the measurable characteristics" were merely "the result of the sintering conditions and input materials that went into manufacturing the PDC." But every inventive element under the sun is the "result" of the process that made it.

The Commission's decision conflicts with the plain language of § 101 and Federal Circuit and Supreme Court caselaw. It also raises serious policy concerns across the materials, chemical, and pharmaceutical industries, which often patent compositions of matter by claiming the physical properties of a material. The Commission should be reversed.

IV. STATEMENT OF THE CASE

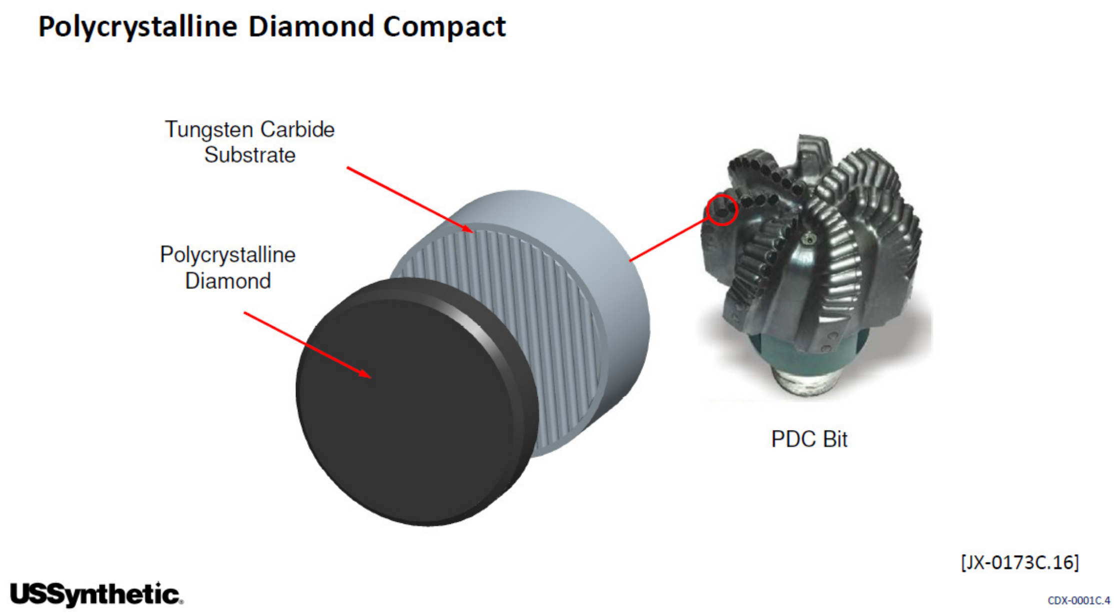
A. USS Is a Leading Manufacturer and Innovator of PDC Technologies

USS is one of the world's largest developers and producers of PDCs. Appx900. PDCs are commonly used in drill bits used for oil and gas exploration. Appx900; Appx903. USS has developed PDCs for drill bits that drill faster and last longer, enhancing the durability of drilling equipment. Appx918; Appx928. USS's research and development center and manufacturing facility are located in Orem, Utah, where the company was founded in 1978. Appx900; Appx904. It does not have overseas operations. *See* Appx904.

USS is globally recognized in the industry as the leader in the PDC market due to the quality of its PDC products. *See* Appx887 (Respondent Iljin's CEO praising USS as "the leader in [the] PDC market"); Appx889 (Respondent SF Diamond noting that USS is the "industry leader in PDC products").

B. USS Developed and Patented Innovative PDC Products

This appeal relates to PDCs. As shown below, a PDC includes a diamond table and a substrate. The substrate is made from metal—typically, a cobalt-cemented tungsten carbide. The diamond table is made from synthetized polycrystalline diamond. PDCs are often shaped as cylinders and are brazed into drill bits to provide cutting elements. Below is an exploded view of a PDC (left) and multiple PDCs in a drill bit (right).



Appx552 (citing Appx1238).

The process of making a PDC, including synthesizing the diamond table, requires intense pressure and temperature to fuse or "sinter[]" the diamond grains to each other. Appx100, 9:54-63. The pressure and temperature also help bond the diamond table to the tungsten carbide substrate. Appx1636, 60:7-18.

A PDC can be fabricated by placing the substrate into a cartridge with a volume of diamond particles on top of the substrate. *See* Appx96, 1:42-46. This cartridge may be loaded into a press. Appx96, 1:45-46. The substrate and diamond particles are processed under the high-pressure and high-temperature conditions in the presence of a catalyst (e.g., cobalt or a similar catalyst that originates from the substrate) that causes the diamond particles to bond to one another, creating a polycrystalline diamond table that is bonded to the substrate. Appx96, 1:46-54.

1. Development of the Invention

USS sought to improve the performance of its PDCs. One way to improve performance is to reduce the amount of metal catalyst (e.g., cobalt) in the diamond table. Appx97, 4:5-12. Having metal catalyst in the diamond matrix is helpful during the sintering process to promote the growth of diamond grains, but the metal catalyst can be harmful to the structural integrity of the diamond table when the PDC is later used for drilling. Appx96, 1:54-2:7; Appx1647-1648, 71:17-72:10.

One method for reducing the amount of catalyst in PDCs is called "leaching." Appx1647-1648, 71:17-72:10. Leaching involves submerging the PDC diamond table (but not the metal substrate) into an acid bath. Appx101, 12:20-47. The acid removes some of the metal catalyst in the diamond table. *Id.* A PDC that has undergone leaching is called a "leached" PDC in the industry. It may have a leached region near its surface (where the acid has removed the metal catalyst) and an unleached region (where the acid did not penetrate). *Id.*; *see also* Appx104, 18:25-42. A PDC that has not undergone any leaching process is referred to in the industry as an "unleached" PDC. Appx1704, 128:18-24. Diamond that is leached of its sintering catalyst often lasts longer under higher temperatures and performs better during abrasion tests than unleached diamond. Appx1653, 77:5-22.

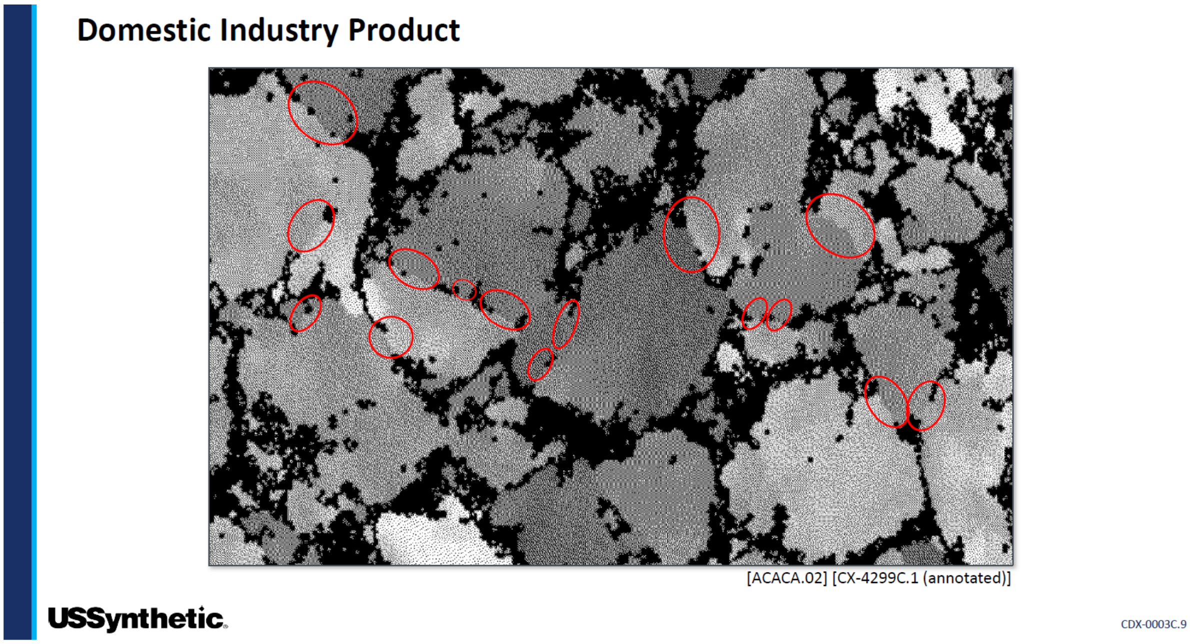
USS sought to create a new, stronger type of PDC by reducing the amount of metal catalyst (e.g., cobalt), thereby increasing the diamond bonding, but without requiring a leaching process to do so—although the product could later be leached later to make it even more wear-resistant. Appx1647-1648, 71:10-72:10. Before the claimed invention, USS and others believed that sintering a PDC at too high a pressure could damage or destroy expensive press equipment without improving diamond bonding. Appx1645-1646, 69:16-70:12. But through significant R&D efforts, USS developed a way to exert higher sintering pressure (e.g., > 7 Gigapascals ("GPa")) and reduce the overall cobalt content in the diamond table even before leaching. *See* Appx922; Appx1642-1648, 68:20-72:23. These manufacturing methods led to a new type of PDC with more diamond bonding and less cobalt.

USS's new PDCs have stronger diamond-to-diamond bonding than those in the prior art. Appx97, 3:66-4:5. USS found that its new PDCs performed surprisingly well in two standard industry tests that simulate drilling conditions. Appx1652-1653, 76:6-77:22 (noting that the claimed invention "was not leached and still beat a leached cutter"). These tests use a vertical turret lathe ("VTL") to grind the PDC against a large, rotating rock cylinder. Appx1651-1652, 75:17-76:5. One test called a "wet VTL" uses a coolant and produces a measurement called "G-Ratio." Appx1717-1718, 141:25-142:5; Appx98, 6:1-13. The other test called "dry VTL" is similar but does not use coolant and produces a measurement called "thermal stability." Appx1734-1735, 158:24-159:12; Appx98, 6:14-38.

USS found that its new PDC performed better in high-abrasion applications, such as earth-boring drill bits. Appx97, 4:46-57. Good PDC performance reduces how frequently drill operators must remove or replace the drill bit. Appx96, 1:26-41. This is important because removing a drill bit from a well that is thousands of feet into the earth's surface can be time consuming and expensive, decreasing the productivity of the drill rig. Appx1634-1635, 58:10-59:2. The patented PDC can also be used to improve the performance of other applications, such as thrust-bearing assemblies, radial-bearing assemblies, wire-drawing dies, artificial joints, machining elements, and heat sinks. Appx105, 20:62-67. The patented PDCs achieved superior performance compared to conventional PDCs that are leached to merely reduce the metal-solvent catalyst content without having stronger diamond-to-diamond bonding. Appx1647-1648, 71:19-72:10.

2. Characterization of the Invention

USS sought to characterize the innovative PDC it invented, including its improved degree of diamond-to-diamond bonding. These bonds could be observed using a scanning electron microscope ("SEM"), as USS expert Dr. German did at the hearing.



Appx568 (red ovals indicating diamond-to-diamond bonding).

Because the degree of diamond-to-diamond bonding cannot be quantified by observation alone, USS used objective measurements to define the characteristics of the diamond microstructure:

Average Grain Size: Average diamond grain size or average grain size refers to an average size of diamond grains measured by a standard method, such as ASTM E112-96 (2004). Appx195-197; Appx1729-1730, 153:20-154:1. The measurements are taken using a scanning electron microscope ("SEM") and other instrumentation. Appx1726-1727, 150:14-151:2; Appx1728-1730, 152:18-154:1. The '502 patent discloses that the claimed PDCs have an average grain size of 50 μm or less. *See* Appx97, 4:36-45.

Seeking other ways to characterize its novel PDC, USS measured electromagnetic properties of the material. Appx2823, 1243:19-25. A PDC's electromagnetic properties are important because they reflect the quantity and spacing of the metal-solvent catalyst left over in the diamond table after sintering, thereby also providing information regarding the diamond that surrounds the catalyst. This metal-solvent catalyst—often cobalt—is magnetic and electrically conductive. Appx3283, 1:55-65; Appx3292-3293, 19:1-21:29. As the diamond particles in the PCD table bond and grow, they displace the metal solvent catalyst in the diamond matrix. Appx97, 3:66-4:17. The new PCD table with a reduced metal-solvent catalyst content exhibited "a higher coercivity, a lower specific magnetic saturation, or a lower specific permeability (i.e., the ratio of specific magnetic saturation to coercivity) than [a] PCD formed at a lower sintering pressure." *Id*. Each of these measurements provides different and quantifiable information about the diamond microstructure.

Coercivity: Coercivity measures resistance to changes in magnetization indicated by the magnetic field intensity needed to reduce the magnetization of the material from saturation to zero. Appx197. Coercivity is correlated with the "mean free path" between neighboring diamond grains of the PCD. Appx97-98, 4:66-5:1. The mean free path "is representative of the average distance between neighboring diamond grains of the PCD, and thus may be indicative of the extent of diamond-to-diamond bonding in the PCD." Appx98, 5:2-5. "A relatively smaller mean free path, in well-sintered PCD, may indicate relatively more diamond-to-diamond bonding." Appx98, 5:5-7. Thus, coercivity reflects how tightly the diamond grains are bonded together in a PCD.

Specific magnetic saturation: Specific magnetic saturation represents a state in which an increase in the magnetizing force does not result in an increase in the magnetization of the material. Appx199-200. The '502 patent discloses that "[t]he amount of the metal-solvent catalyst present in the PCD may be correlated with the measured specific magnetic saturation of the PCD. A relatively larger specific magnetic saturation indicates relatively more metal-solvent catalyst in the PCD." Appx97, 4:61-65. The amount of metal-solvent catalyst in a PCD depends on the PCD microstructure, specifically, the extent of diamond-to-diamond bonding. Appx98, 5:20-22 ("Generally, as the sintering pressure that is used to form the PCD increases, the coercivity may increase and the magnetic saturation may decrease.").

Specific permeability: Specific permeability measures the ratio of specific magnetic saturation to coercivity. Appx199. Specific permeability is a microstructure parameter because it is a ratio of coercivity and specific magnetic saturation, both of which represent a PCD's microstructure. *See* Appx2920, 1340:12-15. USS determined that its polycrystalline diamond table exhibits a specific permeability less than about 0.10 G·cm^3/g·Oe. Appx98, 5:37-41.

3. USS Patented Its PDC Invention

After its research developments, USS tested and analyzed its novel PDCs and characterized properties of their composition, including the average diamond grain size, diameter, coercivity, and magnetic saturation. USS provided the results of this testing in Table I of the '502 patent and related patents, U.S. Patent No. 10,507,565 ("the '565 patent") and U.S. Patent No. 8,616,306 ("the '306 patent") (collectively "the Asserted Patents").

TABLE I

Selected Magnetic Properties of PCD Tables Fabricated According to Embodiments of the Invention

	Average Diamond Particle Size (μm)	Sintering Pressure (GPa)	Specific Magnetic Saturation (G · cm^3/g)	Calculated Co wt %	Coercivity (Oe)	Specific Permeability (G · cm^3/g · Oe)
1	20	7.8	11.15	5.549	130.2	0.08564
2	19	7.8	11.64	5.792	170.0	0.06847
3	19	7.8	11.85	5.899	157.9	0.07505
4	19	7.8	11.15	5.550	170.9	0.06524
5	19	7.8	11.43	5.689	163.6	0.06987
6	19	7.8	10.67	5.150	146.9	0.07263
7	19	7.8	10.76	5.357	152.3	0.07065
8	19	7.8	10.22	5.087	145.2	0.07039
9	19	7.8	10.12	5.041	156.6	0.06462
10	19	7.8	10.72	5.549	137.1	0.07819
11	11	7.8	12.52	6.229	135.3	0.09254
12	11	7.8	12.78	6.362	130.5	0.09793
13	11	7.8	12.69	6.315	134.6	0.09428
14	11	7.8	13.20	6.569	131.6	0.1003

Appx103-104, tbl.I. USS also analyzed and tested prior art products for these same properties. The results of these tests are provided in Tables II and III in the Asserted Patents and show that the microstructure of the PDCs that USS had developed was unique and differed from the prior art. Appx104, tbls.II & III. When compared on equal footing (unleached USS PDC versus unleached prior art PDC), no prior art product exhibited all the characteristics of the PCD table in USS's new PDC. Appx104, tbl.IV.

USS was granted claims covering its inventions, including the '502 patent (Appx80-108) and its claims 1, 2, 11, 15, and 21 (collectively "the Asserted Claims"). Some claims in USS's Patents, not at issue here, claimed the process of making the PDC, including pressures during the sintering process. The Asserted Claims at issue in this appeal, however, address the PDC itself.

Claims 1 and 2 of the '502 patent recite the novel PDC:

> 1. A polycrystalline diamond compact, comprising:
>
> a polycrystalline diamond table, at least an unleached portion of the polycrystalline diamond table including:
>
> a plurality of diamond grains bonded together via diamond-to-diamond bonding to define interstitial regions, the plurality of diamond grains exhibiting an average grain size of about 50 μm or less; and
>
> a catalyst including cobalt, the catalyst occupying at least a portion of the interstitial regions;
>
> wherein the unleached portion of the polycrystalline diamond table exhibits a coercivity of about 115 Oe to about 250 Oe;
>
> wherein the unleached portion of the polycrystalline diamond table exhibits a specific permeability less than about 0.10 $G\cdot cm^3/g\cdot Oe$; and

> a substrate bonded to the polycrystalline diamond table along an interfacial surface, the interfacial surface exhibiting a substantially planar topography;
>
> wherein a lateral dimension of the polycrystalline diamond table is about 0.8 cm to about 1.9 cm.
>
> 2. The polycrystalline diamond compact of claim 1 wherein the unleached portion of the polycrystalline diamond table exhibits a specific magnetic saturation of about 15 $G \cdot cm^3/g$ or less.

Appx106-107, Claims 1, 2.

C. USS Requested This Investigation to Address Infringement of the Asserted Patents by Foreign Manufacturers

USS successfully commercialized its novel PDC products. Its customers include most of the largest oil field service providers and drill bit manufacturers in the industry. Appx1641, 65:2-7; Appx901. When USS introduced its new PDC product to one large customer, the customer was especially interested because it "beat a leached cutter." Appx1651-1653, 75:1-77:22. The sales of USS's domestic industry products covered by the Asserted Patents increased from 2017 through 2019. Appx2072-2073, 495:3-496:13.

After USS publicized its technology, USS started to identify foreign companies infringing the Asserted Patents. These companies include the Respondents: entities from China and Korea who soon began to import infringing

PDC products into the United States.[2] After obtaining samples and testing them, USS determined there was infringement. The only products made by Respondents that had the claimed features were created *after* USS published the disclosure of its patents and sold its own products into the marketplace. This result is unsurprising because Respondents later conceded that they were benchmarking products from USS, who they called the "leader in the industry." *See* Appx1215-1216, 213:21-214:13; Appx887 (Respondent Iljin's CEO praising USS as "the leader in [the] PDC market"); Appx889 (SF Diamond noting that USS is the "industry leader in PDC products"); Appx1892-1893, 315:21-316:7; Appx821.

Throughout this Investigation, Respondents challenged the Asserted Claims as being directed to patent-ineligible natural phenomena or diagnostics. In their pre-hearing brief, Respondents argued that "the claims are directed to diagnostics

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[2] Respondents in this Investigation include **SF Diamond** (which includes SF Diamond Co., Ltd., and SF Diamond USA, Inc.), which is based in Zhengzhou, China, and its subsidiary SF Diamond USA, Inc.; **Iljin** (includes Iljin Holdings Co., Ltd., and its subsidiaries Iljin Diamond Co., Ltd., Iljin USA Inc., Iljin Europe GmbH, Iljin Japan Co., Ltd., and Iljin China Co., Ltd.) is headquartered in South Korea; **Jingrui** (Henan Jingrui New Material Technology Co., Ltd.) is based in Zhengzhou, China; **New Asia** (Zhengzhou New Asia Superhard Materials Composite Co., Ltd.) is based in Zhengzhou, China, and its distributor IDS (International Diamond Services, Inc.) is based in Houston, Texas; **CR Gems** (CR Gems Superabrasives Co., Ltd.) is based in Shanghai, China; **Wanlong** (Fujian Wanlong Superhard Material Technology Co., Ltd.) is based in Quangzhou, China; **JuxTech** (Juxin New Materials Technology Co., Ltd.) is headquartered in Zhuhai, China; and **Haimingrun** (Shenzhen Haimingrun Superhard Materials Co., Ltd.) is based in Shenzhen City, China.

applied to characterize previously unmeasured magnetic and electrical properties of the PCD table in the PDC." Appx3701. Respondents made a similar argument in their post-hearing briefing. Appx3911-3912.

After the evidentiary hearing, the Administrative Law Judge ("ALJ") held that "[a]ll asserted claims of U.S. Patent Nos. 10,507,565, 10,108,502, and 8,616,306 are infringed by at least one Accused Product"; that "[a]ll asserted claims of U.S. Patent Nos. 10,507,565, 10,108,502, and 8,616,306 are invalid"; and that "[e]xcept for the invalidity of the asserted claims, a domestic industry within the meaning of 19 U.S.C. § 1337 exists." Appx391.

With respect to the claims on appeal, the ALJ found that the Asserted Claims of the '502 patent are infringed by the Accused Products. Appx297-299. The ALJ also found that domestic industry products practice claims 1, 2, 11, 15, and 21 of the '502 patent. Appx314-315.

Turning to the Respondents' arguments that the claims are directed to an ineligible natural phenomenon, the Initial Determination ("ID") *rejected* the arguments, holding that "[t]he asserted claims of the 565 patent obviously do recite compositions of matter that are *not* found in nature . . . ." Appx325 (emphasis added). However, the ALJ found the Asserted Claims were invalid under 35 U.S.C. § 101 as being directed to an abstract idea. The ALJ rejected Respondents' other invalidity arguments under §§ 102, 103, and 112 for claims 2, 15, and 21.

Therefore, only the § 101 ruling prevented an exclusion order from issuing against the Respondents.

USS petitioned for review from the Commission. After briefing from both parties, the Commission issued its Final Determination holding that the Asserted Claims are directed to an abstract idea and ineligible under § 101. At *Alice* step one, the Commission reiterated the ALJ's description of the claims as reciting "side effects" and "performance measures." Appx20-21; Appx23. The Commission then held that "the claims are directed to the abstract idea of PDCs that achieve the claimed performance measures and desired magnetic and electrical results, which the specifications posit may be derived from enhanced diamond-to-diamond bonding." Appx24-25. At *Alice* step two, the Commission agreed with the Initial Determination's finding that "the claims read on any PDC structure that achieves the claimed improvements." Appx34 (quoting Appx333). The Commission further stated that "the claims recite results-oriented language and the recited physical elements are conventional." Appx35.

Commissioner Schmidtlein dissented, stating that "the claims are directed to an eligible composition of matter – *i.e.*, polycrystalline diamond compact defined by specific, objective measurements." Appx58. At *Alice* step one, Commissioner Schmidtlein stated that the claims recite various structural elements (e.g., a PCD table, a catalyst occupying at least a portion of interstitial regions, an unleached portion of the PCD table), which are defined by specific ranges of measurable properties (e.g., average diamond grain size, average electrical conductivity, G-Ratio, thermal stability, and lateral dimension of the PCD table) tied to the microstructure of the claimed PCDs. Appx69. Commissioner Schmidtlein noted that the claims do not raise any preemption concerns because the PDC manufacturers can manufacture PDCs that do not read on the claims. Appx75. Commissioner Schmidtlein also distinguished *American Axle & Manufacturing, Inc. v. Neapco Holdings LLC*, 967 F.3d 1285 (Fed. Cir. 2020), *cert. denied*, 142 S. Ct. 2902 (2022), noting that the claims in *American Axle* lacked "any physical structure or steps for achieving the claimed result," unlike the claims on appeal where "the advance of the claimed invention is a *physical structure* described by various measured parameters." Appx74 (quoting *Am. Axle*, 967 F.3d at 1295). Commissioner Schmidtlein concluded in dissent that since the claims are not directed to an abstract idea, she would have reversed and "f[ou]nd a violation based on infringement of claims 1, 2, 11, 15, and 21 of the '502 patent." Appx77.

V. SUMMARY OF THE ARGUMENT

The claimed PDC is a quintessential "composition of matter" under the statute and not an abstract idea. In finding otherwise, the Commission commits legal and factual errors. Under step one of *Alice*, the Commission creates an arbitrary structure/nonstructural distinction, improperly labeling measurements of

PDC properties as "side effects" and "desired results" in a way that misunderstands the underlying technology. The "results" that the Final Determination identifies are not the sort of "results" precedents have called into question, but rather measurements of microstructure of a novel composition of matter. And the Final Determination fails to explain how the claims are "directed to" the measurements alone as required under *Alice* step one. The Final Determination further erred in faulting the Asserted Claims, which are directed to the PDC itself, because they do not recite manufacturing steps. However, the statutory text of § 101 allows an inventor to claim a "composition of matter," not merely a "process."

The Final Determination also errs under *Alice* step two, failing to analyze each Asserted Claim in its ordered combination as directed by the Supreme Court, effectively collapsing the two-step *Alice* test into a one-step test. In doing so, the Final Determination ignores all numerical ranges recited in each Asserted Claim—which are features that define the novel and improved microstructure of the claimed PDC—and concludes that the Asserted Claims are invalid because it found that a few of the elements are generic. These rulings are legally erroneous.

VI. STANDARD OF REVIEW

This Court reviews questions concerning patent-eligible subject matter under § 101 without deference. *Ultramercial, Inc. v. Hulu, LLC*, 772 F.3d 709, 713 (Fed. Cir. 2014).

VII. ARGUMENT

A. This Is Not a Proper Case for Application of the Abstract Idea Exception Under 35 U.S.C. § 101

This is not a proper case for application of the judge-made prohibition on abstract ideas.

PDCs are a "composition of matter" under the statute, a patentable category contemplated by Congress 230 years ago. 35 U.S.C. § 101; Patent Act of 1793, § 1, 1 Stat. 318, 319 (1793) ("any new and useful art, machine, manufacture or composition of matter"). The Supreme Court in *Diamond v. Chakrabarty* defined a *composition of matter* as "all compositions of two or more substances and . . . whether they be the results of chemical union, or of mechanical mixture, or whether they be gases, fluids, powders or solids." 447 U.S. 303, 308 (1980) (citation omitted). The claims here are to a physical, man-made object falling squarely within the permitted statutory categories and the type of products that Congress has deemed appropriate to patent since the founding of the Republic. *Id.* at 307-09 (citing U.S. Const. art. I, § 8); *see Digitech Image Techs., LLC v. Elecs. for Imaging, Inc.*, 758 F.3d 1344, 1348-49 (Fed. Cir. 2014).

Indeed, the Commission has identified no Federal Circuit case, nor have the Respondents cited any, where claims to a man-made "composition of matter"—let alone a novel, nonobvious, definite, and enabled composition of matter as claimed in this case[3]—have been deemed ineligible as an abstract idea. A limited number of cases have addressed whether a composition-of-matter claim is directed to a patent-ineligible *natural law*, but the Commission correctly distinguishes the Asserted Claims here because they "recite compositions of matter that are *not* found in nature." Appx20-21 (emphasis added) (quoting Appx325). However, the Commission then goes on to find that certain limitations in the claims recite properties that are abstract. Appx20-34. This is without precedent. In fact, it has been noted that "[a] new and useful . . . composition of matter is not an abstract idea." *BASCOM Glob. Internet Servs., Inc. v. AT&T Mobility LLC*, 827 F.3d 1341, 1353-54 (Fed. Cir. 2016) (Newman, J., concurring). The PDCs claimed here qualify under the statute as a man-made "composition of matter" and do not fall under the judicial exception barring abstract ideas.

The body of Supreme Court and Federal Circuit cases that the Commission relies on that find abstract ideas are distinguishable from the facts here. They relate to financial methods, processes, math equations, or generic computer componentry applying known ideas; they do not relate to a novel man-made article like a PDC.

- *Alice Corp. v. CLS Bank International*, 573 U.S. 208 (2014), involved claims directed to computer-implemented business methods;

[3] As noted above, claims 1, 2, 11, 15, and 21 of the '502 patent were found invalid only due to § 101.

- *Electric Power Group, LLC v. Alstom S.A.*, 830 F.3d 1350 (Fed. Cir. 2016), involved claims directed to computer-implemented monitoring of the performance of an electric power grid;
- *Apple, Inc. v. Ameranth, Inc.*, 842 F.3d 1229 (Fed. Cir. 2016), involved claims directed to computer-implemented means for generating menus in restaurants;
- *Smart Systems Innovations, LLC v. Chicago Transit Authority*, 873 F.3d 1364 (Fed. Cir. 2017), involved claims for transit system payment systems;
- *Yu v. Apple Inc.*, 1 F.4th 1040 (Fed. Cir. 2021), *cert. denied*, 142 S. Ct. 1113 (2022), involved claims for a digital camera that was capable of producing high-resolution images;
- *ChargePoint, Inc. v. SemaConnect, Inc.*, 920 F.3d 759 (Fed. Cir. 2019), *cert. denied*, 140 S. Ct. 983 (2020), involved claims directed to vehicle-charging stations that communicated with each other over a network;
- *Interval Licensing LLC v. AOL, Inc.*, 896 F.3d 1335 (Fed. Cir. 2018), involved claims directed to a computer-implemented "attention manager" system;

- *O'Reilly v. Morse*, 56 U.S. (15 How.) 62 (1853), involved claims for an electromagnetic telegraph; and
- *Le Roy v. Tatham*, 55 U.S. (14 How.) 156 (1852), involved claims directed to a process for hot-working lead.

The Commission also cited to several cases expressly decided under a law-of-nature theory. *See* Appx20; Appx27; Appx29 (citing *Am. Axle*, 967 F.3d 1285 (decided under a natural-law theory)); Appx28 n.14 (citing *Funk Bros. Seed Co. v. Kalo Inoculant Co*., 333 U.S. 127 (1948) (involved claims for naturally occurring bacteria and decided under a natural-law theory)); Appx33 (citing *Mayo Collaborative Servs. v. Prometheus Lab'ys, Inc*., 566 U.S. 66 (2012) (involved claims directed to measuring metabolites in the blood of patients and decided under a natural-law theory)). However, it is undisputed that the PDCs in this case are not naturally occurring. *E.g.*, Appx20-21. They are man-made. *Id*.

In short, the Commission misapplies abstract-idea precedents to the facts of this case. While true that an inventor's "draftsman's art" cannot be allowed to convert an abstract idea into an eligible claim, *Am. Axle*, 967 F.3d at 1301 (citation omitted), likewise, an incorrect application of § 101 precedent should not be allowed to convert a novel PDC composition into an abstraction.

B. Claims 1, 2, and 11 of the ’502 Patent Are Patent Eligible Under § 101

Claims 1, 2, and 11 of the ’502 patent do not fail either step of *Alice*. Reciting measured material properties in the claims does not cause the claims to be directed to an abstract idea under *Alice* step one. And the claims integrate the material properties in a way that transforms them into a patent-eligible application under *Alice* step two.

1. Claims 1, 2, and 11 of the ’502 Patent Are Not “Directed to” an Abstract Idea Under *Alice* Step One

Claims 1, 2, and 11 are not “directed to” an abstract idea under *Alice* step one. *Alice*, 573 U.S. at 217. This Court has described the step-one inquiry “as looking at the ‘focus’ of the claims.” *ChargePoint*, 920 F.3d at 765 (quoting *Elec. Power Grp.*, 830 F.3d at 1353). “[A]t step one of the *Alice/Mayo* test, ‘it is not enough to merely identify a patent-ineligible concept underlying the claim; [the court] must determine whether that patent-ineligible concept is what the claim is ‘directed to.’” *Illumina, Inc. v. Ariosa Diagnostics, Inc.*, 967 F.3d 1319, 1325 (Fed. Cir. 2020) (citation omitted), *cert. dismissed*, 141 S. Ct. 2171 (2021). The focus “as a whole” of claims 1, 2, and 11 of the ’502 patent, as evidenced by *both* the claim language *and* the specification, is the novel PDC achieved by USS. The claimed PDCs are not directed to a “result” like the precedents cited by the Commission.

a. The Claims Are Directed to a Composition of Matter Defined—in Part—by Its Measured Properties

As Commissioner Schmidtlein correctly explained, "[o]ne only need to look at the language of the claims to observe that they are directed to [a] measurable composition of matter for which eligibility should be routine." Appx69. Nevertheless, the Commission majority held that the Asserted Claims here are directed to the abstract ideas of "enhanced diamond-to-diamond bonding" or "stronger PDCs that achieve certain performance measures and desired magnetic and electrical properties." *See, e.g.*, Appx24-25. The Commission believed that claimed measurements are merely "side effects," Appx23-24; Appx28, but the Commission misunderstands the law and the claimed technology. The claims are directed to a concrete composition of matter—a PDC—described, in part, by objective measurements of its structure. The language of claims 1, 2, and 11 of the '502 patent and the specification confirm that the claims are not "directed to" an abstract idea.

(1) The claimed measurements are directed to structure, not "side effects"

Claim 1 of the '502 patent recites, inter alia, "a polycrystalline diamond table" that includes "an unleached portion," "a plurality of diamond grains . . . exhibiting an average grain size of about 50 μm or less," "a catalyst including cobalt," "the unleached portion . . . exhibit[ing] a coercivity of about 115 Oe to about 250 Oe," "a specific permeability less than about 0.10 G·cm^3/g·Oe," and "a substantially planar topography." Appx106-107, Claim 1. Claim 2 adds that "the unleached portion . . . exhibits a specific magnetic saturation of about 15 G·cm^3/g or less." Appx107, Claim 2. Claim 11 further defines a lateral dimension of the diamond table between "about 1.3 cm to about 1.9 cm." Appx107, Claim 11. Even on their face, claims 1, 2, and 11 are directed to the structure of the polycrystalline diamond material and its material properties, not an abstract idea.

The Commission disagreed and found that "the claims" are directed to the "abstract idea of PDCs that achieve the claimed performance measures and desired magnetic and electrical results, which the specifications posit may be derived from enhanced diamond-to-diamond bonding." Appx24-25. But this is not correct. The properties are not "side effects" or "desired . . . results." They are measurements characterizing properties of PDC samples that USS manufactured, as disclosed in Table I of the '502 patent entitled "Selected Magnetic Properties of PCD Tables Fabricated According to Embodiments of the Invention."

TABLE I-continued

Selected Magnetic Properties of PCD Tables Fabricated According to Embodiments of the Invention.						
Example	Average Diamond Particle Size (μm)	Sintering Pressure (GPa)	Specific Magnetic Saturation (G · cm³/g)	Calculated Co wt %	Coercivity (Oe)	Specific Permeability (G · cm³/g · Oe)
3	19	7.8	11.85	5.899	157.9	0.07505
4	19	7.8	11.15	5.550	170.9	0.06524
5	19	7.8	11.43	5.689	163.6	0.06987
6	19	7.8	10.67	5.150	146.9	0.07263
7	19	7.8	10.76	5.357	152.3	0.07065
8	19	7.8	10.22	5.087	145.2	0.07039
9	19	7.8	10.12	5.041	156.6	0.06462
10	19	7.8	10.72	5.549	137.1	0.07819
11	11	7.8	12.52	6.229	135.3	0.09254
12	11	7.8	12.78	6.362	130.5	0.09793
13	11	7.8	12.69	6.315	134.6	0.09428
14	11	7.8	13.20	6.569	131.6	0.1003

Appx103-104, tbl.I.

The inventors sought to quantify the properties of their inventive PDC microstructure with objective measurements. These measurements address different and quantifiable aspects of the physical material and its microstructure. As the specification explains, measured coercivity is a corollary of "[t]he mean free path between neighboring diamond grains," which is "indicative of the extent of diamond-to-diamond bonding." Appx97-98, 4:66-5:7. The specification teaches measuring the coercivity using a published standard, ASTM B887-03 (2008) e1. Appx98, 5:8-11. Similarly, specific magnetic saturation is indicative of "[t]he amount of the metal-solvent catalyst present." Appx97, 4:61-65. Again, the specification teaches to measure magnetic saturation using a published standard, ASTM B886-03 (2008). Appx98, 5:8-11. Specific permeability is defined in the '502 patent as "the ratio of specific magnetic saturation to coercivity." Appx97, 4:5-12. It is therefore a measure of the extent of diamond-to-diamond bonding and the amount of catalyst as those characteristics relate to each other. Put simply, coercivity, specific permeability, and specific magnetic saturation are neither "merely a result or effect," nor a "side effect," but objective measurements by which different structural aspects of the patented microstructure can be described to the public.

The Commission suggests that "*USS has not proven* that the claimed electrical and magnetic properties are indicative of any specific microstructure." Appx27 (emphasis added). This is incorrect for several reasons. First, the Commission's suggestion that something must be "proven" by USS, *id*., improperly reverses the burden. Respondents, not USS, bear the burden to prove the claims are ineligible under § 101. *Microsoft Corp. v. i4i Ltd. P'ship*, 564 U.S. 91, 95 (2011) ("Under § 282 of the Patent Act of 1952, '[a] patent shall be presumed valid' and '[t]he burden of establishing invalidity of a patent or any claim thereof shall rest on the party asserting such invalidity' . . . by clear and convincing evidence." (alterations in original) (quoting 35 U.S.C. § 282)); *Cellspin Soft, Inc. v. Fitbit, Inc.*, 927 F.3d 1306, 1319 (Fed. Cir. 2019) ("To the extent the district court . . . conclude[ed] that issued patents are presumed valid but not presumed patent eligible, it was wrong to do so.”).

Second, imposing a “structural”/“nonstructural” requirement is nowhere supported by the law. Many inventions claim physical, electrical, compositional, or chemical phenomena that are not “structural” and are yet patent eligible.

Third, it is unclear what the Commission means by a “*specific* microstructure.” Appx27 (emphasis added). Respondents’ experts never opined that the claimed features are not structural. Indeed, the expert testimony shows that the claimed features *are* structural. For example, although Respondents’ expert, Dr. Schaefer, testified that he believed that USS’s PDCs were “conventional” (i.e., not novel) and the claims fell under the natural-law prohibition of § 101 as “diagnostic[]” methods, he did not dispute that the measurements in the claims related to the PDC structure. *See, e.g.*, Appx2407-2408, 828:24-829:19; Appx2411, 832:14-20. Dr. German likewise confirmed that the claimed measurements relate to PDC structure.

> Q. Okay. Turning to slide 282, did you hear Dr. Schaefer testify that the asserted claims are directed to diagnostic methods that merely measure conventional PDCs?
>
> A. Yes, I did.
>
> Q. Do you agree with Dr. Schaefer?
>
> A. No, I don’t.

> Q. Why do you disagree?
>
> A. What we're dealing with is a complicated microstructure. The claims are teaching us about how to do measurements of that microstructure of the quality of this product, showing us a range of properties that would be associated with the performance.

Appx2823, 1243:12-23.

> Q. . . . And do the asserted patents say anything about coercivity?
>
> A. Well, they talk about the property called the mean free path which, again, gets into similar sort of things as the grain size. It's a microstructure parameter. And so it's saying that the mean free path does influence the coercive force.

Appx2834, 1254:4-10.

Seeking to bolster its structural/nonstructural distinction, the Commission states that "the evidence does not support USS's argument that the claimed properties are 'structural elements' of a PDC or indicative of any specific microstructure" because "the measurable characteristics are the result of the sintering conditions and input materials that went into manufacturing the PDC." Appx26. This assertion is a non sequitur.

A measured feature can be both (1) a result of a manufacturing process *and* (2) structural. Most (if not all) structural features are a result of the manufacturing process that created them. The length of a steel beam, for instance, is a measurement of a "structural" feature. And the measured dimension—the length—would "result" from whatever casting, forging, shaping, or material removal processes created the steel beam in its final form. A polycrystalline diamond microstructure is more complex than a steel beam, but its structural and compositional characteristics can likewise be measured and defined objectively, including its constituent materials (e.g., "diamond"/carbon; "catalyst"/"cobalt"), bonding and processing details (e.g., "diamond grains bonded together via diamond-to-diamond bonding" and "unleached"), dimensions of bonded materials (e.g., "average grain size"), and material properties (e.g., "coercivity" and "specific magnetic saturation"). Each of these objectively measurable features was recited, for example, in claims 1 and 2 of the '502 patent.

In short, the claimed PDC of the '502 patent involves a composition of matter that the inventors characterized based on *what it is*, as measured and quantified through various objective features and measurements. That a measured property of the claimed composition of matter at some level "results" from a manufacturing process does not render it nonstructural as the Commission believes. "A compound and its properties are inseparable . . . ." *In re Cescon*, 474 F.2d 1331, 1334 (CCPA 1973) (citations omitted).

(2) The Commission's holding sows mischief in adjacent fields where claiming measurements is common

The Commission's unprecedented finding that measured properties and performance measures are abstract "side effects" and "results" has far-reaching negative implications for mechanical, metallurgical, and pharmaceutical arts. Properties of materials necessarily "result" from manufacturing choices, such as the choice of chemical inputs, processing parameters, and finishing steps for the material. Under the Commission's logic, claiming such "results" is suddenly problematic.

The Commission's logic also casts a shadow over claiming of measured properties. Claims in materials and chemical-compound patents commonly use measurements, like density, volume, and dosage amounts. *See, e.g.*, *In re Willis*, 455 F.2d 1060, 1061 (CCPA 1972) (claim reciting "[e]xpanded cross-linked poly(epihalohydrin) of substantially uniform closed-cell structure, *having a density of from about 8 pounds per cubic foot to about 75 pounds per cubic foot and a percentage compressibility of from about 20% to about 97%*" (emphasis added)). Patents in the materials and chemical-compound space also commonly include claim limitations that describe compounds by a result. *See, e.g.*, *Warner Chilcott Co. v. Teva Pharms. USA, Inc.*, 642 F. App'x 996, 1001-02 (Fed. Cir. 2016) (addressing "pharmaceutically effective absorption"); *Key Pharms. v. Hercon Lab'ys Corp.*, 161 F.3d 709, 713 (Fed. Cir. 1998) (construing "a pharmaceutically effective amount"); *Knoll Pharm. Co. v. Teva Pharms. USA, Inc.*, 367 F.3d 1381, 1383 (Fed. Cir. 2004). ("A pharmaceutical composition which comprises hydrocodone or a pharmaceutically acceptable acid addition salt thereof and ibuprofen or a pharmaceutically acceptable acid addition salt thereof *in amounts that are sufficient to provide an analgesic effect* . . . ." (emphasis added)). Indeed, in *Knoll Pharmaceutical*, the claimed "effect" or "result" was precisely the reason this court found the claim may be valid and warranted further consideration. 367 F.3d at 1384 (reversing and remanding because, "[c]ontrary to the district court's perception, the specification expressly acknowledges that the efficacy of the combination is 'surprising,' in that it provides an analgesic effect greater than that obtained by increasing the dose of either constituent administered alone").

The Commission's ruling miscasting measured properties as "side effects" and not related to structure is contrary to science, law, and good policy. Claims 1, 2, and 11 of the '502 patent are not directed to an abstract idea.

b. Claims 1, 2, and 11 of the '502 Patent Are Not Directed to a "Result" Akin to the Cases Cited by the Commission

Even assuming, *arguendo*, that coercivity, specific permeability, and specific magnetic saturation are "side effects" or "results," they are still not akin to the "result-oriented" claiming found abstract and ineligible under the case law cited by the Commission. *See* Appx21-22; Appx29-30. In those distinguishable cases, the abstract-idea analysis was concerned with claims reciting the end "result," "goal," or "effect" of a claimed invention.

The Commission relies heavily on an unappealed Commission decision: *Certain Light-Emitting Diode Products, Fixtures, and Components Thereof*, Inv. No. 337-TA-1213 ("*Light-Emitting Diode*"), 2021 WL 3829977 (USITC Aug. 17, 2021), *aff'd*, Comm'n Op., 2022 WL 168302 (USITC Jan. 14, 2022). The Commission suggests similarity between the claimed "efficiency" in *Light-Emitting Diode* and the measurements here. Appx29-30 (citing *Light-Emitting Diode*, 2021 WL 3829977, at *20). But *Light-Emitting Diode* differs from this case because it claimed the abstract idea directly and almost nothing more.

Light-Emitting Diode involved a claim to a lighting device that reads as follows:

> 1. A lighting device comprising at least one solid state light emitter, said lighting device, when supplied with electricity of a first wattage, emitting output light having a wall plug efficiency of at least 85 lumens per watt of said electricity.

2021 WL 3829977, at *19 (citation omitted). The ALJ found this and related claims ineligible because "the claims are directed to an abstract goal, namely, the energy efficiency of LED lighting devices at or above 85 [lumens per watt], however achieved." *Id*. at *20. Rather than claiming a structure, claim 1 in *Light-Emitting Diode* claimed the goal of energy efficiency itself. *Id.* The purpose of an

LED lighting device, according to the ALJ, is to take energy and transform it into light; so "energy efficiency" is simply a reflection of the "abstract goal" of the device. *Id*. Aside from this goal, the decision noted that claim 1 "recites only one structure, and only in the most generic terms: 'at least one solid state light emitter.'" *Id*. (citation omitted).

By contrast, claims 1 and 2 of the '502 patent, for example, do not directly claim the goal of "enhanced" or "stronger bonding."[4] Instead, claim 2, for example, recites a variety of different features, which in combination, define the novel composition of matter, including:

Types of claim features	**Specific Limitations from Claim 2**
Constituent materials	• "diamond" • "catalyst including cobalt"
Bonding information	• "grains bonded together via diamond-to-diamond bonding"
Processing state	• "unleached"
Dimensions of diamond grains	• "average grain size of about 50 μm or less"
Measured properties of unleached portion of diamond table	• "exhibits a coercivity of about 115 Oe to about 250 Oe" • "exhibits a specific permeability less than about 0.10 $G \cdot cm^3/g \cdot Oe$" • "exhibits a specific magnetic saturation of about 15 $G \cdot cm^3/g$ or less"

[4] A claim equivalent to *Light-Emitting Diode* would look like: "A drilling element, comprising at least one PDC, said drilling element, when used, having a stronger bonding of at least [X units]." No such claim appears in the '502 patent.

Dimensional information for the table and substrate	• "the interfacial surface exhibiting a substantially planar topography" • "a lateral dimension of the polycrystalline diamond table is about 0.8 cm to about 1.9 cm"

Appx106-107, Claims 1, 2.

Instead of claim 2 abstractly reciting a goal of "stronger bonding," it recites a structure that details *how* to achieve stronger bonding through a unique combination of material constituents, processing states, dimensions, and measured properties. And unlike *Light-Emitting Diode* where improving "wall plug efficiency" would be an end "goal," 2021 WL 3829977, at *20, here Respondents produced no evidence that people in drilling arts were seeking to create a PDC having the claimed "coercivity," "specific permeability," or "magnetic saturation" ranges of the claimed invention.

The Commission also cites to *Yu*, noting that "a claim recites an article of manufacture, or a composition of matter, is not determinative of whether it is in fact directed to an abstract idea." Appx21-22 (citing *Yu*, 1 F.4th at 1044 & n.2). According to the Commission, "[j]ust as the 'digital camera' in *Yu* is directed at patenting an abstract idea, so too is the 'polycrystalline diamond compact' here." Appx22. Like *Light-Emitting Diode*, the Commission misapplies *Yu* to this case.

In *Yu*, the court held that the claim in question was "directed to the abstract idea of taking two pictures (which may be at different exposures) and using one picture to enhance the other in some way." 1 F.4th at 1043. The parties did not dispute that "the idea and practice of using multiple pictures to enhance each other has been known by photographers for over a century." *Id*. The court explained that the abstract idea at issue (i.e., using one picture to enhance the other) was the ultimate result of the claim itself. *Id.* ("At the outset, we note that *claim 1 results in* 'producing a resultant digital image from said first digital image enhanced with said second digital image.'" (emphasis added)). Therefore, the claimed "solution" in *Yu* "*is the abstract idea itself*—to take one image and 'enhance' it with another." *Id*. at 1044 (emphasis added) (citation omitted).

Here, claim 1 of the '502 patent does not recite the alleged abstract idea of "enhanced diamond-to-diamond bonding." Appx23-25. This alleged "goal" is also not recited in any other Asserted Claim of the '502 patent. At most, claim 1 recites "a plurality of diamond grains bonded together via diamond-to-diamond bonding to define interstitial regions." Appx106-107, Claim 1. But this is merely a recitation of structure and lacks any mention of the word "enhancing" or "enhanced." By contrast, claim 1 of *Yu* directly recited the abstract idea, "producing a resultant digital image from said first digital image *enhanced with said second digital image*." 1 F.4th at 1043 (emphasis added). *Yu* is not on point.

Moreover, the claimed PDC and its properties have not been known for "over a century" as in *Yu*. *See id*. Here, Respondents were unable to produce any evidence showing products with the claimed features were known or obvious—or that any of their pre-existing products ever had them—which was why the asserted ’502 patent claims overcame all of the Respondents’ anticipation and obviousness challenges.[5]

Yu likewise does not apply to the Commission’s other formulations of the alleged abstract idea. The Commission refers to the “abstract idea” as being “a PDC that achieves the claimed performance measures (G-Ratio and thermal stability) and has certain measurable side effects (specific magnetic saturation, coercivity, and specific permeability).” Appx23. That is inapposite here, first, because claim 1 of the ’502 patent does not even recite “G-Ratio,” “thermal stability,” or “magnetic saturation.” *See also infra* § VII.B.1.e. For this reason alone, claim 1 fails to align with *Yu*, which expressly claimed the abstract idea itself. It is further inapposite because “a PDC” with defined properties is a tangible composition of matter, not a concept or idea like the one claimed in *Yu* of “taking two pictures (which may be at different exposures) and using one picture to enhance the other in some way.” *See* 1 F.4th at 1043. Expanding *Yu* to apply to the facts of this case would make any claim reciting a material property susceptible to ineligibility. *Cf. Mayo*, 566 U.S. at 71 (“[A]ll inventions at some level embody,

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[5] *Light-Emitting Diode* further found that the specification did not enable a skilled artisan to make a light-emitting diode consistent with claim 1. 2021 WL 3829977, at *24. By contrast, the Commission found that the Asserted Claims were enabled. Appx54-56.

use, reflect, rest upon, or apply laws of nature, natural phenomena, or abstract ideas."); *Diamond v. Diehr*, 450 U.S. 175, 187-88 (1981).

c. The Commission's Decision Conflates Product and Method Claims

The Commission commits additional error by faulting "the claims" for failing to include the manufacturing steps that created the claimed PDC. Appx28-29 (indicating that "[u]nclaimed features of the manufacturing process" cannot save the claims from ineligibility). But the claims are directed to the PDC *composition of matter*, not the *method* of making the PDC. The Commission's requirement that the claims include the method or process steps that created the PDC—or risk failing § 101—belies the language of the statute and undermines precedents relating to 35 U.S.C. § 112.

The Commission states that "[t]he specifications set forth various manufacturing conditions and input materials, and teach that these conditions and inputs may produce PCDs having improved mechanical and/or thermal properties over the prior art. However, other than grain size, none of these conditions/inputs are required by the claims." Appx29 (citation omitted). The Commission continues, "In other words, the asserted claims cover all PDCs exhibiting the claimed properties no matter what pressure was used to make them or how much catalyst is present in the PCD." Appx29. But claims 1, 2, and 11 of the '502 patent focus on the PDC, not the method or process of how it was made. It is, therefore, unremarkable that the inventors did not include process steps in the claims.

The law nowhere requires parties to claim their inventive contributions in only one manner. Section 101 on its face recognizes multiple ways to claim inventions: "[w]hoever invents or discovers any new and useful [1] *process*, [2] *machine*, [3] *manufacture*, or [4] *composition of matter*, or any new and useful improvement thereof, may obtain a patent therefor . . . ." 35 U.S.C. § 101 (emphases added). Congress left it to patent filers to determine how best, considering the technological and commercial context, to convey and claim the invention. There is no dispute that § 101 permits USS to claim the process steps for making PDCs, including temperatures, pressures, and other processing steps. However, § 101 also permits USS to claim the "composition of matter" itself. Requiring inventors to include manufacturing steps in their composition-of-matter claims, or risk claiming ineligible subject matter, contravenes the statute.

Similarly, the Asserted Claims need not recite how the PDCs are manufactured to constitute a patent-eligible technological improvement. *See Uniloc USA, Inc. v. LG Elecs. USA, Inc.*, 957 F.3d 1303, 1308-09 (Fed. Cir. 2020) (rejecting defendant's argument that a claim must state the claimed invention's advantage over prior art, holding that "[c]laims need not articulate the advantages of the claimed combinations to be eligible"). The claims are to the composition of matter (*what the material is*), not a method or process (*how the material is made*). Yet, the Commission erroneously declares the Asserted Claims patent ineligible for not reciting manufacturing steps without citing any binding legal authority for this proposition.

The Commission also states that the "causal connection" between the specification's manufacturing variables and the claim limitations is "loose and generalized." Appx27 (quoting Appx327). But it is unclear what evidence and expert testimony the Commission or ALJ relied on for this characterization (neither cites any), and the Commission elsewhere rejected the Respondents' arguments that the PDC claims are not enabled by the manufacturing parameters in the specification. Appx54-56. In any event, the Commission ultimately focuses on the wrong question. Requiring a direct "causal" connection between the manufacturing variables and the claim limitations is merely another way of requiring that manufacturing steps be recited in the product claims, which is incorrect for the reasons discussed above.

Section 101 allowing an inventor to claim an invention in different forms—as a method of manufacturing or a resulting composition of matter—supports the policy goals of the intellectual property right. An inventor may wish to sell a product and not a service into the marketplace. This makes the product the more significant economic unit for the inventor's business. Requiring the inventor to conflate the product and process together to obtain patent protection creates unintended business constraints and inefficient market outcomes.

One unintended consequence of the Commission's rationale relates to patent law's most fundamental right: the right to exclude. 35 U.S.C. § 154(a)(1). The right to exclude in the United States is self-policed. A product claim allows an inventor to monitor infringement based on a competitor's products in the open marketplace. Market products can be purchased immediately and anonymously. They can be analyzed and tested objectively. By contrast, a competitor's process steps may be hidden from view, alterable, or performed in foreign countries that limit access to discovery. *See In re Valsartan, Losartan, and Irbesartan Prods. Liab. Litig.*, MDL No. 2875 (RBK), 2021 WL 6010575, at *2 (D.N.J. Dec. 20, 2021) ("A theme in Federal Court litigation is that PRC defendants, when in doubt as to their potential liability for the production of PRC state secrets, invoke the SSL [PRC State Secret Law] and don't produce," which "can work to the advantage of PRC defendants to avoid or minimize their liability in U.S. courts."). Under the Commission's § 101 requirement, an inventor may have limited or no ability to police and establish infringement of a foreign competitor's processes.

Imposing a requirement that the manufacturing steps be recited in the product claim (to achieve patent eligibility) is inconsistent with the plain language of § 101 and it curtails statutory rights.

d. Claims 1, 2, and 11 of the ’502 Patent Are Not Preemptive

The Commission incorrectly suggests that USS’s claims are preemptive and that this indicates the claims are directed to an abstract idea. Appx31. Claims 1, 2, and 11 of the ’502 patent do not preempt the use of *all PDCs* but are instead directed only to *the novel PDC that USS created*, described using features and standard measurements of the composition of matter. There was significant evidence that Respondents had designed other products that did not fall within the claims. The Asserted Claims provide no impediment to using “basic building blocks of scien[ce].” Appx20 (citation omitted).

In suggesting preemption, the Commission cites to *ChargePoint*, which itself cites *Morse*. Appx31 (citing *ChargePoint*, 920 F.3d at 766); *see ChargePoint*, 920 F.3d at 769 (citing *Morse*, 56 U.S. at 112-13). *Morse* was a seminal case in developing the exception to § 101 and the broad contours of the notion of scientific preemption (dealing with Samuel Morse’s invention of the electromagnetic telegraph). Of it, the Federal Circuit explained:

> In *Morse*, the Court upheld claims related to the details of Samuel Morse’s invention of the electromagnetic telegraph, but invalidated a claim for the use of “electromagnetism, however developed for marking or printing intelligible characters, signs, or letters, at any distances.”
>
> . . .

> [I]n *Morse* . . . , [the] inventor "lost a claim that encompassed all solutions for achieving a desired result" because those claims "were drafted in such a result-oriented way that they amounted to encompassing the 'principle in the abstract' no matter how implemented."

ChargePoint, 920 F.3d at 769 (first quoting *Morse*, 56 U.S. at 112; and then quoting *Interval Licensing*, 896 F.3d at 1343).

Applying this "result-oriented" understanding, *ChargePoint* reached the same conclusion, finding that "the broad claim language would cover any mechanism for implementing network communication on a charging station, thus preempting the entire industry's ability to use networked charging stations." *Id.* at 770. Therefore, the claims at issue in *ChargePoint* were found "directed to" the abstract idea of communication over a network because, as drafted, they preempted "any mechanism" solving the problem faced by the inventors: a lack of networking. *See id.*; *see also Light-Emitting Diode*, 2021 WL 3829977, at *20 (finding claims "directed to an abstract goal, namely, the energy efficiency of LED lighted devices . . . , however achieved"). These cases were cited by the Commission here, but are distinguishable—those claims were all directed to an abstract idea because they were not adequately limited to the invention described in the specification and would instead preempt all solutions to the problem.

The present claims, in contrast, do not preempt all other PDCs that have the alleged abstract idea of "enhanced" or "stronger diamond-to-diamond bonding";

only those PDCs having all the elements of the specific technical solutions in the novel PDC with its claimed features, including the objective measurements, are covered by the claims. The Commission premised its preemption concerns on its belief that "USS seeks a monopoly on any PDCs that exhibit the claimed properties however achieved." *See* Appx30-31. This assertion is not supported by the evidence presented during this Investigation, which showed that the Asserted Claims do not improperly preempt prior art PDCs, current PDCs in the market, or PDCs that could be developed in the future.

As a legal matter, USS never accused, nor could it accuse, a product that merely met the "claimed properties" and lacked the other features of the claims. USS accused and demonstrated infringement where products met *each and every* claim element. *See Linear Tech. Corp. v. Int'l Trade Comm'n*, 566 F.3d 1049, 1060 (Fed. Cir. 2009) ("To prove infringement, a patentee must show that a defendant has practiced each and every element of the claimed invention, and may do so by relying on either direct or circumstantial evidence." (citation omitted)).

The Commission's preemption analysis is also wrong factually:

- First, Respondents would be free to practice their *prior art* products relative to the Asserted Patents. Respondents collectively sell (and have sold) hundreds of different product lines and variations of products within those product lines. Respondents did not and could not identify *one single prior art product* made by them having the claimed features. Respondents would be free to practice all their prior art products.

- Second, the Commission's finding of preemption overlooks Respondents' *current* products that USS tested but did not accuse of infringement. USS tested scores of Respondents' products for infringement (*see* Appx891-898), but USS only included a fraction of the tested products in their final infringement mappings. *Compare* Appx891-898 (listing tested products), *with* Appx233-234 (listing the Accused Products).
- And third, Respondents have already fashioned redesigns. SF Diamond produced a line of "redesign products" and the Commission found that these products do not fall within the claim scope. *See* Appx75-76.

Together, these represent a substantial number of products. Given all the sources of products that did not fall within the claimed limitations, the Commission's assertions about "USS seek[ing] a monopoly" are conclusory and conflict with the evidence of record. Appx30-31.

In suggesting a "monopoly" across hundreds of products, the Commission points to only two examples. The Commission points to Haimingrun's accused S18 product, noting that it was allegedly made with a different pressure and catalyst weight percentage than what is disclosed in the patent. Appx31-32. The Commission also points to New Asia's Dragon 2 product as being allegedly made with a different pressure. Appx32. Both examples are irrelevant and incorrect. They are irrelevant because the Asserted Claims of the '502 patent do not recite manufacturing pressure. The asserted '502 patent claims are to the composition of matter, not the process. The asserted '502 patent claims also do not recite the catalyst weight percentage.

The Commission's examples are also incorrect factually. The Commission points to Haimingrun's interrogatory response created after the litigation was filed (Appx1280-1282) and states that it lists the cavity pressure measurement for the S18 below the pressure used in the '502 patent disclosure (Appx1473). However, this assertion by Haimingrun conflicts with the actual pressure-curve document, which reveals a manufacturing pressure consistent with the pressures disclosed in the '502 patent when the input pressure they disclose is applied to their own graph. Appx1474; *see also* Appx3326. Similarly, New Asia's conclusory interrogatory response asserting knowledge of its manufacturing pressure conflicts with the testimony given by its corporate representative. *See* Appx3412-3414; Appx3494-3496.

The Commission also frames USS's analysis of Appx1474 as "attorney argument" and faults USS's expert for not questioning New Asia's sintering pressure. Appx32. USS was merely addressing Respondents' own attorney argument from their post hearing briefing regarding Appx1474 and New Asia, on an issue which Respondents bore the burden. The Commission's statements are further improper burden reversals.

Given the scores of prior, current, and future products that do not fall within the claims, these Asserted Claims of the '502 patent do not preempt the use by others of a mere abstract idea (such as, for example, "enhanced diamond-to-diamond bonding"). Other solutions to the same problem are left open.

e. The Commission Fails to Analyze Any Individual Claim

The Commission's analysis fails for yet another reason. The specific *claims* define the invention and are the subject of eligibility analysis. *Alice*, 573 U.S. at 217. ("[W]e consider the elements of each claim both individually and 'as an ordered combination . . . .'"); *see also Realtime Data LLC v. Reduxio Sys., Inc.*, 831 F. App'x 492, 495-96 (Fed. Cir. 2020) (requiring a claim-specific analysis during *Alice* step one). The Commission never analyzes the specific claims, nor does it analyze a single claim and find that such claim is representative of the other claims at issue. This was error and the Commission's gloss over the analysis should be rejected.

When addressing *Alice* step one, the Commission only ambiguously refers to "the claims" or "the asserted claims." Appx23 ("It is clear from the language of *the claims* that *the claims* involve an abstract idea . . . ." (emphasis added)); Appx23-24 ("Here, the specifications suggest that *the asserted claims* are directed to the abstract idea of PDCs that achieve the claimed performance measures and have side effects . . . ." (emphasis added)); Appx24-25 ("[T]he Commission finds that *the claims* are directed to the abstract idea of PDCs that achieve the claimed performance measures and desired magnetic and electrical results . . . ." (emphasis added)); Appx28 ("*The claims* run afoul of section 101 . . . ." (emphasis added)); Appx28 ("[*T*]*he claims* here cover a set of goals." (emphasis added)); Appx28 ("*The claims* do not recite a way of achieving the claimed characteristics . . . ." (emphasis added)). Indeed, the first time that the Commission's § 101 analysis mentions a specific claim in its § 101 analysis is not until *Alice* step two, and it does so merely in passing when quoting the Initial Determination. Appx34 (citing Appx333). Patent law requires element-by-element and claim-by-claim analysis; it does not permit mass invalidation upon a generic analysis of "the claims."

Each claim and its language must be given weight. *Alice*, 573 U.S. 208 at 217. The Commission admits this point, stating that "the 'directed to' inquiry must focus on the language of the claims themselves." Appx23 (citing *ChargePoint*, 920 F.3d at 767). Analyzing specific claims also matters here because the "asserted claims" differ. The evidentiary hearing involved three different patents, having five independent claims and six different dependent claims. Exemplary features addressed in only *some* claims include: "thermal stability" (Appx107, Claims 15, 21; Appx3295-3296, Claim 18); a "first" and "second polycrystalline diamond layer" (Appx956, Claim 15); "G ratio" (Appx3295, Claims 1, 2, 4, 6); "average electrical conductivity" (Appx3295-3296, Claims 1, 2, 4, 6, 18); "the interfacial surface exhibiting a substantially planar topography" (Appx106-107, Claims 1, 2, 11, 15, 21); and "specific magnetic saturation" (Appx107, Claims 2, 15; Appx3295, Claim 4; Appx956, Claim 15). The Commission must analyze the combinations of limitations, in the context of specific claims, when analyzing whether they meet the requirements of *Alice*.

The Commission's error is like the error in *Realtime Data*:

> One critical shortcoming in the district court's analysis is a failure to identify which, if any, claims are representative. Although the court articulated a "fair description" of each patent-in-suit, it failed to tie those descriptions to any specific claim or to clarify whether those descriptions are the abstract ideas that the claims are "directed to" within the meaning of § 101 jurisprudence. It is, of course, incorrect to consider whether a patent as a whole is abstract. ***The analysis is claim specific***. If, as we suspect, the district court's analysis simply generalized the claims, absent a finding of the representativeness of certain claims and without considering the "directed to" inquiry, that was error.

831 F. App'x at 497 (emphasis added) (citation omitted).

Even assuming the Commission had identified and analyzed a representative claim—which it did not—its analysis would fail for additional reasons. A court may analyze a representative claim only in "certain situations," such as "if the patentee does not present any meaningful argument for the distinctive significance of any claim limitations not found in the representative claim or if the parties agree to treat a claim as representative." *Berkheimer v. HP Inc.*, 881 F.3d 1360, 1365 (Fed. Cir. 2018), *cert. denied*, 140 S. Ct. 911 (2020). None of the conditions was met here. USS never agreed to a representative claim, and USS presented pages of arguments regarding the differences between the claims and their limitations, challenging how the ALJ had conflated terms across different claims and patents.

In its briefing before the Commission, USS explained that the Initial Determination had not been consistent in its analysis of the abstract idea, proposing three competing formulations that conflated claim limitations across several claims from the '565 and '502 patents:

> (1) "the goal or result of a particular measure of wear resistance (i.e., G-Ratio) or thermal resilience (i.e., thermal stability)" ([Appx328]);
>
> (2) "improved coercivity, electrical conductivity, G-Ratio" ([Appx332-333]); and
>
> (3) some "problematic" "performance measure" or "side effect" ([Appx327-328]).

Appx414.

USS noted:

> [T]he analysis for the ’502 Patent must be different than the analysis for the ’565 Patent claims because the claims have different and non-overlapping features. For example, no asserted claim of the ’502 Patent recites either “G-Ratio” or “electrical conductivity.” [Appx106-108; Appx357.] These features are found only in the asserted claims of the ’565 Patent.
>
> . . .
>
> The same is true of the ID’s inference that the claims cover “the goal or result of a particular measure of wear resistance (i.e., G-Ratio) or thermal resilience (i.e., thermal stability).” Neither “G-Ratio” nor “thermal stability” are found in claims 1, 2, and 11 of the ’502 patent. They are found in other claims.

Appx415. Rather than correct the issue, the Commission again conflated the claims, stating that “*the claims* involve an abstract idea,” and listing elements found across several different claims and patents: “G-Ratio,” “thermal stability,” “specific magnetic saturation,” “coercivity,” and “specific permeability.” Appx23 (emphasis added).

As was once said, “the name of the game is the claim.” Giles S. Rich, *The Extent of the Protection and Interpretation of Claims—American Perspectives*, 21 Int’l Rev. Indus. Prop. & Copyright L. 497, 499 (1990). The Commission’s analysis was improper at least because it never analyzes any one claim under *Alice* step one.

2. Claims 1, 2, and 11 of the '502 Patent Recite "Something More" Under *Alice* Step Two

Only if the court properly determines that the claim is "directed to" a judicially created exception such as a law of nature, a natural phenomenon, or an abstract idea, *Alice*, 573 U.S. at 221-22, does it proceed to *Alice* step two: assess the elements "as an ordered combination" to determine whether *the claim as a whole* integrates the exception in a manner sufficient to "'transform' the claimed abstract idea into a patent-eligible application." *Id*. at 217, 221-22. Here, the Commission's *Alice* step-two analysis is infected by the errors of its step-one analysis. And it failed to consider the transformative nature of the invention claimed as an ordered combination.

a. The Commission's *Alice* Step-One Errors Carried Through to Step Two

The Commission's incorrect analysis of *Alice* step one infected the remainder of its analysis at *Alice* step two. The Commission again irrelevantly fixates on the manufacturing steps it deems *should* have been claimed, rather than what is *actually* claimed. Appx34-35. The claims are directed to a novel composition of matter, not a method or process for making the composition. Thus, the claims need not recite the method or process for making the composition for patent eligibility. The Commission also finds that the "recited *physical* elements are conventional." Appx35 (emphasis added). But this again treats a measurement of a physical structure as somehow nonphysical. The Commission erred both as a matter of science and law.

b. The Commission Does Not Address the Claims as an Ordered Combination

In *Alice* step two, a court must assess the elements "both individually and 'as an ordered combination'" to determine whether *the claim as a whole* integrates the exception in a manner sufficient to "'transform' the claimed abstract idea into a patent-eligible application." *Alice*, 573 U.S. at 217, 221-22; *Rapid Litig. Mgmt. Ltd. v. CellzDirect, Inc.*, 827 F.3d 1042, 1051 (Fed. Cir. 2016). Thus, a new combination of elements "may be patentable even though all the constituents of the combination were well known and in common use before the combination was made." *Rapid Litig.*, 827 F.3d at 1051 (citation omitted). "To require something more at step two would be to discount the human ingenuity that comes from applying a natural discovery in a way that achieves a 'new and useful end.'" *Id.* at 1051-52 (quoting *Alice*, 573 U.S. at 217).

When searching for an inventive concept at *Alice* step two, the court must be careful not to "'oversimplify[] the claims' by looking at them generally and failing to account for the specific requirements of the claims." *CardioNet, LLC v. InfoBionic, Inc*, 955 F.3d 1358, 1371 (Fed. Cir. 2020) (citation omitted), *cert. denied*, 141 S. Ct. 1266 (2021); *see also Koninklijke KPN N.V. v. Gemalto M2M GmbH*, 942 F.3d 1143, 1151 (Fed. Cir. 2019).

In reaching its patent-ineligible conclusion, Appx34-36, the Commission never properly considers the claim "as an ordered combination" to determine whether it contains an inventive concept. *Alice*, 573 U.S. at 225. Even in its would-be step-two analysis, which is merely four paragraphs long, the Commission does not use the word "combination" other than its recitation of the legal standard. *See* Appx34-36.

Instead, the Commission adopts the Initial Determination's flawed separation of some of the claim elements into three categories—"structural limitations" and "objectionable claimed limitations," referring to "results-oriented language"—and analyzed the eligibility of each category on its own. Appx34-35. But it failed to analyze whether the elements of each Asserted Claim when read "as an ordered *combination*" in fact "'transform the nature of the claim' into a patent-eligible application." *Alice*, 573 U.S. at 217 (emphasis added) (citation omitted).

Claim 2 of the '502 patent, for example, shows the ordered combination of the composition of matter at issue having a host of structural features:

- "a polycrystalline diamond table"
- "a substrate" having "a substantially planar topography"
- "an average grain size of about 50 µm or less"
- "a coercivity of about 115 Oe to about 250 Oe"

- "a plurality of diamond grains bonded together via diamond-to-diamond bonding to define interstitial regions"
- "a catalyst including cobalt, the catalyst occupying at least a portion of the interstitial regions"
- "an unleached portion of the polycrystalline diamond table"
- "a specific permeability less than about 0.10 $G \cdot cm^3/g \cdot Oe$"
- "a specific magnetic saturation of about 15 $G \cdot cm^3/g$ or less."

See Appx106-107, Claims 1-2. The Commission ignored or otherwise dismissed USS's evidence concerning the nature of the combination of all elements—including the numerical ranges—without citing any contrary evidence. *See* Appx35.

First, USS and its expert, Dr. German, produced evidence that the combination of all these elements is directed to a PDC having a denser diamond microstructure, which provides significant utility in oil-drilling applications, such as wear resistance and thermal stability. Appx1642-1645, 66:20-69:5 (explaining that the patents disclose PDCs with "even greater diamond-to-diamond bonding, lower metal content, higher diamond density, and better wear resistance"); Appx2823, 1243:12-25 (referring to the Asserted Claims as "teaching us about how to do measurements of [a complicated] microstructure of the quality of this product, [and] showing us a range of properties that would be associated with the performance”). The evidence showed that the combination of high coercivity, low specific magnetic saturation, and low specific permeability along with other elements recited in claims 1, 2, and 11 reflect a novel PCD microstructure with enhanced diamond-to-diamond bonding that did not exist in conventional PCDs. Appx97, 4:5-12; Appx1693-1695, 117:3-119:25 (testifying that the claimed properties “would come from higher performance . . . .”).

Second, the Commission erred by omitting all analysis of the numerical ranges recited in the Asserted Claims, and the Commission never grapples with their implications in *Alice* step two. Each Asserted Claim recites a specific numerical range for each measurement parameter, providing a specific implementation of the parameter. For example, claim 2 of the ’502 patent recites a specific range of coercivity (about 115 Oe to about 250 Oe), specific permeability (less than about 0.10 $G \cdot cm^3/g \cdot Oe$), and specific magnetic saturation (about 15 $G \cdot cm^3/g$ or less). Appx106-107, Claims 1, 2. The specific numerical limitations relate to the improved PCD microstructure. Appx2823, 1243:12-25 (referring to the Asserted Claims as “teaching us about how to do measurements of [a complicated] microstructure of the quality of this product, [and] showing us a range of properties that would be associated with the performance.”); Appx2834, 1254:4-10 (referring to coercivity as “a microstructure parameter”). The Commission does not cite any contrary evidence to rebut USS’s evidence, but rather relies on the ALJ's conclusory analysis in the ID, which relied on misleading arguments in Respondents' initial post-hearing brief on pages 51-52. Appx34-35; Appx332. Contrary to Respondents' arguments, there is no evidence that a PDC having the claimed ranges of coercivity, magnetic saturation, specific permeability, and other features was known in the art.

Nowhere does the Commission or the Initial Determination address these numerical limitations, contravening the Federal Circuit's caution against "'oversimplifying the claims' by looking at them generally and failing to account for the specific requirements of the claims." *CardioNet*, 955 F.3d at 1371 (citation omitted); *see also Koninklijke KPN*, 942 F.3d at 1148, 1151 (holding that the claim reciting "to *modify* the permutation *in time*" was a sufficiently specific implementation improving the overall technological process of detecting systematic errors in data transmission of an existing tool, a "check data generating device"). Had *Alice* step two been properly performed, the ordered combination of recited claim elements, including the various measurement parameters and their specific numerical limitations, would have demonstrated patent-eligible technological improvement over prior art—i.e., specific types of novel PDCs with unique and desirable properties for oil-drilling applications. *BASCOM*, 827 F.3d at 1352.

When read as an "ordered combination," the novel USS PDC is a quintessential *transformation* of numerous elements into a tangible product and should have been patent eligible under *Alice* step two. *Alice*, 573 U.S. at 217. Instead, the analysis of the claimed invention as a whole—with more than a dozen "structural and design features" in the claim—was sidestepped in the second half of the Commission's *Alice* analysis. *See* Appx34-36. Thus, rather than properly applying the Supreme Court's two-step framework for evaluating subject matter eligibility, the Commission erroneously collapsed it into a subjective one-step determination dependent on the intuition of the ALJ looking at elements in isolation.

C. Claims 15 and 21 of the '502 Patent Are Patent Eligible Under § 101

The Commission's Final Determination is erroneous for yet another reason—it failed to consider elements in claims 15 and 21 of the '502 patent that confer patent eligibility. Claims 15 and 21 recite specified material properties, such as average grain size, coercivity, specific permeability, and specific magnetic saturation, but they also add the feature of "a thermal stability, as determined by a distance cut, prior to failure in a vertical lathe test, of about 1300 m to about 3950 m." Appx107, Claims 15, 21. The Commission once again failed to properly analyze claims 15 and 21 under *Alice* steps one and two.

The Commission commits various errors, including (1) failing to clearly identify the abstract idea to which claims 15 and 21 are supposedly directed, (2) misunderstanding the magnetic properties used to measure the diamond microstructure as mere "side effects," (3) misinterpreting case law considering claims reciting only the intended result or effect of an invention, and (4) failing to consider the scope of the claims and the context of the invention and the problem it solves as defined in the specification and by the claim language. The Commission also failed to consider claims 15 and 21 individually, which alone was error. *See supra* § VII.B.1.e.

The additional "thermal stability" feature of claims 15 and 21 is not an abstract idea. It relates to a standard industry test for measuring PDC properties. Dr. German testified that he measured thermal stability using a VTL test without any coolant and observed how long it can cut before the PCD graphitizes and leaves a black mark in the granite workpiece. Appx1736, 160:3-16 ("[T]he cutter is heating up, and it's going to . . . the destruction. And it's leaving that black line behind, which is the graphite, which is the characteristic measurement that we make to determine the thermal stability. So the longer it goes, the more thermally stable it is."). Thus, thermal stability represents a different way of characterizing and measuring the microstructure of the claimed PDCs.

Claims 15 and 21 are not "directed to" an abstract idea because, unlike the claims in *Light-Emitting Diode*, which were found "not limited to any particular structure, but instead *read on any and all means* of achieving the claimed efficiencies," *Light-Emitting Diode*, 2021 WL 3829977, at *20 (emphasis added), claim 15 and 21 do not read on "any and all means of achieving the claimed" thermal stability. Instead, they are limited to those PDCs that meet the thermal stability requirement *in addition to* having "particular structure" related to the other measured properties. *See* Appx107, Claim 15 (reciting "wherein the unleached portion of the polycrystalline diamond table exhibits: a coercivity of about 115 Oe to about 250 Oe; [and] a specific magnetic saturation of about 10 $G \cdot cm^3/g$ to about 15 $G \cdot cm^3/g$"), Claim 21 (reciting "[t]he polycrystalline diamond compact of claim 15" and further "a specific permeability less than about 0.10 $G \cdot cm^3/g \cdot Oe$"). Thus, the thermal stability requirement is another feature that only further limits the claims rather than expanding their scope. The scope of infringing products in this case bore that out. Specifically, USS only accused a limited subset of products of infringing claims 15 and 21 of the '502 patent. *See, e.g.*, Appx16; Appx891-898 (list of tested products). Therefore, there is no preemption for claim 15 for this reason in addition to all the reasons noted above for claims 1, 2, and 11. *See supra* § VII.B.

As with claims 1, 2, and 11, the Commission's *Alice* step-two analysis is infected by the errors of its step-one analysis and fails to consider the transformative nature of the invention claimed as an ordered combination. For these reasons, the Commission's step-two analysis also fails.

VIII. CONCLUSION

For the foregoing reasons, the Court should reverse the ITC's Final Determination of no violation of Section 337 by Respondents. The Court should also reverse the ITC's Initial Determination finding claims 1, 2, 11, 15, and 21 of the '502 patent to be ineligible under 35 U.S.C. § 101.

Date: May 19, 2023

Respectfully submitted,

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ADDENDUM

UNITED STATES INTERNATIONAL TRADE COMMISSION
Washington, D.C.

In the Matter of

CERTAIN POLYCRYSTALLINE DIAMOND COMPACTS AND ARTICLES CONTAINING SAME

Investigation No. 337-TA-1236

COMMISSION OPINION

Table of Contents

I. INTRODUCTION

On May 9, 2022, the Commission determined to review in part the final initial determination ("ID") of the presiding administrative law judge ("ALJ"), which issued on March 3, 2022. Specifically, the Commission determined to review certain of the ID's findings relating to validity of the asserted claims of U.S. Patent Nos. 10,507,565 ("the '565 patent"), 10,508,502 ("the '502 patent"), and 8,616,306 ("the '306 patent") (collectively, "the Asserted Patents"), and the ID's findings regarding the economic prong of the domestic industry requirement. The Commission determined not to review the ID's finding that the sole asserted claim of the '306 patent is invalid under 35 U.S.C. § 102(b).

On review, the Commission has determined to affirm in part, modify in part, reverse in part, and take no position on certain issues in the ID that are under review. Consistent with those determinations, the Commission affirms the ALJ's determination that there has not been a violation of section 337 of the Tariff Act of 1930, 19 U.S.C. § 1337.[1] This opinion sets forth the Commission's reasoning in support of its determination.

II. BACKGROUND

A. Procedural History

The Commission instituted this investigation on December 29, 2020, based on a complaint filed by US Synthetic Corporation ("USS" or "Complainant") of Orem, Utah. 85 Fed. Reg. 85661-662 (Dec. 29, 2020). The complaint alleged violations of section 337 based upon the importation into the United States, the sale for importation, and the sale within the United States after importation of certain polycrystalline diamond compacts and articles containing

[1] Commissioner Schmidtlein supports finding a violation with respect to the asserted claims of the '502 patent. She offers below her dissenting views.

same by reason of infringement of certain claims of the ’565, ’502, and ’306 patents and U.S. Patent Nos. 9,932,274 (“the ’274 patent”) and 9,315,881 (“the ’881 patent”).[2] *Id*. The complaint further alleged that an industry in the United States exists as required by section 337. *Id.* The notice of investigation named as respondents: SF Diamond Co., Ltd. and SF Diamond USA, Inc. (collectively, “SF Diamond”); Element Six Abrasives Holdings Ltd., Element Six Global Innovation Centre, Element Six GmbH, Element Six Limited, Element Six Production (Pty) Limited, Element Six Hard Materials (Wuxi) Co. Limited, Element Six Trading (Shanghai) Co., Element Six Technologies US Corporation, Element Six US Corporation, ServSix US, and Synergy Materials Technology Limited (collectively, “Element Six”); Iljin Diamond Co., Ltd., Iljin Holdings Co., Ltd., Iljin USA Inc., Iljin Europe GmbH, Iljin Japan Co., and Ltd., Iljin China Co., Ltd. (collectively, “Iljin”); Henan Jingrui New Material Technology Co., Ltd. (“Jingrui”); Zhenzghou New Asia Superhard Materials Composite Co., Ltd. and International Diamond Services, Inc. (“IDS”) (collectively, “New Asia”); CR Gems Superabrasives Co., Ltd. (“CR Gems”); FIDC Beijing Fortune International Diamond (“FIDC”); Fujian Wanlong Superhard Material Technology Co., Ltd. (“Wanlong”); Zhujau Juxin Technology (“Juxin”);[3] and Shenzhen Haimingrun Superhard Materials Co., Ltd. (“Haimingrun”). *Id*. at 85662. The Office of Unfair Import Investigations did not participate in the investigation. *Id.*

USS moved to terminate the investigation as to various respondents over the course of the investigation. All of the motions were granted by non-final IDs, and the Commission did not review them. ID at 2 (citing Order Nos. 6, 8, 10, and 16). Thus, the only remaining respondents

[2] The ’274 and ’881 patents were terminated from the investigation.

[3] On February 8, 2021, Guangdong Juxin Materials Technology Co., Inc. was substituted in place of Zhuhai Juxin Technology. ID at 1 n.1 (citing Order No. 8).

are Iljin, SF Diamond, New Asia, Haimingrun, Juxin, IDS, CR Gems, Jingrui, and Wanlong (collectively, "Respondents").

USS also moved for partial termination of the investigation with respect to certain patents and claims. All of the motions were granted by non-final IDs, and the Commission did not review them. ID at 3 (citing Order Nos. 26, 32, and 57). The following asserted patents and claims were at issue in the final ID, with the independent claims in bold:

Patent	Claims
'565 patent	**1**, 2, 4, 6, **18**
'502 patent	**1**, 2, 11, **15**, 21
'306 patent	**15**

Id. (citing Order No. 59 (August 9, 2021), *unreviewed by* Comm'n Notice (Aug. 20, 2021)).

On May 24, 2021, Order No. 23 issued, which construed certain claim terms of the Asserted Patents. An evidentiary hearing was held on October 18-22, 2021.

The ALJ issued his final ID on March 3, 2022, finding no violation of section 337 by Respondents. Specifically, the ID found at least one accused product infringes all asserted claims of the Asserted Patents, but those claims are patent ineligible under 35 U.S.C. § 101 and/or invalid under 35 U.S.C. § 102. The ID also found that Complainant has shown that the domestic industry requirement has been satisfied with respect to the Asserted Patents.

On March 15, 2022, USS filed a petition for review seeking review of certain patent ineligibility and invalidity findings.[4] That same day, Respondents filed two contingent petitions for review.[5] The first petition, submitted by all active Respondents, sought review of certain

[4] *See* Complainant US Synthetic's Petition for Review of Initial Determination (Mar. 15, 2022) ("Compl. Pet.").

[5] *See* Respondents' Contingent Petition for Review of the Initial Determination (Mar. 15, 2022) ("1st Resp. Pet."); Petition for Commission Contingent Review by Zhengzhou New Asia

findings related to infringement, the technical prong of the domestic industry requirement, and invalidity. The second petition, submitted by Respondents New Asia, Haimingrun, and Juxin, sought review of Order No. 46, which allowed Complainant to present evidence regarding its revenue-based investment allocation method for the economic prong of the domestic industry requirement. On March 23, 2022, the parties filed separate replies to the petitions for review.[6] On March 31, 2022, the Iljin Respondents submitted a public interest statement.

The Commission determined to review in part the final ID. 87 Fed. Reg. 29375-377 (May 13, 2022). Specifically, the Commission determined to review: (1) the ID's finding that the asserted claims are patent ineligible under 35 U.S.C. § 101; (2) the ID's finding that the asserted claims of the '565 patent are not entitled to an earlier priority date and, thus, they are invalid as anticipated by the sale of the [redacted] product; (3) the ID's finding that the Mercury product anticipates claims 1 and 2 of the '565 patent and claims 1 and 11 of the '502 patent; (4) the ID's finding that Respondents did not prove that the asserted claims are not enabled; and (5) the ID's findings regarding the economic prong of the domestic industry requirement (including the ruling allowing USS to supplement its domestic industry contentions with a revenue-based allocation method). The Commission determined not to review any other findings presented in the final ID, including the ID's finding that the sole asserted claim of the '306 patent is invalid under 35 U.S.C. § 102(b).

Superhard Materials Co., Ltd., Shenzhen Haimingrun Superhard Materials Co., Ltd., and Guangdong Juxin New Materials Technology Co., Ltd. (Mar. 15, 2022) ("2nd Resp. Pet.").

[6] *See* Complainant US Synthetic's Response to Respondents' Contingent Petitions for Review of Initial Determination (Mar. 23, 2022) ("Compl. Reply"); Respondents' Response to Complainant US Synthetic's Petition for Review of Initial Determination (Mar. 23, 2022) ("Resp. Reply").

The Commission also asked the parties to brief certain issues under review and to brief issues of remedy, the public interest, and bonding. The parties filed timely initial submissions[7] and reply submissions.[8]

B. The Asserted Patents

The technology at issue in this investigation relates to polycrystalline diamond compacts ("PDCs"), which are compacts made of a polycrystalline diamond ("PCD") and a substrate. PDCs can be shaped as cylindrical parts as shown, for example, in Fig. 11A of the '565 patent (reproduced below) and Fig. 3B of the '502 patent. *See, e.g.*, '565 patent (JX-0002),[9] at 15:63-16:21.

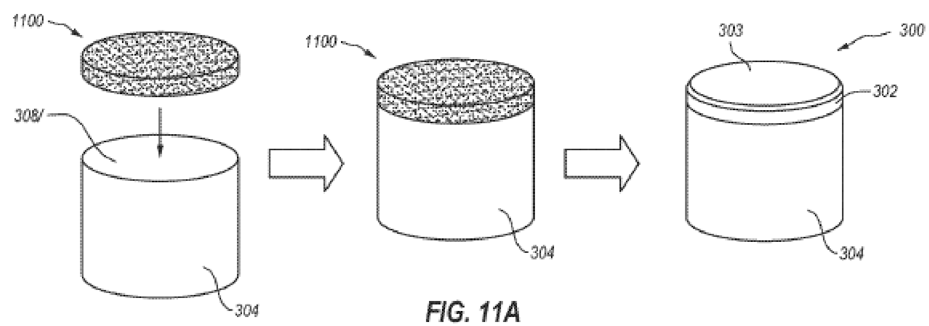


FIG. 11A

[7] Complainant US Synthetic's Written Submission in Response to the Commission's Determination to Review-In-Part a Final Initial Determination of a Violation of Section 337, EDIS Doc ID 771391 (May 23, 2022) ("Compl. Sub."); Respondents' Opening Submission on the Issues Under Review and on Remedy, Bond, and Public Interest, EDIS Doc ID 771380 (May 23, 2022) ("Resp. Sub.").

[8] Complainant US Synthetic's Response to Respondents' Opening Submission on the Issues Under Review and on Remedy, Bond, and Public Interest, EDIS Doc ID 771964 (May 31, 2022) ("Compl. Reply Sub."); Respondents' Responsive Submission on the Issues Under Review and on Remedy, Bond, and Public Interest, EDIS Doc ID 771966 (May 31, 2022) ("Resp. Reply Sub.").

[9] Citations are to the '565 patent only. The '502 and '306 patents share the same specification and provide similar disclosures as the '565 patent for purposes of this investigation unless otherwise specified.

In one disclosed embodiment, the PDC **300** includes "a superabrasive diamond layer commonly referred to as a diamond table" or "PCD table **302**," a working surface **303** of the PCD table **302**, and a substrate **304**. *Id.* at 1:28-30, 9:44-47; *see id.* at 15:62-16:10. The substrate **304** is often made from a cemented hard metal composite, like cobalt-cemented tungsten carbide. *See id.* at 6:43-45, 9:44-45, 14:44-50. At least a portion of the PCD table **302** includes a plurality of diamond grains defining a plurality of interstitial regions. *Id.* at 4:64-67. The plurality of interstitial regions "may be occupied by a metal-solvent catalyst, such as iron, nickel, cobalt, or alloys of any of the foregoing metals." *Id.* at 4:67-5:4. The plurality of diamond grains "may exhibit an average grain size of about 50 μm or less, such as about 30 μm or less or about 20 μm or less." *Id.* at 5:8-10.

Conventional PDCs were fabricated by placing the substrate into a cartridge with a volume of diamond particles next to the substrate. *Id.* at 1:42-46; *see* Order No. 23 (*Markman* Order) at 22 (May 24, 2021). This cartridge may be loaded into a press that creates high-pressure and high-temperature ("HPHT") conditions. '565 patent (JX-0002) at 1:45-46. The substrate and diamond particles are processed under the HPHT conditions in the presence of a catalyst material (*e.g.*, from the substrate) that causes the diamond particles to bond to one another, creating a PCD table that is bonded to the substrate. *Id.* at 1:46-54, 9:28-32. The '565 patent specification explains the drawbacks to the conventional approach:

> The presence of the solvent catalyst in the PCD table is believed to reduce the thermal stability of the PCD table at elevated temperatures. For example, the difference in thermal expansion coefficient between the diamond grains and the solvent catalyst is believed to lead to chipping or cracking of the PCD table during drilling or cutting operations, which can degrade the mechanical properties of the PCD table or cause failure. Additionally, some of the diamond grains can undergo a chemical breakdown or back-conversion to graphite via interaction with the solvent catalyst. At elevated high temperatures, portions of the diamond grains may

> transform to carbon monoxide, carbon dioxide, graphite, or combinations thereof, thus degrading the mechanical properties of the PDC.
>
> One conventional approach for improving the thermal stability of a PDC is to at least partially remove the solvent catalyst from the PCD table of the PDC by acid leaching. However, removing the solvent catalyst from the PCD table can be relatively time consuming for high-volume manufacturing. Additionally, depleting the solvent catalyst may decrease the mechanical strength of the PCD table.

Id. at 1:66-2:19.

To overcome the difficulties with the conventional approaches, the specifications disclose that:

> It is currently believed by the inventors that forming the PCD by sintering diamond particles at a pressure of at least about 7.5 GPa may promote nucleation and growth of diamond between the diamond particles being sintered so that the volume of the interstitial regions of the PCD so-formed is decreased compared to the volume of interstitial regions if the same diamond particle distribution was sintered at a pressure of, for example, up to about 5.5 GPa and at temperatures where diamond is stable.

Id. at 7:53-61. In other words, the specifications state the inventors' belief that the disclosed embodiments of PCDs sintered at a pressure of "at least about 7.5 GPa" differ from conventional HPHT products because they "may promote" "enhanced diamond-to-diamond bonding" or a "high-degree of diamond-to-diamond bonding." *Id.* at 2:27-28, 2:51-54, 4:34-35, 4:58-65, 7:53-61.

USS's expert opined that "enhanced" bonding in this context means "the level of bonding is evident typically in a cross-section micrograph, and so we're talking about more bonding, stronger bonding, larger bonds. That kind of thing would be enhanced diamond-to-diamond bonding over what had previously existed." Tr. (German) at 117:14-22; *see also* Compl. Sub. at

14-15 (citing Tr. (German) at 116:8-119:25). Dr. Bertagnolli, a named inventor of the patents, also confirmed and explained how the inventors viewed this concept:

> [W]e had this hypothesis that, well, if we could make the diamond table more dense, so in a sense we want less metal, less of that cobalt metal and more diamond, if we can do that, then we could keep the cutter sharper longer and our customers would be more happy with our products.
>
> So early on in our sort of journey here, we were experimenting with ways to increase density. And one thing that we saw was that, as we increased sintering pressure, the pressure applied by the press, we saw that we would get, in the PDC, we would have a lower metal content.
>
> And so we thought that meant that instead of so much metal being there, that meant we had *more diamond, more diamond-to-diamond bonding, greater diamond density. And, indeed, that turned out to have better wear characteristics*.

Tr. (Bertagnolli) at 67:10-68:25 (emphases added).

Disclosed embodiments of PCD tables are fabricated by subjecting a cell assembly comprising a plurality of diamond particles of about 30 µm or less and a metal-solvent catalyst to a temperature of at least about 1000° Celsius and a pressure in the pressure transmitting medium of at least about 7.5 GPa. ’565 patent (JX-0002) at 2:47-54 & Table I.

The specifications disclose that PCD tables fabricated using the disclosed embodiments may exhibit improved mechanical and/or thermal properties. Generally, as the sintering pressure that is used to form the PCD increased above 7.5 GPa, the coercivity and wear resistance or G_{ratio} of the PCD may increase while the magnetic saturation and electrical conductivity may decrease relative to PCD formed at lower pressures. *Id.* at 5:61-63, 6:63-65. The disclosed PCD tables may exhibit “a coercivity of 115 Oe or more,” “a specific magnetic saturation of about 15 $G \cdot cm^3/g$ or less, a metal-solvent catalyst content of about 7.5 weight % [] or less, an electrical conductivity of less than about 1200 S/m,"[10] a G_{ratio} of "at least about 4.0×10^6," or combinations thereof. *Id.* at 4:34-49, 4:58-64, 6:66. The specifications teach "[b]y maintaining the metal-solvent catalyst content below about 7.5 wt %, the PCD may exhibit a desirable level of thermal stability suitable for subterranean drilling applications." *Id.* at 5:28-31. The specifications posit that "[m]any physical characteristics of the PCD may be determined by measuring certain magnetic and electrical properties of the PCD because the metal-solvent catalyst may be ferromagnetic." *Id.* at 5:32-35. Regarding coercivity, the specifications state that:

> The mean free path between neighboring diamond grains of the PCD may be correlated with the measured coercivity of the PCD. A relatively large coercivity indicates a relatively smaller mean free path. The mean free path is representative of the average distance between neighboring diamond grains of the PCD, and thus may be indicative of the extent of diamond-to-diamond bonding in the PCD. A relatively smaller mean free path, in well-sintered PCD, may indicate relatively more diamond-to-diamond bonding.

Id. at 5:40-48. The specifications also posit that the amount of the metal-solvent catalyst present in the PCD may be correlated with the measured specific magnetic saturation and electrical conductivity (σ) of the PCD. *Id.* at 5:35-39; 15:24-31. A relatively larger specific magnetic saturation indicates relatively more metal-solvent catalyst in the PCD and a relatively small amount of metal-solvent catalyst within the PCD generally indicates a relatively small value of electrical conductivity. *Id.* Moreover, the specifications disclose that the "specific permeability (*i.e.*, the ratio of specific magnetic saturation to coercivity) of the PCD may be about 0.10 or less." *Id.* at 6:27-29. The specifications further disclose that the "G_{ratio} is the ratio of the volume of workpiece cut to the volume of PCD worn away during a cutting process,

[10] The "electrical conductivity of less than about 1200 S/m" language and other disclosures related to electrical conductivity were added to the continuation-in-part application that issued as the '565 patent and do not appear in the '502 and '306 patents. *See infra* at Part IV(B).

such as in a vertical turret lathe ("VTL") test in which the workpiece is cooled during the cutting process," also known as wet VTL. *Id.* at 7:2-5; *see* Tr. (Bertagnolli) at 75:21-76:5. Thermal stability is "evaluated by measuring the distance cut in a workpiece prior to catastrophic failure, without using coolant, in a vertical lathe test (e.g., vertical turret lathe or a vertical boring mill)," also known as dry VTL. '565 patent (JX-0002) at 7:24-28.

PDCs can be used in "drilling tools (e.g., cutting elements, gage trimmers, etc.), machining equipment, bearing apparatuses, wire-drawing machinery, and in other mechanical apparatuses." *Id.* at 1:21-25. PDCs have found particular utility in cutters in rotary drill bits **800**, as shown in Fig. 13 of the '565 patent below. *Id.* at 22:66-23:1, 23:11-12. A plurality of PDCs **812** are affixed to the bit body **802,** as shown in Fig. 14 below. *Id.* at 23:21-24.

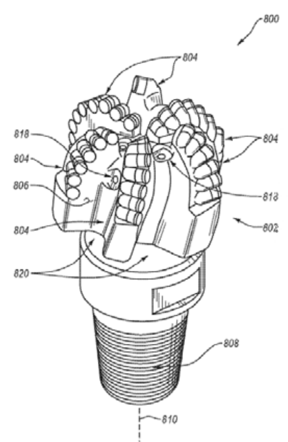


FIG. 13

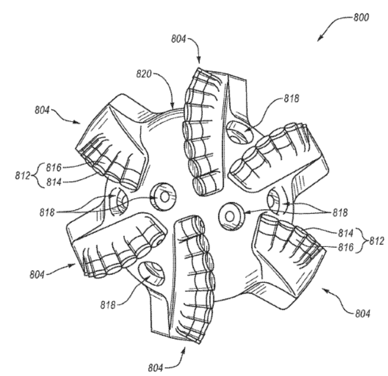


FIG. 14

A PDC with higher diamond-to-diamond bonding allows "wear parts," such as drill bits, to last longer and perform better in high-abrasion applications, such as earth-boring. ID at 8 (quoting '502 patent (JX-0003) at 4:41-49). Thus, drill operators do not have to remove or replace the drill bits as frequently. *Id.* (citing '502 patent at 1:26-41).

Complainant alleges that Respondents infringe claims 1, 2, 4, 6, and 18 of the ’565 patent, claims 1, 2, 11, 15, and 21 of the ’502 patent, and claim 15 of the ’306 patent. Independent claims 1 and 18 of the ’565 patent read as follows:

> **1**. A polycrystalline diamond compact, comprising:
>
> a polycrystalline diamond table, at least an unleached portion of the polycrystalline diamond table including:
>
> a plurality of diamond grains directly bonded together via diamond-to-diamond bonding to define interstitial regions, the plurality of diamond grains exhibiting an average grain size of about 50 μm or less;
>
> a catalyst occupying at least a portion of the interstitial regions;
>
> wherein the unleached portion of the polycrystalline diamond table ***exhibits a coercivity of about 115 Oe or more***;
>
> wherein the unleached portion of the polycrystalline diamond table ***exhibits an average electrical conductivity of less than about 1200 S/m***; and
>
> wherein the unleached portion of the polycrystalline diamond table ***exhibits a*** G_{ratio} ***of at least about*** 4.0×10^6; and
>
> a substrate bonded to the polycrystalline diamond table.
>
> **18**. A polycrystalline diamond compact, comprising:
>
> a polycrystalline diamond table, at least an unleached portion of the polycrystalline diamond table including:
>
> a plurality of diamond grains directly bonded together via diamond-to-diamond bonding to define interstitial regions, the plurality of diamond grains exhibiting an average grain size of about 30 μm or less;
>
> a catalyst occupying at least a portion of the interstitial regions;

> wherein the unleached portion of the polycrystalline diamond table ***exhibits a coercivity of about 115 Oe to about 175 Oe***;
>
> wherein the unleached portion of the polycrystalline diamond table ***exhibits an average electrical conductivity of less than about 1200 S/m***; and
>
> wherein the unleached portion of the polycrystalline diamond table ***exhibits a thermal stability***, as determined by distance cut, prior to failure in a vertical lathe test, ***of at least about 1300 m***.

’565 patent at 25:47-65 (emphasis added), 26:63-27:14 (emphasis added). Independent claims 1 and 15 of the ’502 patent read as follows:

> **1**. A polycrystalline diamond compact, comprising:
>
> > a polycrystalline diamond table, at least an unleached portion of the polycrystalline diamond table including:
> >
> > a plurality of diamond grains bonded together via diamond-to-diamond bonding to define interstitial regions, the plurality of diamond grains exhibiting an average grain size of about 50 μm or less; and
> >
> > a catalyst including cobalt, the catalyst occupying at least a portion of the interstitial regions;
> >
> > wherein the unleached portion of the polycrystalline diamond table ***exhibits a coercivity of about 115 Oe to about 250 Oe***;
> >
> > wherein the unleached portion of the polycrystalline diamond table ***exhibits a specific permeability less than about 0.10*** $G \cdot cm^3/g \cdot Oe$; and
> >
> > a substrate bonded to the polycrystalline diamond table along an interfacial surface, the interfacial surface exhibiting a substantially planar topography;
> >
> > wherein a lateral dimension of the polycrystalline diamond table is about 0.8 cm to about 1.9 cm.

15. A polycrystalline diamond compact, comprising:

a polycrystalline diamond table, at least an unleached portion of the polycrystalline diamond table including:

a plurality of diamond grains bonded together via diamond-to-diamond bonding to define defining interstitial regions, the plurality of diamond grains exhibiting an average grain size of about 50 μm or less; and

a catalyst including cobalt, the catalyst occupying at least a portion of the interstitial regions;

wherein the unleached portion of the polycrystalline diamond table exhibits:

a coercivity of about 115 Oe to about 250 Oe;

a specific magnetic saturation of about 10 G·cm^3/g to about 15 G·cm^3/g; and

a thermal stability, as determined by a distance cut, prior to failure in a vertical lathe test, ***of about 1300 m to about 3950 m***;

wherein a lateral dimension of the polycrystalline diamond table is about 0.8 cm or more.

’502 patent at 22:61-23:13 (emphasis added), 23:65-24:17 (emphasis added). The sole asserted claim 15 of the ’306 patent reads as follows:

15. A polycrystalline diamond compact, comprising:

a substrate; and

a polycrystalline diamond table including a first polycrystalline diamond layer bonded to the substrate and at least a second polycrystalline diamond layer, the second polycrystalline diamond layer exhibiting a second average diamond grain size that is less than a first average diamond grain size of the first polycrystalline diamond layer, at least an un-leached portion of the polycrystalline diamond table including:

> a plurality of diamond grains defining a plurality of interstitial regions;
>
> a metal-solvent catalyst occupying at least a portion of the plurality of interstitial regions; and
>
> wherein the plurality of diamond grains and the metal-solvent catalyst collectively ***exhibit a coercivity of about 115 Oe or more and a specific magnetic saturation of about 15 G·cm3/g or less***.

’306 patent (JX-0001) at 24:22-40 (emphasis added).

The asserted claims are directed to PDCs exhibiting certain structural features (*e.g.*, grain size and a catalyst), performance measures (*e.g.*, G_{ratio} and thermal stability), and various electrical and magnetic properties (*e.g.*, coercivity, specific magnetic saturation, specific permeability, and average electrical conductivity). The following chart summarizes the features of the PCDs in each of the asserted claims.

Material Characteristic Features

’565 Patent

Claim #	Depends from	Grain Size	Coercivity	Specific Magnetic Saturation	Average Electrical Conductivity	G-Ratio	Thermal Stability
1	Ind.	< 50	>115	---	< 1200	> 4 x10^6	---
2	1	< 50	115 – 250	---	< 1200	> 4 x10^6	---
4	1	< 50	>115	< 15	< 1200	> 4 x10^6	---
6	1	< 50	>115	---	25 – 1000	> 4 x10^6	---
18	Ind.	< 30	115 – 175	---	< 1200	---	>1300

’502 Patent

Claim #	Depends from	Grain Size	Coercivity	Specific Magnetic Saturation	Specific Permeability	Thermal Stability
1	Ind.	<50	115 – 250	---	<0.10	---
2	1	<50	115 – 250	<15	<0.10	---
11	1	<50	115 – 250	---	<0.10	---
15	Ind.	<50	115 – 250	10 – 15	---	1300 – 3950
21	15	<50	115 – 250	10 – 15	<0.10	1300 – 3950

’306 Patent

Claim #	Depends from	Grain Size in Layers	Coercivity	Specific Magnetic Saturation
15	Ind.	$d_{(2nd\ layer)} < d_{(1st\ layer)}$	>115	< 15

C. Products at Issue

Pursuant to Commission Rule 210.10(b)(1), 19 C.F.R. § 210.10(b)(1), the plain language description of the accused products or category of accused products, which defines the scope of the investigation, is "polycrystalline diamond compacts (PDC), PDC cutters, drill bits including PDC cutters, and PDC bearings and bearing elements." 85 Fed. Reg. 85662.

1. The Accused Products

The following product lines are accused of infringement:

Party	Infringing Product Series	Asserted Claims Practiced		
		'565	'502	'306
Iljin	UP8N	1, 2, 4	1, 2, 11	
	UP9N	1, 2, 4, 6, 18	1, 2, 11	
New Asia / IDS	Dragon 2	1, 2, 4, 6	1, 2, 11	15
SF Diamond	[redacted]		1, 2, 11	15
			1, 2, 11	15
		1, 2, 4	1, 2, 11	15
			1, 2, 11	15
[redacted]	[redacted]/[redacted]	1, 2, 4, 18	1, 2, 11, 15, 21	15
Haimingrun	C20	1, 2, 4	1, 2, 11	
	S18	1, 2, 4, 6	1, 2, 11	15
	C19		1, 2, 11	
Juxin	RC		1, 2, 11	
	C2		1, 2, 11	
	Z1		1, 2, 11	15
	Z2		1, 2, 11	15
Jingrui	R11A	1, 2, 4, 6, 18	1, 2, 11, 15, 21	
	R22	1, 2, 4, 6, 18	1, 2, 11, 15, 21	
Wanlong	ZT2-B	1, 2, 4, 6, 18	15	
	ZTA-B	1, 2, 4, 18	15	
	RFA-B	1, 2, 4, 6, 18	15	
	RF2-B	1, 2, 4, 6, 18	15	
CR Gems*	GPCD-CRM	1, 2. 4, 6	1, 11	
	GPCD-My69	1, 2, 4, 6	1, 11	

ID at 10. SF Diamond has a redesigned line of products called the A-series, which the ID found is properly within the scope of the investigation and does not infringe any asserted patent claims. *Id.* at 11, 39-43, 55, 68, 77.

2. The Domestic Industry Products

The following USS products are alleged to practice the Asserted Patents:

Patents	Part Numbers
'502 Patent, '565 Patent	40127-01 (16 mm [redacted]), 40095-01 (16 mm [redacted] various), 40133-01 (16 mm [redacted], 40233-01 (16 mm [redacted]) ("DI I Products")
'306 Patent	40233-01 (16 mm [redacted]) ("DI II Product")

CDX-0004C.9. The "DI I Products" allegedly practice claims of the '565 and '502 patents and the "DI II Product" allegedly practice claims of the '306 patent. ID at 90-92.

III. COMMISSION REVIEW OF THE FINAL ID

With respect to the issues under review, "the Commission may affirm, reverse, modify, set aside or remand for further proceedings, in whole or in part, the initial determination of the administrative law judge." 19 C.F.R. § 210.45(c). The Commission also "may take no position on specific issues or portions of the initial determination," and "may make any finding or conclusions that in its judgment are proper based on the record in the proceeding." *Id.*

IV. ANALYSIS

The Commission did not review, and thus adopted, the ID's finding that the sole asserted claim of the '306 patent is invalid under 35 U.S.C. § 102(b) and, therefore, USS has not established a violation of section 337 with respect to the '306 patent. On review, the Commission has determined that USS has also not established a violation of section 337 with respect to claims 1, 2, 11, 15, and 21 of the '502 patent and claims 1, 2, 4, 6, and 18 of the '565 patent. Specifically, the Commission affirms with modifications the ID's finding that the asserted claims are directed to an abstract idea and, thus, are patent ineligible under 35 U.S.C. § 101. The Commission also affirms with modifications the ID's finding that the asserted claims of the '565 patent are invalid under 35 U.S.C. § 102(b) by the sale of the [redacted] product. Because the Commission finds certain testimony from third-party Diamond Innovations, Inc.'s ("Diamond Innovations") witness should be stricken in view of the ALJ's rulings in Order No. 48 and at trial, the Commission reverses the ID's finding that the Mercury PDC anticipates claims 1 and 2 of the '565 patent and claims 1 and 11 of the '502 patent. The Commission further affirms with modification the ID's finding that Respondents have not proven that the asserted claims of the '502, '565, and '306 patents are not enabled. Finally, in view of the

Commission's finding that all asserted claims are directed to patent ineligible subject matter and/or invalid, the Commission takes no position on the ID's economic prong findings, including the ALJ's determination to allow USS to supplement its contentions with a new domestic industry allocation method. The Commission affirms and adopts the ID's findings, conclusions, and supporting analysis that are not inconsistent with the Commission's opinion.[11]

A. The Asserted Patent Claims Are Directed to an Abstract Idea and Are Patent Ineligible Under 35 U.S.C. § 101

"The statement of patent-eligible subject matter has been substantially unchanged since the first Patent Act in 1790." *Classen Immunotherapies, Inc. v. Biogen IDEC*, 659 F.3d 1057, 1063 (Fed. Cir. 2011). As now codified, it reads:

> § 101. Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title.

Id.; 35 U.S.C. § 101. The Supreme Court has "long held that this provision contains an important implicit exception: Laws of nature, natural phenomena, and abstract ideas are not patentable." *Alice Corp. v. CLS Bank Int'l*, 573 U.S. 208, 216 (2014).

The determination of whether a claim is directed to ineligible subject matter is based on a two-step test set forth by the Supreme Court in *Alice*. The first step evaluates "whether the claims at issue are directed to one of [the] patent-ineligible concepts"—"laws of nature, natural phenomena, and abstract ideas." *Id.* at 217. The Court explained that the "abstract ideas"

[11] Commissioner Schmidtlein joins the Commission's decision affirming the ID's section 102 findings as modified in the Majority opinion but dissents from the Majority's decision to affirm the ID's section 101 findings as explained below in her dissenting views. She would also affirm with modifications the ID's conclusion that USS established the economic prong of the domestic industry requirement for the '565 patent and the '502 patent under subsections (A), (B), and (C) of 337(a)(3). Accordingly, she would find a violation based on infringement of claims 1, 2, 11, 15, and 21 of the '502 patent.

category embodies "the longstanding rule that '[a]n idea of itself is not patentable.'" *Id.* at 218; *see Le Roy v. Tatham*, 55 U.S. 156, 175 (1852) ("A principle, in the abstract, is a fundamental truth; an original cause; a motive; these cannot be patented, as no one can claim in either of them an exclusive right."). Speaking specifically to the issue of whether a claim is directed to an abstract idea, the Court said to consider whether the claim seeks to cover a "fundamental [] practice" or basic "building block." *Alice*, 573 U.S. at 220, 217.

The Federal Circuit has described the first-stage inquiry as looking at the "focus" of the claims, "whether the claim, as a whole" is "directed-to" patent-ineligible matter such as an abstract idea. *Elec. Power Grp., LLC v. Alstom S.A.*, 830 F.3d 1350, 1353 (Fed. Cir. 2016); *see Ancora Techs., Inc. v. HTC Am., Inc.*, 908 F.3d 1343, 1347 (Fed. Cir. 2018). This inquiry involves determining whether the claims "focus on a specific means or method that improves the relevant technology" or are "directed to a result or effect that itself is the abstract idea and merely invoke generic processes and machinery." *Apple, Inc. v. Ameranth, Inc.*, 842 F.3d 1229, 1241 (Fed. Cir. 2016).

If a claim is directed to a patent-ineligible concept, the second step evaluates whether the claim's elements both individually and as an ordered combination of elements transform the nature of the claim into a patent-eligible application. *Alice*, 573 U.S. at 217. The Federal Circuit has described the second-stage inquiry as looking more precisely at what the claim elements add, whether they identify an "inventive concept" in the application of the ineligible matter to which the claim is directed. *Elec. Power Grp.*, 830 F.3d at 1353.

Before applying the two-step *Alice* test, the Commission first addresses USS's argument that "Respondents waived their abstract idea argument because they raised it for the first time in their Post-Hearing Brief." Compl. Sub. at 6. USS asserts that Respondents previously only argued that the claims are "directed to laws of nature, but never abstract ideas which is a different framework." *Id*. However, USS failed to argue waiver of this issue in its petition for review, and thus has waived its own waiver argument. *See* Compl. Pet. at 14-39; 19 C.F.R. § 210.43(b). Regardless, Respondents did not waive their argument. While Respondents repeatedly referred to the claimed properties as "natural phenomena" in their prehearing brief, *see* Resp. Pre-Hearing Br. at 61, 65, they characterized the claims as "directed to abstract subject matter," *id.* at 71, and cited case law that found claims unpatentable under the abstract idea judicial exception, *see, e.g.*, *id.* at 67, 68, 72. Moreover, other than its conclusory assertion, USS does not articulate or show support for any "different framework" for analyzing patent claims purportedly directed to abstract ideas as opposed to laws of nature. Compl. Sub. at 6. There is no indication in the case law that different principles or modes of analysis apply to these judicially recognized exceptions. *See Am. Axle & Mfg., Inc. v. Neapco Holdings LLC*, 967 F.3d 1285, 1297 (Fed. Cir. 2020) (stating the "same principle" applies in cases involving the abstract idea and natural law), *cert. denied*, 142 S. Ct. 2902 (2022); *Smart Sys. Innovations, LLC v. Chicago Transit Authority*, 873 F.3d 1364, 1377 (Fed. Cir. 2017) (J. Linn dissenting in part and concurring in part) ("[T]here is no principled difference between the judicially recognized exception relating to 'abstract ideas' and those relating to laws of nature and natural phenomena. All three nonstatutory exceptions are intended to foreclose only those claims that preempt and thereby preclude or inhibit human ingenuity with regard to basic building blocks of scientific or technological activity.").

1. *Alice* Step One

Regarding *Alice* step one, the ID observed that the asserted claims "recite compositions of matter that are not found in nature," but they also recite "certain structural and design features (for example, a particular grain size and a catalyst), performance measures (G-Ratio . . . and thermal stability . . .), and side effects (the various electrical and magnetic parameters)." ID at 102, 104; *see also id.* at 100, 134. The ID found the structural and design features are not problematic under *Alice* but the performance measures and side effects are problematic. *Id.* at 104-105. Specifically, relying on the patent specifications and one of Dr. Bertagnolli's published papers, the ID found that the properties of "wear resistance" and "thermal resilience," as measured by G_{ratio} and thermal stability, respectively, "are not merely results or effects, but are actually performance measures." *Id.* at 102 (citing JX-0002 ('565 patent) at 2:22-28; CX-0394.3 ("wear resistance," "thermal resilience," and fracture toughness are three "properties relevant to drilling")). The ID also found that Dr. Bertagnolli's paper and the patents explain that the claimed electrical and magnetic properties are "side effect[s] or result[s] of the fabrication processes and microscopic characteristics of a PDC." *Id.*; *see also id.* at 103-104. The ID summarized the patented inventions as follows:

> In short, nothing in the asserted patents, or the rest of the record, suggests that any of these parameters solve any problems, rather than simply being measures of other, actually beneficial characteristics. Nor are the electrical and magnetic parameters sufficiently tied to any such beneficial characteristics through inherency, as explained above. There may be some causal connection between grain size, catalyst concentration, and other, unspecified design and fabrication choices, on the one hand, and electrical and magnetic behavior, on the other hand. But that causal connection is so loose and generalized that the claimed limitations appear to be little more than side effects; thus, the recitation of, say, an electrical conductivity of less than 1200 S/m appears to be gratuitous rather than inventive.

Id. at 104. Thus, the ID concluded that the asserted claims are directed to patent ineligible matter.

USS argues that the asserted claims are directed to "manmade PDCs—patent-eligible articles of manufacture and compositions of matter," which are "quintessential patent-eligible subject matter under 35 U.S.C. § 101." Compl. Sub. at 5, 3. However, under well-settled law, that a claim recites an article of manufacture, or a composition of matter, is not determinative of whether it is in fact directed to an abstract idea. *Yu v. Apple Inc.*, 1 F.4th 1040, 1044 & n.2 (Fed. Cir. 2021) (finding claims directed to an "improved digital camera" patent ineligible under § 101). The Supreme Court confirmed in *Alice* that what matters is the reality behind the machine or system claim language, whether or not it simply clothes abstract concepts.

> The fact that a computer "necessarily exist[s] in the physical, rather than purely conceptual, realm," Brief for Petitioner 39, is beside the point. There is no dispute that a computer is a tangible system (in § 101 terms, a "machine"), or that many computer-implemented claims are formally addressed to patent-eligible subject matter. But if that were the end of the § 101 inquiry, an applicant could claim any principle of the physical or social sciences by reciting a computer system configured to implement the relevant concept. Such a result would make the determination of patent eligibility "depend simply on the draftsman's art," *Flook, supra,* at 593, 98 S.Ct. 2522, thereby eviscerating the rule that "'[l]aws of nature, natural phenomena, and abstract ideas are not patentable,'" *Myriad,* 569 U.S., at ——, 133 S.Ct., at 2116.

Alice, 573 U.S. at 224. Just as the "digital camera" in *Yu* is directed at patenting an abstract idea, so too is the "polycrystalline diamond compact" here.

USS next argues that, instead of determining whether the claim, as a whole, is directed to an abstract idea, the ID improperly "created its own framework, looking at individual claim elements, bucketing the elements into different groups, and analyzing whether each group is directed to an abstract idea." Compl. Sub. at 5 (citing ID at 101-107). According to USS, the ID then "blessed one group as 'structural' (e.g., a particular grain size and a catalyst) and condemned other groups as merely 'side effects' (e.g., magnetic saturation, coercivity, and specific permeability) or 'performance measures' (e.g., G-Ratio and thermal stability)." *Id.* (citing ID at 102, 104).

We consider the ID to have examined the claims as a whole in determining that they were directed to an abstract idea and that the ID's level of abstraction in discussing what the claims are "directed to" does not meaningfully impact the patentability analysis. The Federal Circuit has recognized that an "abstract idea can generally be described at different levels of abstraction." *Ameranth*, 842 F.3d at 1340-41. Here, the ID examined the language of the claims as a whole, explaining that it found certain claim elements to be performance measures or side effects rather than structural or design parameters. *See, e.g.*, ID at 105 (finding that the "claims of the '565 patent [] incorporate the [abstract] goal or result of a particular measure of wear resistance (i.e., G-Ratio) or thermal resilience (i.e., thermal stability), however achieved," and "certain electrical and magnetic side effects that themselves are simply imperfect proxies for unclaimed features"). It is clear from the language of the claims that the claims involve an abstract idea—namely, the abstract idea of a PDC that achieves the claimed performance measures (G-Ratio and thermal stability) and has certain measurable side effects (specific magnetic saturation, coercivity, and specific permeability), which, as discussed below, the specifications posit are derived from enhanced diamond-to-diamond bonding in the PCDs.

While the "directed to" inquiry must focus on the language of the claims themselves, the Federal Circuit has explained that "the specification may [] be useful in illuminating whether the claims are 'directed to' the identified abstract idea." *ChargePoint, Inc. v. SemaConnect, Inc.*, 920 F.3d 759, 767 (2019) ("The 'directed to' inquiry "may also involve looking to the specification to understand 'the problem facing the inventor' and, ultimately, what the patent describes as the invention."). Here, the specifications suggest that the asserted claims are directed to the abstract idea of PDCs that achieve the claimed performance measures and have side effects that the inventors believed may be derived from "enhanced" or "a high-degree of diamond-to-diamond bonding." *See, e.g.*, '565 patent[12] (JX-0002) at Abstract ("Embodiments of the invention relate to polycrystalline diamond compacts ('PDC') exhibiting enhanced diamond-to-diamond bonding."), 2:20-29 (patent purports to disclose "PCD materials that exhibit improved mechanical and/or thermal properties" via "enhanced diamond-to-diamond bonding"), 4:58-64 ("According to various embodiments, unleached PCD sintered at a pressure of at least about 7.5 GPa may exhibit . . . a high-degree of diamond-to-diamond bonding . . . ."), 7:47-52 ("[I]n one or more embodiments of the invention, PCD exhibits . . . a greater amount of diamond-to-diamond bonding between diamond grains than that of a PCD sintered at a lower pressure . . . ."), 21:17-29 (conventional PDC tables listed in Table II exhibit "a lower coercivity indicative of a relatively greater mean free path between diamond grains, and thus may indicate relatively less diamond-to-diamond bonding between the diamond grains").

The problem identified in the specifications was that the "residual stresses" in the PCD table and substrate following the HPHT process "may result in premature failure of the PDC." '565 patent (JX-0002) at 1:62-2:7; *see* '502 patent (JX-0003) at 1:62-2:7. The specifications state that the inventors believed that "forming the PCD by sintering diamond particles at a pressure of at least about 7.5 GPa may promote nucleation and growth of diamond between the diamond particles being sintered," thereby forming a PCD "having a metal-solvent catalyst content of less than about 7.5 wt %." '565 patent (JX-0002) at 7:53-8:5. The specifications also state the inventors' belief that PCDs formed at a sintering pressure above 7.5 GPa and with the metal-solvent catalyst content below about 7.5 wt % may exhibit increased wear resistance and improved thermal stability. *Id.* at 4:54-57, 5:43-44, 5:63-64, 6:14-22. In short, looking at the

[12] Citations are to the '565 patent only. The '502 and '306 patents provide similar disclosures. *See* '502 patent (JX-0003) at 2:19-20, 3:66-4:12, 4:21-24, 6:45-59; '306 patent (JX-0002) at 2:16-18, 3:64-4:9, 4:18-23, 6:44-52.

problem identified in the patents, as well as the way the inventors describe their invention, the Commission finds that the claims are directed to the abstract idea of PDCs that achieve the claimed performance measures and desired magnetic and electrical results, which the specifications posit may be derived from enhanced diamond-to-diamond bonding.

The Commission finds that the concept of stronger PDCs that achieve certain performance measures and desired magnetic and electrical properties is an abstract idea for purposes of *Alice* step one.[13] USS does not dispute that the focus of the claims is stronger bonding. *See* Tr. (German) at 116:8-16 (testifying that the disclosed PDCs are differentiated from prior art PDCs by "the key term [that] shows up in both the summary and the abstract, and it says *enhanced diamond-to-diamond bonding*") (emphasis added), 117:7-12 (testifying that "embodiments of the invention relate to polycrystalline diamond compacts exhibiting enhanced diamond-to-diamond bonding"), 118:12-119:15 (testifying that although the word "enhanced" is not in the claims, "the implications from the – the relative properties that follow in both of those claims would be satisfied by an enhanced level of bonding").

USS argues that achieving the claimed properties and stronger bonding are not abstract ideas. *See* Compl. Pet. at 7-10. Central to USS's argument and the dissent's view is that the claims are directed to "objective measurements" of the diamond microstructure and the measurements are, thus, "structural elements." Compl. Sub. at 4, 5. In its petition for review, USS asserts:

[13] There is no dispute that the main goal for the PDC industry is enhanced or more diamond-to-diamond bonding. *See* Resp. Sub. at 13-14 (stronger bonding is "top of mind for everyone in the PDC industry") (citing Tr. (German) at 119:17-25 (USS's expert noting that "enhanced diamond-to-diamond bonding" is "driving the economics" in the drill rig industry)); *Alice*, 573 U.S. at 218 (defining an abstract idea as "a fundamental truth; an original cause; a motive") (quoting *Le Roy*, 55 U.S. at 175).

> Before the claimed invention, USS and others believed that sintering a PDC at too high a pressure could cause problems, such as exerting strain on the press equipment. [Tr. (Bertagnolli)], 73:3-9. Extremely high pressures can also destroy the press. *Id.*, 68:8-11. Through significant R&D efforts, USS developed a way to exert higher sintering pressure (e.g., 7.8 GPa). *See* CX-2349. These manufacturing methods led to a new type of PDC with more diamond bonding and less cobalt.

Compl. Pet. at 7. USS submits that "each parameter measures how tightly the diamond grains in the PCD table are packed together, indicating a greater diamond density, which is directly tied to the PDC's superior performance in drilling applications." Compl. Sub. at 28; *see also id.* at 9 (the asserted claims "claim *how* an enhanced or a high-degree of diamond-to-diamond bonding is achieved with measurements within associated numerical ranges). USS argues that "many claim features are observed or measured in some way," and if such features are found abstract, "the abstract-idea exception would spill well beyond its boundaries." Compl. Reply Sub. at 2.

The evidence does not support USS's argument that the claimed properties are "structural elements" of a PDC or indicative of any specific microstructure. Instead, as USS's expert agreed, the measurable characteristics are the result of the sintering conditions and input materials that went into manufacturing the PDC. Tr. (German) at 1338:24-1339:4. Thus, as the ID states, G_{ratio} and thermal stability are performance measurements (specifically of a PDC's wear resistance and thermal properties), which the specifications posit may be derived from stronger diamond-to-diamond bonding. *See* ID at 102 (citing '565 patent at 2:22-28, 6:64-66, 7:16-39; CX-0394.3); Tr. (German) at 119:5-15 (testifying "G-ratio [] is a wear characteristic," "[t]he higher the G-ratio, as we would know, is more successful [] the diamond cutter would be.").

As for the electrical and magnetic properties of a PCD, there is no dispute that the presence of cobalt or other metal-solvent catalyst in the PCD is measurable. *See* Tr. (German) at

156:10-16 (testifying that coercivity measures "the degree of magnetization necessary to take [a PCD] sample back to zero magnetism"); '565 patent (JX-0002) 5:49-60 (the specification teaches to measure the coercivity and specific magnetic saturation using published standards and commercially available instruments). However, USS has not proven that the claimed electrical and magnetic properties are indicative of any specific microstructure. *See* ID at 102-104 (citing CX-0394.2-3). Relying on the patent specifications and Dr. Bertagnolli's paper, the ID found the electrical and magnetic properties are "not design choice[s] or manufacturing variable[s], but are instead [] indirect measures of the effectiveness of other design choices and manufacturing variables," such as sintering pressure, temperature, metal content, and grain size, none of which, besides grain size, are recited in the claims. ID at 103. We agree with the ID that "[t]here may be some causal connection between grain size, catalyst concentration, and other, unspecified design and fabrication choices, on the one hand, and electrical and magnetic behavior, on the other hand," "[b]ut that causal connection is so loose and generalized that the claimed limitations appear to be little more than side effects; thus, the recitation of, say, an electrical conductivity of less than 1200 S/m appears to be gratuitous rather than inventive." *Id.* at 104.

Contrary to the dissent's view, the fact that the claimed characteristics of PDCs may be measured does not make the claims any less abstract for purposes of *Alice*. The Federal Circuit has explained that the patent eligibility inquiry requires that the claim "identify 'how' [a] functional result is achieved by limiting the claim scope to structures specified at some level of concreteness, in the case of a product claim, or to concrete action, in the case of a method claim." *Am. Axle*, 967 F.3d at 1302. The Court noted that the "Supreme Court has so required dating back at least to the Court's rejection of Morse's claim 8 in *O'Reilly v. Morse*." *Id.* The Court explained that Morse's claim 8 was struck down because "it 'was a claim for a patent for an effect produced by the use of electro-magnetism, distinct from the process or machinery necessary to produce it,' whereas other claims incorporated the descriptions of how to produce the effect." *Id.* at 1302 n.14 (quoting *Dolbear v. Am. Bell Tel. Co*., 8 S. Ct. 778, 782 (1888)) (internal quotations omitted); *see also Interval Licensing LLC v. AOL, Inc.*, 896 F.3d 1335, 1342-43 (Fed. Cir. 2018) (explaining that the inventor in *Morse* "received a patent containing at least one claim directed to a particular technical solution to a problem," but also "lost a claim that encompassed all solutions for achieving a desired result," because the latter claim "failed to recite a practical way of applying an underlying idea; [it] instead [was] drafted in such a result-oriented way that [it] amounted to encompassing the 'principle in the abstract' no matter how implemented."). Thus, while it is not *per se* impermissible to claim PDCs that achieve certain properties and stronger bonding characteristics, the claims run afoul of section 101 due to the "essentially result-focused, functional character of claim language."[14] *Elec. Power Grp.*, 830 F.3d at 1356. The claims here cover a set of goals for the PDCs that the specifications posit may be derived from enhanced diamond-to-diamond bonding. The claims do not recite a way of achieving the claimed characteristics; they simply recite the desired range of values for each characteristic. Some claims do not even place a cap on those ranges.

[14] The dissent argues the claimed properties at issue here are not the sort of results that have been called into question in cases related to software functionality in computers. The dissent reads these cases too narrowly, and the principles expressed in those cases are not limited to cases involving software or computers. Moreover, while recent abstract idea precedent has focused on computer-based and business method patents, the judicially recognized exceptions can be found in more than these fields. *See, e.g.*, *Le Roy*, 55 U.S. at 174-76 (articulating the abstract idea exception in discussing claims directed to making lead pipes); *Funk Bros. Seed Co. v. Kalo Inoculant Co.*, 333 U.S. 127, 130-32 (1948) (product claims to composite cultures of inoculants); *O'Reilly v. Morse*, 56 U.S. 62, 112-13 (1853) (claims directed to the use of electro-magnetism for marking or printing characters).

The details set forth in the specifications do not change the conclusion under *Alice* step one. The specifications set forth various manufacturing conditions and input materials, and teach that these conditions and inputs may produce PCDs having improved mechanical and/or thermal properties over the prior art. '565 patent (JX-0002) at 2:47-54, 5:61-63, 6:63-65. However, other than grain size, none of these conditions/inputs are required by the claims. Moreover, USS contends and the ALJ agreed that the patentees did not disavow the claim scope to limit certain parameters. *See* Order No. 23 (*Markman* Order) at 18-20 (construing claims "such that there is no requirement for all PDCs to have been made with a sintering pressure of at least 7.5 GPa . . . ."); Compl. Reply at 20 (denying patentees limited claims to PCD tables manufactured with a cell pressure of 7.5 GPa or above and a metal-solvent catalyst amount of 7.5 wt. % or less"). In other words, the asserted claims cover all PDCs exhibiting the claimed properties no matter what pressure was used to make them or how much catalyst is present in the PCD. Unclaimed features of the manufacturing process "cannot function to remove [the claims] from the realm of ineligible subject matter." *Am. Axle*, 967 F.3d at 1295 (citing *ChargePoint*, 920 F.3d at 766).

Recently, in *Certain Light-Emitting Diode Products, Fixtures, and Components Thereof*, Inv. No. 337-TA-1213 ("*Light-Emitting Diode*"), the Commission found a claim that recites, *inter alia*, a lighting device "having a wall plug efficiency of at least 85 lumens per watt of said electricity" is directed to the abstract goal of energy efficiency at or above 85 LPW, however that goal is achieved. Final ID at 21-22, 2021 WL 3829977, at *19-20 (Aug. 17, 2021), *aff'd by* Comm'n Op., 2022 WL 168302, at *3 (Jan. 14, 2022). There, the complainant had argued that the claim is not directed to an abstract goal because it recites "a particular physical structure (a 'lighting device') with objective, measurable characteristics (a 'wall plug efficiency')." Resp.

Sub. at 18 (quoting *Light-Emitting Diode*, Compl. Pet. at 28). The Commission adopted the ALJ's finding that the claims are directed to an abstract goal because "the *claims themselves*, even when properly construed in light of the specification, do not delineate how the claimed [result (*i.e.*, efficiency)] is achieved." *Light-Emitting Diode*, Final ID at 23, 2021 WL 3829977 at *20. USS attempts to distinguish *Light-Emitting Diode* by arguing that the claim at issue recited "one novel structural element," *i.e.,* "a wall plug efficiency of at least 85 lumens per watt of said electricity," whereas the asserted claims here recite numerous parameters, "the combination of which defines the claimed microstructure with enhanced diamond-to-diamond bonding." Compl. Reply Sub. at 7. USS does not cite any cases to support its argument that the number of parameters claimed somehow matters in the patent eligibility inquiry, particularly given that the testing data discussed below contradicts USS's assertion that the parameters it claims define a particular microstructure.

The testimony submitted by USS highlights that its research and development efforts resulted in the ability to manufacture PDCs at higher pressure without damaging the manufacturing press. Tr. (Bertagnolli) at 67:10-68:25. But rather than claiming a specific structure or way of making a PDC, or any improvements to the manufacturing equipment itself, USS purports to monopolize every potential structure or way of creating stronger PDCs with the claimed characteristics. Whereas patenting a particular solution "would incentivize further innovation in the form of alternative methods for achieving the same result," allowing claims like USS's claims here would "inhibit[ ] innovation by prohibiting other inventors from developing their own solutions to the problem without first licensing the abstract idea." *Elec. Power Grp.*, 830 F.3d at 1356.

Courts have found that preemption is an indication that claims are directed to an abstract idea. *See ChargePoint*, 920 F.3d at 766 ("[T]he concern that drives the judicial exceptions to patentability is one of preemption[.]") (internal quotation marks omitted). USS contends that the "Asserted Claims do not cover all PCDs with enhanced diamond-to-diamond bonding, but rather PDCs with the type of diamond-to-diamond bonding characterized by the numerical parameters recited in the claims." Compl. Reply Sub. at 11. In particular, the dissent agrees with USS that there is no preemption here because the claims do not cover "the conventional PDCs disclosed in the specification of the Asserted Patents (*see, e.g.*, JX-0002.31-.32 at Tbls. II-III), several products tested in this Investigation (*see, e.g.*, CX-0383C.5, .7), and SF Diamond's redesign products developed during this Investigation (*see* ID at 55, 68)." Compl. Reply Sub. at 20. The Commission finds this argument unpersuasive. The fact that one respondent, SF Diamond, was able to redesign its product with a [redacted] than what is claimed, *see* ID at 77, does not render the preemption concern moot. Either [redacted] is irrelevant (contrary to USS's assertion) and SF Diamond's redesign is equivalent to the patented PDCs, or the only path forward for others is practicing the inferior prior art PDCs. USS seeks a monopoly on any PDCs that exhibit the claimed properties however achieved, which the law precludes in these circumstances.

The evidence also shows that certain accused products in this case achieved the claimed properties using manufacturing conditions and input materials different from those disclosed in the specifications. *See* Resp. Sub. at 8-9 (citing Resp. Reply at 17-18; CX-0383C; Tr. (German) at 375:2-19; JX-0192C). For example, respondent Haimingrun's accused S18 product was found infringing because it met all of the coercivity, magnetic saturation, permeability, and electrical conductivity thresholds. ID at 10, 63-64 (citing CX-0383C.3-4); CDX-0003C.77-78. Yet, the

S18 product was manufactured at a sintering pressure of [redacted] GPa and included a catalyst weight percentage of more than [redacted]. JX-0192C; CX-0383C.3-4; *cf.* '565 patent (JX-0002) at 5:28-31, 5:64-6:3, 6:63-65 (teaching embodiments with less than 7.5% wt catalyst and greater than 7.5 GPa sintering pressure). USS contends that JX-0192C shows the S18 product was manufactured at a cell (cavity) pressure above [redacted] GPa. Compl. Reply Sub. at 21. However, JX-0192C (at 1) lists the cavity pressure measurement as [redacted] GPa for the S18. The Commission finds USS's attorney argument insufficient to disregard the express statement in the document. Moreover, even if USS is correct that the S18 product was manufactured at cell pressure above [redacted] GPa, USS does not challenge Respondents' assertion that the S18 product had a catalyst weight percentage of more than [redacted], which goes against the teachings in the patents.

As another example, respondent New Asia's accused Dragon 2 product was found to meet all the claimed property thresholds, but New Asia reported that it was manufactured at a sintering pressure of less than 7.5 GPa. *See* ID at 64 (citing CX-0383C.3), 68-70; CDX-0003C.77-78; CDX-0003C.151; Tr. (German) at 375:2-19 (confirming that New Asia reported "the Dragon 2 product, even though it's an accused product, is manufactured using less than 7.5 gigapascals" and "greater than the 7.5 percent cobalt or metal-solvent catalyst content described in the asserted patents"). USS now argues that "New Asia's *pre-suit* documents . . . touted that its PDC products are manufactured at [redacted] GPa." Compl. Reply Sub. at 22 (citing JX-0348C). JX-0348C is not an admitted exhibit and, therefore, the Commission gives no weight to this exhibit. Moreover, USS has not shown that the "*pre-suit* documents" relate to the specific PDC samples tested for infringement, and its own expert did not question New Asia's reported sintering pressure.

In view of the above, we agree with Respondents that the fact that PDCs produced with manufacturing conditions and input materials different from what is taught in the patents may still satisfy the claimed characteristics contradicts USS's assertion that the measured properties "characterize the PDC's microstructure" and "are structural parameters." Resp. Sub. at 19; Compl. Pet. at 20. This is especially problematic because, as Respondents point out, even assuming that the PCD embodiments in Table I have "enhanced" diamond-to-diamond bonds, as the patents posit, the claimed ranges are broader than the ranges of the embodiments in Table I, "illustrating that the claims are not limited to whatever microstructure those embodiments might have." Resp. Sub. at 13.

To the extent that the dissent agrees with USS that "broad preemption" is required to indicate the claims are directed to an abstract idea, Compl. Reply Sub. at 12, the Supreme Court has rejected that notion. The Court explained that "the underlying functional concern here is a *relative* one: how much future innovation is foreclosed relative to the contribution of the inventor." *Mayo Collaborative Servs. v. Prometheus Labs., Inc.*, 566 U.S. 66, 89 (2012) (citation omitted). "A patent upon a narrow law of nature may not inhibit future research as seriously as would a patent upon Einstein's law of relativity, but the creative value of the discovery is also considerably smaller." *Id.* at 88. And, as the Court recognized, "even a narrow [ineligible subject matter] can inhibit future research." *Id.* The Court said that its "cases have endorsed a bright-line prohibition against patenting laws of nature, mathematical formulas, and the like, which serves as a somewhat more easily administered proxy for the underlying 'building-block' concern." *Id.* at 89; *see also Alice*, 573 U.S. at 217 (claims directed to no more than a "fundamental [] practice" or basic "building block" of human ingenuity are not patentable because doing so "would risk disproportionately tying up the use of the underlying ideas"). As discussed above, in this case, the inventors do not claim to be the first to make a PDC by sintering a catalyst with diamond particles in a press under high-temperature, high-pressure conditions. The discovery described in the patents here is far narrower—that using existing machinery to sinter diamond particles at a pressure of at least about 7.5 GPa may result in PDCs that achieve certain performance measures and desired magnetic and electrical properties. USS's contribution does not allow it to monopolize every potential structure or way of creating PDCs with the claimed characteristics.

In sum, the Commission finds the asserted claims are directed to the abstract idea of stronger PDCs that achieve the claimed performance measures and desired magnetic and electrical results no matter how implemented.

2. *Alice* Step Two

The ID found that the claims also fail *Alice* step two because they "invoke[] well-understood, routine, [and] conventional components to apply the abstract idea[s]" recited in the claims. ID at 110. The ID found the "claims here recite several structural limitations (a polycrystalline table, an unleached portion, a plurality of diamond grains, a catalyst, and a substrate) that are generic to all PDCs." *Id.* at 109. The ID stated that "[w]hile the inventors may have discovered methods of manufacturing PDCs that have the specific improved properties claimed," they failed "to recite structures, methods [*e.g.*, the manufacturing steps], or any other inventive feature to achieve the objectionable claimed limitations (G-Ratio, thermal stability, electrical and magnetic parameters)." *Id.* The ID reasoned that "the claims read on any PDC structure that achieves the claimed improvements" and this "mismatch between the specification" and "the breadth of claim 1 underscores that the focus of the claimed advance is the abstract idea and not the particular configuration discussed in the specification that allegedly departs from the prior art." *Id*. at 110.

We agree with the ID's analysis of *Alice* step two. The elements of the asserted claims—individually and as an ordered combination—do not transform the nature of the claims into something patent-eligible. As explained above, the claims recite results-oriented language and the recited physical elements are conventional. *See* Compl. Reply Sub. at 26-27 (citing Resp. Sub. at 27-28) (not disputing the following limitations of claim 1 of the '565 patent are conventional: "polycrystalline diamond compact," "an unleached portion of the polycrystalline diamond table," "a plurality of diamond grains directedly bonded together via diamond-to-diamond bonding to define interstitial regions, the plurality of diamond grains exhibiting an average grain size of about 50 µm or less," "a catalyst occupying at least a portion of the interstitial regions," and "a substrate bonded to the polycrystalline diamond table."); *see also* Resp. Sub. at 28-30. Thus, the claims do not include some "additional feature" or "inventive concept" showing that it is "more than a drafting effort designed to monopolize the" abstract idea. *ChargePoint*, 920 F.3d at 773; *Alice*, 573 U.S. at 221.

USS argues the asserted claims contain "an inventive concept" based only on the claimed properties of the PDC. *See* Compl. Sub. at 28-29. These properties are the only thing that USS puts forward as non-conventional. But, as discussed above, achieving the claimed properties is abstract because they effectively cover any PDCs with those properties no matter how it is made and, therefore, they do not qualify as an "inventive concept." Thus, the Commission finds there is nothing "significantly more" to the claims than the abstract idea cloaked in physical elements. *Bascom Glob. Internet Servs., Inc. v. AT&T Mobility LLC*, 827 F.3d 1341, 1349 (Fed. Cir. 2016) (stating this allegedly inventive concept "cannot simply be an instruction to implement or apply the abstract idea" and "must be significantly more than the abstract idea itself").

In view of the above, the Commission affirms with modified reasoning the ID's finding that the asserted claims of the '502, '565, and '306 patents are directed to ineligible subject matter under § 101.

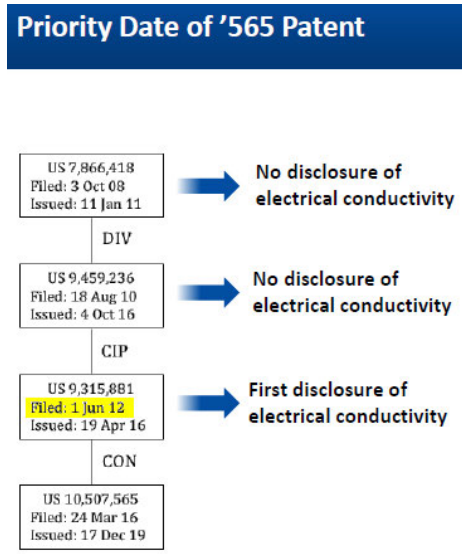
B. The Asserted Claims of the '565 Patent Are Invalid Under 35 U.S.C. § 102(b) by the Sale of the [redacted] Product

A patent is invalid under § 102(b) (pre-AIA[15]) if "the invention was . . . on sale in this country, more than one year prior to the date of the application for patent in the United States." *Abbott Labs. v. Geneva Pharms., Inc.*, 182 F.3d 1315, 1318 (Fed. Cir. 1999). A two-prong test governs the application of the on-sale bar: "First, the product must be the subject of a commercial offer for sale. . . . Second, the invention must be ready for patenting." *Pfaff v. Wells Elecs., Inc.*, 525 U.S. 55, 67 (1998). USS does not dispute that the [redacted] product was on sale in this country by April 2008 and was ready for patenting at that time. *See* ID at 110; Compl. Pet. at 40. USS also does not dispute that the [redacted] product was a commercial "PCD cutter product" embodying each and every limitation of the asserted claims of the '565 patent. ID at 110 (citing JX-0400C.2-.3; CX-2385C; JX-0034C.179).

The parties dispute whether the [redacted] was on sale more than one year before the effective filing date of the '565 patent, *i.e.*, the critical date for the on-sale bar. "The significance of the critical date is that a sale of the invention before that date can be invalidating." *Helsinn Healthcare S.A. v. Teva Pharms. USA, Inc.*, 855 F.3d 1356, 1360 (Fed. Cir. 2017), *aff'd*, 139 S.Ct. 628 (2019). The '565 patent is a continuation of the '881 patent, filed on June 1, 2012.

[15] The Leahy–Smith America Invents Act ("AIA") changed 35 U.S.C. § 102. Pub. L. No. 112-29, § 3(b), 125 Stat. 284, 285-86 (2011). However, because the applications from which the Asserted Patents issued have never contained a claim having an effective filing date on or after March 16, 2013, the pre-AIA version of § 102 applies. *Id.* § 3(n)(1), 125 Stat. at 293.

The ’881 patent claims priority to U.S. Patent No. 7,866,418 (“the ’418 patent”; JX-0365), filed on October 3, 2008, through a chain of continuing applications, as shown below.



RDX-0006C.95. Any claim in a continuation-in-part application which is directed *solely* to subject matter adequately disclosed under 35 U.S.C. § 112 in the parent application is entitled to the benefit of the filing date of the parent application. If the ’565 patent is entitled to claim priority to the ’418 patent, then USS contends the critical date for the on-sale bar is October 3, 2007, one year before the filing date of the ’418 patent, and the sale of the [redacted] product in 2008 does not invalidate the asserted claims of the ’565 patent.[16]

However, if a claim in a continuation-in-part application recites a feature that was not disclosed or adequately supported under 35 U.S.C. § 112 in the parent application, but which was first introduced or adequately supported in the continuation-in-part application, such a claim is entitled only to the filing date of the continuation-in-part application, which in this case is June

[16] The parties do not dispute that the ’502 patent is entitled to the October 3, 2008 priority date of the ’418 patent and, therefore, the [redacted] product does not qualify as prior art to the asserted claims of the ’502 patent. *See* ID at 135.

1, 2012. *See, e.g.*, *In re Chu,* 66 F.3d 292 (Fed. Cir. 1995). The ID found the '565 patent could not claim priority to the '418 patent because the '418 patent failed to disclose a PDC with "an average electrical conductivity of less than about 1200 S/m," as required by the asserted claims of the '565 patent. ID at 97. The ID found the first disclosure of electrical conductivity is in the '881 patent, filed on June 1, 2012, and, therefore, the critical date for the on-sale bar is June 1, 2011. On review, the Commission affirms with modified reasoning the ID's findings that the asserted claims of the '565 patent are not entitled to the priority date of the '418 patent and, thus, those claims are invalid under § 102(b) because the claimed invention was sold prior to the critical date of June 1, 2011.

The '565 patent specification includes numerous descriptions of electrical conductivity that are found nowhere in the earlier filed '418 patent. Tr. (Barron) at 700:6-701:22. The table below provides example paragraphs highlighting the new disclosures:

	The '236 Patent and the '418 Patent	The '881 Patent and/or the '565 Patent
Detailed Description	According to various embodiments, PCD sintered at a pressure of at least about 7.5 GPa may exhibit a coercivity of 115 Oe or more, a high-degree of diamond-to-diamond bonding, a specific magnetic saturation of about 15 G·cm³ /g or less, and a metal-solvent catalyst content of about 7.5 weight % ("wt %") or less. The PCD includes a plurality of diamond grains directly bonded together via diamond-to-diamond bonding to define a plurality of interstitial regions.	According to various embodiments, unleached PCD sintered at a pressure of at least about 7.5 GPa may exhibit a coercivity of 115 Oe or more, a high-degree of diamond-to-diamond bonding, a specific magnetic saturation of about 15 G·cm³ /g or less, a metal-solvent catalyst content of about 7.5 weight % ("wt %") or less, ***an electrical conductivity of less than about 1200 S/m, or combinations thereof***. The PCD includes a plurality of diamond grains directly bonded together via diamond-to-diamond bonding to define a plurality of interstitial regions.
Detailed Description	Generally, as the sintering pressure that is used to form the PCD increases, the coercivity may increase and the magnetic saturation may decrease. The PCD defined collectively by the bonded diamond grains and the metal-solvent catalyst may exhibit a coercivity of about 115 Oe or more and a metal-solvent catalyst content of less than about 7.5 wt % as indicated by a specific magnetic saturation of about 15 G·cm³ /g or less.	Generally, as the sintering pressure that is used to form the PCD increases, the coercivity may increase while the magnetic saturation ***and electrical conductivity*** may decrease. The PCD defined collectively by the bonded diamond grains and the metal-solvent catalyst may exhibit ***one or more of the following properties:*** a coercivity of about 115 Oe or more, a metal-solvent catalyst content of less than about 7.5 wt % as indicated by a specific magnetic saturation of about 15 G·cm³ /g or less, ***or an electrical conductivity less than about 1200 S/m. For example, the electrical conductivity may be an average electrical conductivity of the PCD (e.g., a PCD table) or a region of the PCD.***

RDX-0006C.96. The '565 patent also includes teachings regarding the correlation between higher cobalt content and increased electrical conductivity properties of PCDs that are not found in the '418 patent.

As shown in Tables I, III, and IV, the conventional PCD tables of Tables III and IV exhibit a higher cobalt content therein than the PCD tables listed in Table I as indicated by the relatively higher specific magnetic saturation values. This is believed by the inventors to be a result of the PCD tables listed in Tables III and IV being formed by sintering diamond particles having a relatively greater percentage of fine diamond particles than the diamond particle formulations used to fabricate the PCD tables listed in Table I.

Embodiments of Applications for PCD and PDCs

’418 patent, 15:51-61.

As shown in Tables I, III, and IV, the conventional PCD tables of Tables III and IV exhibit a higher cobalt content therein than the PCD tables listed in Table I as indicated by the relatively higher specific magnetic saturation values. This is believed by the inventors to be a result of the PCD tables listed in Tables III and IV being formed by sintering diamond particles having a relatively greater percentage of fine diamond particles than the diamond particle formulations used to fabricate the PCD tables listed in Table I.

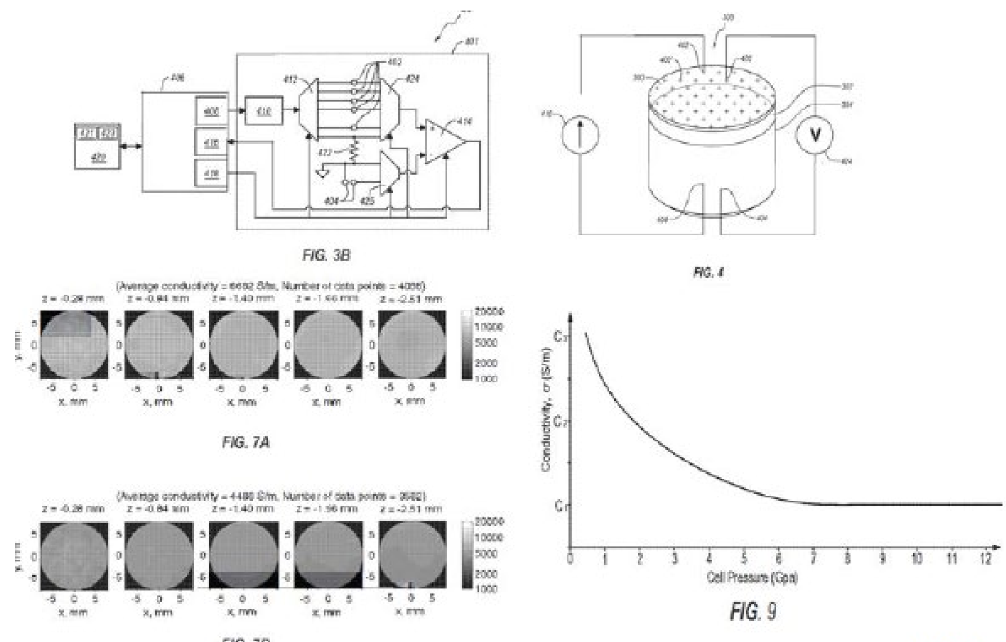
A similar correlation between higher cobalt content and increased electrical conductivity properties of PCD tables has also been observed. Sensitivity of electrical conductivity measurements of PDC diamond tables of a given PCD microstructure may provide an excellent method for estimation and imaging of metal content in the diamond table. Such types of estimates are sensitive to changes in bulk average metal-solvent content and local changes in the metal-solvent content, allowing for a sensitive estimation of both metal content and cutting performance.

Referring back to FIGS. **9** and **10**, electrical conductivity trends with metal-solvent content suggest that lowering the metal-solvent content, and thus the electrical conductivity, increases performance of a PDC. In fact, relatively lowered metal-solvent content in the PDC appears to substantially influence cutting performance. Therefore, it follows that the electrical conductivity, also dependent on metal-solvent catalyst content, may also be used as a quality characteristic for evaluating PDC cutting performance. For example, a PCD cutting element with electrical conductivities below about 1200 S/m (in an unleached region of PCD) have been found to increase cutting performance.

Embodiments of Applications for PCD and PDCs

’565 patent, 22:33-64.

The ’565 patent further includes five figures related to electrical conductivity that are not found in the earlier ’418 patent.



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RDX-0006C.97. The Commission finds the ’565 patent’s extensive disclosures about electrical conductivity that are not found in the ’418 patent suggest the inventors believed that they were adding new matter to the ’881 and ’565 patents with the teachings regarding electrical conductivity.

Nonetheless, USS asserts the ’565 patent claims are entitled to the earlier filing date of the ’418 patent, October 3, 2008, on the grounds that the ’418 patent inherently discloses the electrical conductivity limitation. The Commission disagrees. “Under the doctrine of inherent disclosure, when a specification describes an invention that has certain undisclosed yet inherent properties, that specification serves as adequate written description to support a subsequent patent application that explicitly recites the invention’s inherent properties.” *Yeda Rsch. & Dev. Co. v. Abbott GMBH & Co. KG*, 837 F.3d 1341, 1345 (Fed. Cir. 2016). For a disclosure to be inherent, “the missing descriptive matter must *necessarily* be present in the parent application’s specification such that one skilled in the art would recognize such a disclosure.” *Tronzo v. Biomet, Inc.*, 156 F.3d 1154, 1159 (Fed. Cir. 1998) (emphasis added).

USS asserts that the ’418 and ’565 patents disclose the exact same working examples in Table I, made using the same disclosed fabrication method. *See* ID at 98; Compl. Sub. at 32-33. USS argues that since the ’565 patent discloses that all of the example PDCs in Table I exhibit an average electrical conductivity of less than about 1200 S/m and PDCs made under the same manufacturing conditions and input materials exhibit the same electrical conductivity, then the same examples in the ’418 patent necessarily exhibit an average electrical conductivity of less than about 1200 S/m. *See* Compl. Sub. at 32-33. The Commission finds the ID erred in finding that the ’418 and ’565 patents do not disclose the same working examples in Table I. However, this error does not change the fact that the record evidence shows that the examples in Table I do not necessarily have an average electrical conductivity that is less than about 1200 S/m.

The ID erred by finding that USS has not shown that the ’418 patent “adequately teaches the same starting materials and the same manufacturing conditions” for the example PDCs in Table I. ID at 98. While the ’418 and ’565 patent disclosures do not expressly disclose all sintering conditions used to manufacture the PDCs in Table I, as the ID found, there is no reason to believe that the PDCs in Table I are not the same in both patents. The magnetic properties of the PDC tables are exactly the same and the descriptions of Table I are nearly verbatim in both patents. *Compare* ’418 patent (JX-0365) at 16:55-17:20 (Tbl. I) *with* ’565 patent at 20:15-37 (Tbl. I). Indeed, Respondents do not dispute that “the 418 Patent and the 565 Patent describe the same working examples.” Resp. Reply Post-Hearing Br. at 69; *see also* Resp. Reply at 37 (“[I]t is true that the ’418 Patent and the ’565 Patent describe the same working examples and the same fabrication methods.”).

However, even if the PDCs disclosed in Table I of both patents are the same, nowhere does the ’565 patent disclose that any of the examples in Table I necessarily exhibit an average electrical conductivity of less than about 1200 S/m. The ’565 patent states that certain unspecified disclosed embodiments may result in a PDC having an electrical conductivity of less than about 1200 S/m. *See, e.g.*, ’565 patent at 5:64-6:10 (“The PCD defined collectively by the bonded diamond grains and the metal-solvent catalyst ***may exhibit*** one or more of the following properties . . . ***an electrical conductivity less than about 1200 S/m***.” (emphasis added)). USS asserts that “the ’565 patent presents Table I, which provides ‘detail[s] about the magnetic properties of PCD tables of PDCs fabricated in accordance with the principles of ***some*** of the specific embodiments of the invention (i.e., PDCs having an average electrical conductivity of less than about 1200 S/m).” Compl. Sub. at 32 (emphasis added) (citing ’565 patent at 19:1-4; Abstract). The ’565 patent at column 19, lines 49-51, states that “Table I below lists PCD tables that were fabricated in accordance with the principles of ***certain*** embodiments of the invention discussed above" (emphasis added), but electrical conductivity is not a property listed in the table and there is no indication that the examples in Table I necessarily exhibit the claimed electrical conductivity parameter.

Indeed, in response to the Commission's question asking whether the '418 and the '565 patents disclose, either expressly or inherently, an exemplary PDC exhibiting "an average electrical conductivity of less than about 1200 S/m," USS admits the examples in Table I of the '565 patent do not expressly disclose the average electrical conductivity values but argues "that is unnecessary because the specification makes clear that PCDs manufactured using specific input materials under specific manufacturing conditions produce PDCs having the claimed electrical conductivity values." Compl. Reply Sub. at 28; *see* Compl. Sub. at 31, 32-33 (asserting the samples in Table I of the '565 patent disclose the claimed electrical conductivity but pointing only to claim 1, the Abstract, and certain manufacturing methods) (citing '565 patent at Abstract, 19:1-4, 19:51-54, 20:4-6). However, USS also admits that the '418 patent specification "discloses ranges of manufacturing parameters," and that a person of ordinary skill in the art ("POSITA") would have "to select appropriate numbers within those ranges to arrive at the claimed PDCs, in light of the specific working examples." Compl. Reply Sub. at 29; *see* '565 patent at 12:20-13:26 (describing ranges for sintering pressure, temperature, input diamond particle size, etc.). USS does not explain why a POSITA would necessarily choose parameters to achieve an average electrical conductivity of less than 1200 S/m, particularly given that electrical conductivity is not listed in Table I and not discussed anywhere in the '418 patent specification.

USS relies on Dr. German's testimony in an attempt to fill in the gaps. USS submits that Dr. German testified that the sample PCDs of Table I in the '418 patent inherently exhibit the claimed electrical conductivity. Compl. Sub. at 35 (citing Tr. (German) at 1245:2-1247:25). Every PDC may have a measurable electrical conductivity due to the presence of cobalt or other metal catalyst, but that does not mean the PDCs necessarily have an average electrical conductivity of less than 1200 S/m. *See* Tr. (Barron) at 747:2-5 (agreeing that "a polycrystalline diamond table that contains cobalt will have some electrical conductivity as a property"). As the ID noted, Dr. German never actually measured the electrical conductivity of the samples listed in Table I. Rather, he based his opinion solely on the '418 patent's disclosure regarding the cobalt content of the samples. *See* Compl. Sub. at 43 ("Dr. German consistently explained that the average electrical conductivity of a PDC reflects the PDC's microstructure, such as the amount of cobalt in a PDC, which is determined by the input materials and manufacturing methods used to produce it."); Tr. (German) at 1245:22-1246:6. However, the ID found Dr. German's testimony unreliable because "there is no disclosure of actual cobalt concentration [since] the concentrations given in Table I are simply the specific magnetic saturation measurements divided by 2.01," and it found the 2.01 proportionality constant "is not a clearly reliable measure of cobalt concentration." ID at 99. The Commission did not review this finding in the ID, *id.* at 94-95, and thus agrees that Dr. German's opinion based on the cobalt content of the samples is unreliable. Moreover, as the ID found, Dr. German's opinion conflicts with his previous testimony during the hearing. *Id.* at 99;[17] Tr. (German) at 364:21-365:6, 365:18-366:3, 366:8-

[17] The ID (at 99) cites to Dr. German's testimony that "when [a PDC is] leached, the electrical conductivity drops down." ID at 99 (quoting Tr. (German) at 128:14-129:21). USS argues "this is not relevant to the electrical conductivity of the PDCs disclosed in the '418 Patent, *which are not leached*." Compl. Pet. at 46. The Commission finds Dr. German's testimony irrelevant and potentially confusing because the '565 patent claims require "the *unleached* portion of the polycrystalline diamond table exhibits an average electrical conductivity of less than about 1200 S/m" and the '565 patent specification discloses that "a PCD cutting element with electrical conductivities below about 1200 S/m (in an *unleached*

367:2 (testifying that despite having detailed manufacturing information about certain products, Dr. German could not determine whether the products met the claim limitations, including the electrical conductivity limitation, unless he tested those products). In sum, the Commission finds that Dr. German's testimony regarding the inherent disclosure of the average electrical conductivity parameter in the '418 patent is unreliable.

USS also submits that Respondents' expert, Dr. Barron, does not dispute that the PDC examples in Table I of the '418 patent inherently disclose the claimed average electrical conductivity. Dr. Barron's opinion was based on his belief that the only thing a POSITA needs to know to predict the electrical conductivity is the percentage of cobalt by weight. Tr. (Barron) at 747:21-25, 749:7-13; *see* RDX-0006C.68-72. In particular, Dr. Barron testified that "any PDC that has a cobalt percentage less than 25 percent cobalt by weight will have an electrical conductivity of less than 1200 siemens per meter." Tr. (Barron) at 749:7-13. Dr. Barron's model was based on teachings from prior art references, including Akaishi. *See* ID at 96-97 (citing Tr. (Barron) at 681:18-684:4); Resp. Reply Sub. at 38. The Commission did not review the ID's finding that Akaishi does not disclose the same manufacturing conditions and input materials as the '418 and '565 patents, ID at 96-97, 118-19, and, thus, Dr. Barron's model based on the prior art is not a reliable measure of the average electrical conductivity of PDCs manufactured according to the embodiments disclosed in the '418 and '565 patents.

Moreover, as with Dr. German's opinion, the Commission agrees with the ID's finding that Dr. Barron's model for electrical conductivity is "conclusively refuted by Dr. German's testing" (discussed below). ID at 97 (citing CX-0383C). Specifically, the Commission agrees

region of PCD) have been found to increase cutting performance." '565 patent at 22:60-62 (emphasis added). Thus, the Commission determines to strike this citation in the ID.

with the ID's finding that Dr. German's actual testing of the domestic industry products and accused products show that the sample PCDs of Table I in the '418 patent do not necessarily exhibit the claimed electrical conductivity. *Id.* In particular, the ID found that the "cobalt concentration of every tested sample was significantly less than 20 weight percent, but dozens of samples displayed a conductivity exceeding 1200 S/m, in some cases by wide margins." *Id.* (citing CX-0383C.07 (Juxin 1613 CT200 (BBBBA.03) had [redacted] cobalt and electrical conductivity of [redacted]).

USS argues that the ID's finding regarding Dr. German's testing "is premised on a false equivalence between the incomplete manufacturing information provided by Respondents and the '418 patent's and '565 patent's more complete disclosures." Compl. Reply Sub. at 32. Yet, the ID found the '418 patent fails to disclose input materials and manufacturing conditions "particularly relevant for electrical conductivity," including the "sintering time at any particular pressure/temperature combination" and "the cobalt concentration in the tungsten carbide substrate." ID at 98-99. While certain Respondents did not provide all relevant manufacturing parameters for their accused products, neither did USS. *Id.* at 100 (finding "USS does not identify the sintering pressures and temperatures" for its DI Products). And even where Respondents reported manufacturing parameters that are "particularly complete" and "show a striking consistency (namely, identical sintering pressure and temperature, relatively low grain size, and relatively high cobalt concentration)" as the manufacturing conditions disclosed in the '418 patent, "their electrical conductivities vary between [redacted]" *Id.* (citing CX-0383C.2-.3); *see also* Tr. (German) at 365:10-366:22 (testifying [redacted] products have the same starting materials and manufacturing processes, but despite having the same manufacturing information, certain samples were below 1200 S/m and others were above the threshold).

Moreover, USS does not refute the ID's finding that "[t]hree of the four DI Products consistently exhibit electrical conductivity below 1200 S/m, but their input diamond particle sizes are significantly larger than specified in the 418 patent," and the "fourth DI Product, the [redacted], does not consistently exhibit electrical conductivity below 1200 S/m, even though it has the same input diamond particle size as the [redacted] and approximately the same cobalt concentration." ID at 99 (CX-0383C.2; CX-2141C ([redacted] specification); CX-2142C ([redacted] specification); CX-2143C ([redacted] specification); CX-2144C); *see* Resp. Reply Sub. at 31 (explaining that different samples of [redacted] have "electrical conductivity values that ranged from 903 S/m (less than about 1200 S/m) to 1513 S/m (much greater than about 1200 S/m)"). Accordingly, the Commission finds the record evidence does not support USS's inherency argument and agrees with the ID that "it cannot be concluded that the '418 patent discloses even a single [PDC] example that necessarily possesses an electrical conductivity of 1200 S/m or below." ID at 100.

Contrary to USS's argument, this case is not analogous to *Kennecott Corp. v. Kyocera Int'l, Inc.*, 835 F.2d 1419 (Fed. Cir. 1987). In that case, the defendants had conceded the claim limitation at issue in the asserted '299 patent was inherently disclosed in the parent '954 application:

> In this case, the invention of the '299 claims is a ceramic product. That product is the same as the product in the '954 application, and has the same structure. It was conceded that anyone with a microscope would see the microstructure of the product of the '954 application. The disclosure in a subsequent patent application of an inherent property of a product does not deprive that product of the benefit of an earlier filing date.

Id. at 1423. As discussed above, although USS asserts that both parties' experts testified that the '418 patent inherently discloses the electrical conductivity limitation, the ID found both experts' testimonies were unreliable and contradicted other testimony and test data. The Commission agrees with the ID's assessment of the record on this point.

The Commission finds that the record evidence does not support USS's argument that the '418 patent inherently discloses that the examples necessarily have an average electrical conductivity of less than 1200 S/m. The Commission affirms with the above modified reasoning the ID's findings that the asserted claims of the '565 patent are not entitled to the priority date of the '418 patent but rather have a priority date of June 1, 2012. USS does not dispute that the [redacted] product meets all of the limitations of the asserted claims of the '565 patent, and that at least one was sold in April 2008. ID at 110 (citing JX-0400C.2-.3; CX-2385C; JX-0034C.179). Accordingly, the Commission finds that a product meeting all the limitations of the asserted claims of the '565 patent was on sale more than one year before the effective filing date of the '565 patent and therefore the asserted claims of the '565 patent are invalid under § 102(b).

C. Respondents Have Not Shown That the Mercury PDC Anticipates Claims 1 and 2 of the '565 Patent and Claims 1 and 11 of the '502 Patent

Respondents contend that the Mercury PDC, which was manufactured by third-party Diamond Innovations and produced pursuant to subpoena, was "known or used by others in this country" prior to the date of invention of the '565 and '502 patents under pre-AIA 35 U.S.C. § 102(a) and, therefore, anticipates claims 1 and 2 of the '565 patent and claims 1 and 11 of the '502 patent. The Commission finds that the record evidence supports the ID's finding that the Mercury PDC tested by Respondents' expert, Mr. Bellin, meets all the limitations of claims 1 and 2 of the '565 patent and claims 1 and 11 of the '502 patent. Respondents, however, failed to establish by clear and convincing evidence that the Mercury PDC is prior art to the '565 and ’502 patents under § 102(a) (pre-AIA), and thus, the Commission reverses the ID’s finding that the Mercury PDC anticipates claims 1 and 2 of the ’565 patent and claims 1 and 11 of the ’502 patent.

An article qualifies as prior art if it was “known or used by others in this country . . . before the invention thereof by the applicant for patent.” 35 U.S.C. § 102(a) (pre-AIA). The Federal Circuit has interpreted the “known or used” prong of § 102(a) to mean “knowledge or use which is accessible to the public.” *BASF Corp. v. SNF Holding Co.*, 955 F.3d 958, 964 (Fed. Cir. 2020). Since the parties do not dispute that the date of invention for the asserted claims of the ’502 and ’565 patents is January 4, 2008, we assume this date for the purpose of our analysis of this issue. *See* ID at 111; JX-0034C.179. Thus, Respondents must show that the Mercury PDC was made publicly available before January 4, 2008 to succeed in its argument.

Respondents assert that a letter from Diamond Innovations’ counsel (“the Brinkman Letter,” RX-0554C) accompanying the production of the Mercury 1613 samples tested by Mr. Bellin establishes the Mercury PDC was publicly available before January 2008. Resp. Sub. at 57. The Brinkman Letter states that the Mercury 1613 sample is one of [redacted] RX-0554C.003. The letter includes information that Diamond Innovations’ witness, Mr. Gledhill, personally retrieved and other information that Mr. Gledhill obtained by a staff member querying Diamond Innovations’ “system.” ID at 112 (citing Tr. (Gledhill) at 530:20-531:9). According to a chart (reproduced below) included in the Brinkman Letter, the Mercury **1613** was [redacted]. *Id.*; *see* Tr. (Gledhill) at 534:24-535:2.

[redacted]

Resp. Sub. at 62 (citing RX-0554C.3 (annotated)). Even assuming the information in the chart is reliable, the Commission finds it does not establish the Mercury PDC was publicly available before January 2008, because it is not clear [redacted] or whether the Mercury **1613** was sold or otherwise made available to the public before January 2008.

Respondents assert that the Brinkman Letter is corroborated by USS' own testing of a Mercury **1608** prior to October 2008 and the trial testimony of Mr. Gledhill.[18] The ID appears to assume the Mercury **1608** and Mercury **1613** are identical for all relevant purposes and found it "reasonable to infer that as a competitor of Diamond Innovations, USS obtained [a Mercury **1608**] by a purchase prior to October 2008." ID at 112 (citing Tr. (Bertagnolli) at 101:10-102:22; JX-0370C.62; *see also* JX-0517C (Mukhopadhyay Dep. Tr.) at 96:4-16). However, Dr. Bertagnolli testified that he did not know how USS obtained the Mercury **1608** sample for testing. Tr. (Bertagnolli) at 101:10-102:22. Moreover, Mr. Gledhill could not find any evidence that the Mercury **1613** was sold or otherwise made available to the public at any time, let alone prior to the date of the invention. *See* Tr. (Gledhill) at 535:6-14, 536:13-15. Even if USS

[18] Mr. Gledhill's Declaration was stricken because it was produced eleven days after the close of fact discovery, as discussed below. *See* Order No. 48 (Oct. 14, 2021).

purchased a Mercury **1608** prior to October 2008, the evidence does not establish public availability of either Mercury PDC before January 2008, the date of the invention under § 102(a).

Moreover, USS argues the "ID erroneously mixed and matched the evidence concerning . . . one product (Mercury 1608) and the evidence concerning how a different product (Mercury 1613) practiced the claim elements." Compl. Reply Sub. at 45-46. Respondents contend that Mercury **1608** has the same PDC table and, thus, exhibits the same properties, as the Mercury **1613**. Resp. Reply Sub. at 45-46 (citing Tr. (Bellin) at 1005:15-1006:20 (testifying that between the Mercury **1608** and **1613**, the "diamond tables are usually the same height" and "[o]nly the carbide, the substrate changes, its length"); Tr. (Bertagnolli) at 107:7-23 (explaining that PDCs are named using this four-digit number, where the "first two numbers refer to the diameter in millimeters" of the PDC, and the "second two numbers refer to the height in millimeters" of the PDC)). The Commission finds that Respondents' argument conflicts with statements they made in their motion to compel USS to produce the Mercury **1608**. In their motion, Respondents argued the two PDCs "are different products." Resp. Mot. to Compel[19] at 4 n.3 ("Diamond Innovations only produced a Mercury 1613 sample, not a Mercury 1608 sample. These are different products that exhibit different characteristics, and thus are not duplicative.").

USS does not dispute Mr. Bellin's and Dr. Bertagnolli's testimonies regarding the PDC industry's naming convention, but argues that "it is common practice in the PDC industry to make a variety of different products under the same product name" and to "make new

[19] Respondents' Motion to Compel, EDIS Doc ID 746382 (Jul. 7, 2021) ("Resp. Mot. to Compel").

experimental products, assign them new product designations under an existing brand name, and test them for internal research and development purposes, without ever selling them or otherwise disclosing it to the public." Compl. Reply Sub. at 47. The evidence is unclear as to whether the two PDCs would exhibit the same properties. Since the burden falls on Respondents, the Commission finds Respondents failed to show by clear and convincing evidence that the Mercury **1608** and Mercury **1613** would exhibit the same properties. *See Intel Corp. v. U.S. Int'l Trade Comm'n*, 946 F.2d 821, 830 (Fed. Cir. 1991). Therefore, the information regarding the Mercury **1613** in the Brinkman Letter, even when considered in light of USS's testing of a Mercury **1608** prior to October 2008, is not sufficient to prove that the Mercury PDC was publicly available before January 2008.[20]

Mr. Gledhill testified regarding the meaning of [redacted] in the Brinkman letter, and Diamond Innovation's historical PDC [redacted] *See* Tr. (Gledhill) at 530:7-19 (explaining that [redacted] (emphasis added), 532:8-24 (testifying that [redacted] 532:25-533:8 (explaining that [redacted]

[20] Respondents also cite to Mr. Bellin's testimony that he tested Mercury PDCs when he worked at Varel, but Mr. Bellin did not join Varel until 2009, which is after the January 2008 date of invention. Resp. Sub. at 64 (citing Tr. (Bellin) at 956:5-13); Tr. (Bellin) at 1013:14-16.

Although Respondents assert that Mr. Gledhill's testimony supports finding the Mercury **1613** was commercially available and exhibits the same properties as the Mercury **1608**, the Commission finds the above-cited portions of Mr. Gledhill's testimony should be stricken in view of the ALJ's rulings in Order No. 48 and at trial. By way of background, the Brinkman Letter and the Mercury **1613** samples were produced on May 19, 2021. Compl. MIL[21] at 1. On June 28, 2021, the last day of fact discovery and the last day to supplement their invalidity contentions, Respondents served invalidity contention charts that asserted invalidity based on the Mercury PDC. *Id.* The charts relied on the Brinkman Letter and made references to a Diamond Innovations' written declaration, which had not yet been produced. *Id.* On July 2, 2021, USS informed Respondents that no declaration was produced. *Id.* at 2. On July 9, 2021, eleven days after the close of fact discovery, Respondents served a declaration from Mr. Gledhill. *See* Doc ID 752820, Ex. 1 (Gledhill Decl.). The declaration contained new information regarding the Mars and Mercury PDCs that was not previously disclosed during fact discovery. Order No. 48 at 2-3. In particular, Mr. Gledhill's declaration purported to explain manufacturing practices at Diamond Innovations prior to his employment and the [redacted] that Respondents received from Diamond Innovations in this investigation. *Id*. USS filed a motion *in limine* to exclude Mr. Gledhill's written declaration, which was granted by the ALJ in Order No. 48. *Id.* at 2-4. Order No. 48 excluded the Gledhill Declaration, which "(1) stated [redacted]

[21] *See* Complainant's Motion *in Limine* No. 3 to Exclude the Declaration of Andrew Gledhill, EDIS No. 752820 (Sep. 28, 2021) ("Compl. MIL").

[redacted] Order No. 48 at 3.

Although his declaration was excluded, the ALJ permitted Mr. Gledhill to testify at the hearing regarding information contained in the Brinkmann Letter. The ALJ excluded Mr. Gledhill's testimony that was outside the scope of the Brinkmann Letter except information such as his background, the nature of Diamond Innovations' business, and document authentication. Tr. at 669:13-24. The ALJ instructed the parties to submit proposed redactions to the transcript when they submitted their post-hearing briefs. *Id.* at 1112:5-22.

After the evidentiary hearing, the parties met and conferred regarding proposed redactions of Mr. Gledhill's hearing testimony. The ALJ did not rule on the parties' proposed redactions. The parties agreed that the following portions of Mr. Gledhill's testimony would be stricken: Tr. at 527:17-528:9, 533:9-534:3, 534:7-23. *See* EDIS Doc ID 756022 (Respondents' proposed redactions); EDIS Doc ID 756029 (Complainant's proposed redactions). USS and Respondents could not reach an agreement on the other portions of his testimony: Tr. at 522:13-16, 528:10-529:9, 529:21-530:19, 530:24-25, 532:8-533:8, and 534:4-6. The Commission finds Mr. Gledhill's testimony at Tr. 530:24-25 should not be stricken because it pertains directly to how Mr. Gledhill obtained the samples in the Brinkmann Letter. *See* ID at 112. The testimony at Tr. 522:13-16 is like the testimony at Tr. at 530:24-25 and thus should also not be stricken.

The testimony at Tr. 534:4-6 should not be stricken because it relates to Mr. Gledhill's work experience at Diamond Innovations.

The other disputed portions of Mr. Gledhill's testimony should be stricken because they relate to technical information disclosed for the first time at the hearing. *See* Tr. at 671:13-672:11 (ALJ excluding technical information that is neither in the Brinkman letter nor the Gledhill Declaration). In particular, the testimony at Tr. 528:10-529:9 relates to Diamond Innovations' [redacted] Compl. Sub. at 44, and is similar to topic (1) stricken by Order No. 48. The testimony at Tr. 529:21-530:19 relates to Diamond Innovations' [redacted] and is like topic (2) stricken by Order No. 48. The testimony at Tr. 532:8-533:8 relates to Diamond Innovations' product naming and manufacturing practices.

In short, the Commission finds that the evidence that is properly a part of the record, including the Brinkman Letter, USS's testing of a Mercury **1608** prior to October 2008, and testimony regarding the PDC industry's naming convention, is not sufficient to prove the Mercury PDC was publicly available before January 2008. The Commission therefore reverses the ID's finding that Respondents established by clear and convincing evidence that the Mercury PDC is prior art and that the Mercury PDC anticipates claims 1 and 2 of the '565 patent and claims 1 and 11 of the '502 patent under § 102(a).

D. Respondents Have Not Shown That the Asserted Claims of the '502, '565, and '306 Patents Are Not Enabled

The Commission affirms with modified reasoning the ID's finding that Respondents failed to provide clear and convincing evidence that the asserted claims of the '502, '565, and '306 patents are not enabled.

A patent is enabled if "at the time of filing the application one skilled in the art, having read the specification, could practice the invention without 'undue experimentation.'" *Cephalon, Inc. v. Watson Pharms., Inc.*, 707 F.3d 1330, 1336 (Fed. Cir. 2013) (citation omitted). "Whether undue experimentation is required 'is not a single, simple factual determination, but rather is a conclusion reached by weighing many factual considerations," known as the *Wands* factors. *Id.* The *Wands* factors include: (1) the quantity of experimentation necessary, (2) the amount of direction or guidance presented, (3) the presence or absence of working examples, (4) the nature of the invention, (5) the state of the prior art, (6) the relative skill of those in the art, (7) the predictability or unpredictability of the art, and (8) the breadth of the claims. *Id*.

Respondents argue that the Asserted Patents failed to enable the claimed magnetic properties, electrical conductivity, G_{ratio}, and thermal stability ranges. 1st Resp. Pet. at 17. Respondents relied on the testimony of Complainant's expert and fact witnesses. Specifically, Respondents' evidence supporting lack of enablement was based primarily on Mr. Bertagnolli's testimony that more manufacturing information such as "the full particle size distribution and the sintering pressure profile is needed" to predict the properties of the PDC and Dr. German's testimony that "the only way a POSITA could ever determine whether a product met the claimed properties was to test each and every individual product." *Id*. at 18-19 (citing JX-0350 (Bertagnolli Tr.) at 61:3-64:6, 100:7-101:4, 141:23-142:22; Tr. (German) at 366:17-368:4). Neither witness, however, opined on whether the experimentation necessary to make a PDC with the claimed properties would be unduly extensive. For that, Respondents make only attorney arguments that it would require undue experimentation to determine what processing parameters are necessary to result in the claimed properties. *See, e.g.*, 1st Resp. Pet. at 18, 20; *see also* Compl. Reply at 17.

USS asserts that the Asserted Patents disclose "detailed manufacturing information" and "working examples in Table I with a specific set of input conditions" such that a POSITA "would know how the manufacturing information disclosed in the Asserted Patents can be used to achieve the claimed PDCs." Compl. Reply at 17-19 (citing JX-0003 at 8:26-10:15; Tr. (German) at 1272:3-1273:8). While Dr. Bertagnolli testified that the patents do not disclose the particle size distribution information for making the PCDs in Table I, he explained that the universe of possible particle size distributions is limited by the magnetic properties disclosed in Table I. Tr. (Bertagnolli) at 97:19-99:16. He also testified that a POSITA would make the disclosed PCDs in Table I through trial and error, choosing various different particle size distributions and then testing them to see if they got the reported magnetic properties. *Id.* Thus, even if the particular particle size distribution information was needed, Respondents have not shown that it would take undue experimentation for a person of ordinary skill in the art to figure that out, given the narrow set of possible particle size distributions, the other properties described in the patents, and a POSITA's general knowledge of manufacturing PCDs. Compl. Reply at 20. The evidence also shows that "a POSITA could have easily measured these properties without any undue experimentation," *id.* at 21, and that "it is routine practice in the industry to test PDCs after manufacturing to ensure consistent quality and performance," *id.* at 19. In view of the evidence as a whole, the Commission finds that Respondents have not shown that a POSITA with the knowledge disclosed in the patents would require undue experimentation to make PDCs with the claimed properties. Accordingly, the Commission affirms with modified reasoning the ID's finding that Respondents did not prove by clear and convincing evidence that the asserted claims are not enabled.

E. Domestic Industry

In view of the Commission's finding that all asserted claims of the '502, '565, and '306 patents are directed toward ineligible subject matter and/or invalid, the Commission determines to take no position on the ID's economic prong findings, including the ALJ's determination to allow USS to supplement its contentions with a new domestic industry allocation method.

V. CONCLUSION

For the reasons set forth herein, the Commission determines that USS has not established a violation of section 337 by Respondents with respect to claims 1, 2, 4, 6, and 18 of the '565 patent, claims 1, 2, 11, 15, and 21 of the '502 patent, and claim 15 of the '306 patent. Accordingly, the investigation is terminated with a finding of no violation of section 337.

By order of the Commission.

Katherine M. Hiner
Acting Secretary to the Commission

Issued: October 26, 2022

UNITED STATES INTERNATIONAL TRADE COMMISSION
Washington, D.C.

In the Matter of **CERTAIN POLYCRYSTALLINE DIAMOND COMPACTS AND ARTICLES CONTAINING SAME**	**Investigation No. 337-TA-1236**

DISSENTING OPINION OF COMMISSIONER SCHMIDTLEIN

This matter involves the Commission's review of the presiding administrative law judge's final initial determination ("ID"). The ID found no violation of section 337 by Respondents. Specifically, the ID found at least one accused product infringes all asserted claims of the asserted patents, but found all of the claims ineligible under 35 U.S.C. § 101. The ID also found a subset of the asserted claims invalid under 35 U.S.C. § 102. I join the Commission's decision today affirming the ID's section 102 findings as modified in the Commission's opinion.

The section 101 findings are a different matter. The ID found the asserted claims reciting a manufactured composition of matter – a class of invention that has historically been patent eligible – ineligible for being directed to an abstract idea. In my view, the claims are directed to an eligible composition of matter – *i.e.*, polycrystalline diamond compact defined by specific, objective measurements. I therefore dissent from the Majority's decision to affirm the ID's section 101 findings.

Because I would reverse the ID's section 101 findings, I would also reverse the ID's finding of no violation in this investigation for the asserted claims that were not otherwise found invalid under section 102.

I. PATENTED TECHNOLOGY

The patents addressed in the ID are U.S. Patent Nos. 10,507,565 (the "'565 patent"), 10,508,502 (the "'502 patent"), and 8,616,306 (the "'306 patent").[1] The patents relate to polycrystalline diamond compacts ("PDCs"), which are manufactured compositions that include polycrystalline diamond ("PCD"). PDCs are utilized in a variety of mechanical applications, including use in in drilling tools, among other applications. '565 patent (JX-0002)[2] at 1:21-25. According to the patents, "PDCs have found particular utility as superabrasive cutting elements in rotary drill bits." *Id*. at 1:26-28.

A PDC cutting element typically includes a superabrasive diamond layer referred to as a polycrystalline diamond table that is bonded to a substrate. The polycrystalline diamond table is made from synthetized diamond. Figure 11A of the '565 patent (reproduced below) depicts a PDC embodiment. *See, e.g.*, *id*. at 15:63-16:21.

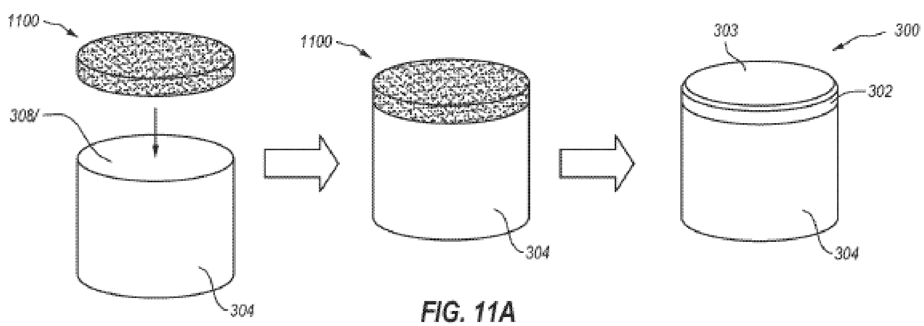

FIG. 11A

[1] Complainant US Synthetic Corporation ("USS") did not petition for review of the ID's finding of no violation with respect to the '306 patent, including the finding that the sole asserted claim is invalid under 35 U.S.C. § 102(b). Accordingly, USS's claim of a violation based on the '306 patent has been abandoned. *See* 19 C.F.R. § 210.43(b)(2). Because USS has abandoned its claim of a violation based on the '306 patent, my dissent focuses on the claims of the '565 and '502 patents.

[2] Citations are primarily to the '565 patent. The '502 patent provides, to a significant extent, similar disclosures as the '565 patent. Some differences between the specifications are noted in my dissent. Any difference between the specifications do not impact the conclusion that the asserted claims of both patents are eligible.

Figure 11A of the ’565 patent shows the diamond table **302**, a working surface **303** of the table **302**, and a substrate **304**. *Id.* at 1:28-30; 9:44-47; 15:62-16:10. The substrate **304** is often made from a cemented hard metal composite, like cobalt-cemented tungsten carbide. *See id.* at 6:43-45, 9:44-45, 14:44-50.

Figures 13 and 14 of the ’565 patent (reproduced below) depict PDC used in rotary drill bit **800**. 22:66-23:1, 23:11-12. In those figures, a plurality of PDCs **812** are affixed to blades **804**, which are affixed to the drill bit body **802,** as shown below. *Id.* at 23:21-24.

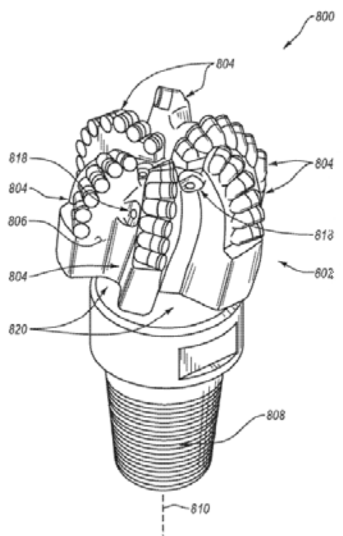

FIG. 13

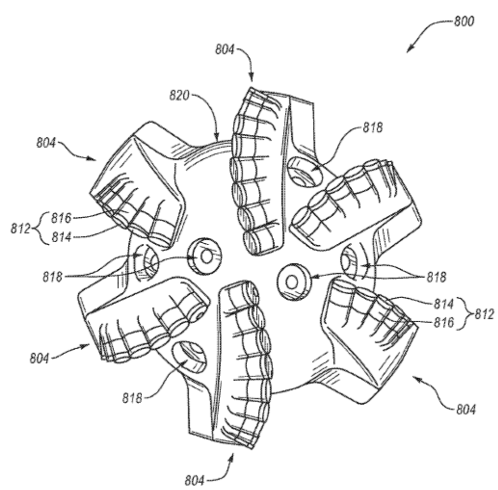

FIG. 14

The process of making a PDC, including synthesizing the diamond table, requires intense pressure and temperature to fuse or “sinter” the diamond grains to each other. *Id*. at 13:53-62. The pressure and temperature also help bond the diamond table to the substrate. Tr. (Bertagnolli), 60:7-18.

The patents explain that conventional PDCs were fabricated by placing the substrate into a cartridge with a volume of diamond particles next to the substrate. JX-0002 at 1:42-46. The cartridge is then loaded into a press that creates high-pressure and high-temperature conditions. *Id.* at 1:45-46. Cobalt from the substrate liquefies during the process and sweeps into interstitial regions between the diamond particles. *Id*. at 55-60. The substrate and diamond particles are processed under those conditions in the presence of the cobalt, or other metal catalyst, that causes the diamond particles to bond to one another, creating a polycrystalline diamond table that is bonded to the substrate. *Id.* at 1:46-62, 9:28-32.

The conventional approach is described as having drawbacks. JX-0002 at 1:66-2:19. Having metal catalyst in the diamond matrix is helpful during the sintering process to promote diamond growth, but the metal catalyst can be detrimental to diamond table performance when the PDC is later used for drilling. *Id*.; Tr. (Bertagnolli), 71:19-72:10. One method for addressing the performance issues caused by having the metal catalyst in the diamond matrix is called "leaching." *Id*., 71:17-72:10. Leaching involves submerging the diamond table into an acid bath, which removes some of the metal catalyst. JX-0002 at 2:13-15; *see also* '502 patent (JX-0003) at 12:20-47.

USS sought to create an improved type of PDC by reducing the amount of metal catalyst (*e.g*., cobalt) and increasing the diamond bonding, but without requiring a leaching process to do so. USS Pet. at 7 (citing Tr. (Bertagnolli), 71:10-72:10). USS alleges it developed a way to exert higher sintering pressure. USS Pet. at 7 (citing CX-2349). These manufacturing methods led to the improved PDC described in the asserted patents with more diamond bonding and less cobalt. JX-0002 at 7:53-61.

The specifications teach that PDCs sintered at a pressure of at least about 7.5 GPa differ from conventional high-pressure and high-temperature products because they have "enhanced" or a "high-degree" of diamond-to-diamond bonding as a result of "increased nucleation and growth of diamond between the diamond particles." *Id.* at 2:27-28, 4:34-49, 4:58-65, 7:53-61. Increasing the amount of diamond bonding reduces the size of the interstitial regions occupied by a metal-solvent catalyst and thereby affects the balance of metal-solvent catalyst to diamond grain in a PCD. *Id*. at 4:41-45; 7:53-61.

The specifications disclose that the improved PDC exhibits improved mechanical and/or thermal properties and performs better in high-abrasion applications, such as earth-boring drill bits. *See* ID at 8; JX-0002 at 5:28-31, 6:63-7:39. Good PDC performance reduces how frequently drill operators must remove or replace the drill bit. *See* ID at 8.

USS obtained patents containing various types of claims to its invention. USS Pet. at 11. Some claims, not at issue here, claimed the improved process of making the PDC. *Id*. The claims at issue in this investigation address the improved PDC itself.

The parties focus on limitations in claim 1 of the ’565 patent and claims 1 and 15 of the ’502 patent. Claim 1 of the ’565 patent recites:

> **1**. A polycrystalline diamond compact, comprising:
>
> a polycrystalline diamond table, at least an unleached portion of the polycrystalline diamond table including:
>
> > a plurality of diamond grains directly bonded together via diamond-to-diamond bonding to define interstitial regions, the plurality of diamond grains exhibiting an average grain size of about 50 μm or less;
> >
> > a catalyst occupying at least a portion of the interstitial regions;
> >
> > wherein the unleached portion of the polycrystalline diamond table exhibits a coercivity of about 115 Oe or more;
> >
> > wherein the unleached portion of the polycrystalline diamond table exhibits an average electrical conductivity of less than about 1200 S/m; and
> >
> > wherein the unleached portion of the polycrystalline diamond table exhibits a G_{ratio} of at least about 4.0×10^6; and
> >
> > a substrate bonded to the polycrystalline diamond table.

Claims 1 and 15 of the '502 patent recite:

> **1**. A polycrystalline diamond compact, comprising:
>
> a polycrystalline diamond table, at least an unleached portion of the polycrystalline diamond table including:
>
> a plurality of diamond grains bonded together via diamond-to-diamond bonding to define interstitial regions, the plurality of diamond grains exhibiting an average grain size of about 50 μm or less; and
>
> a catalyst including cobalt, the catalyst occupying at least a portion of the interstitial regions;
>
> wherein the unleached portion of the polycrystalline diamond table exhibits a coercivity of about 115 Oe to about 250 Oe;
>
> wherein the unleached portion of the polycrystalline diamond table exhibits a specific permeability less than about 0.10 $G\cdot cm^3/g\cdot Oe$; and
>
> a substrate bonded to the polycrystalline diamond table along an interfacial surface, the interfacial surface exhibiting a substantially planar topography;
>
> wherein a lateral dimension of the polycrystalline diamond table is about 0.8 cm to about 1.9 cm.
>
> **15**. A polycrystalline diamond compact, comprising:
>
> a polycrystalline diamond table, at least an unleached portion of the polycrystalline diamond table including:
>
> a plurality of diamond grains bonded together via diamond-to-diamond bonding to define defining interstitial regions, the plurality of diamond grains exhibiting an average grain size of about 50 μm or less; and
>
> a catalyst including cobalt, the catalyst occupying at least a portion of the interstitial regions;
>
> wherein the unleached portion of the polycrystalline diamond table exhibits:
>
> a coercivity of about 115 Oe to about 250 Oe;
>
> a specific magnetic saturation of about 10 $G\cdot cm^3/g$ to about 15 $G\cdot cm^3/g$; and

> a thermal stability, as determined by a distance cut, prior to failure in a vertical lathe test, of about 1300 m to about 3950 m; wherein a lateral dimension of the polycrystalline diamond table is about 0.8 cm or more.

As can be seen in the claim language above, to define the improved PDC, the asserted claims require certain properties for the PDC set forth in numerical thresholds. The intrinsic evidence indicates that the properties reflect the structure of the PDC.

Specifically, the "average grain size" refers to an average size of diamond grains. *See* JX-0002 at 5:8-18. In addition, the asserted claims recite numerical thresholds for magnetic and electrical properties of the PCD. The claimed magnetic and electrical properties are coercivity,[3] electrical conductivity,[4] specific magnetic saturation,[5] and specific permeability.[6]

The specification of the '502 patent teaches that coercivity, specific magnetic saturation, and specific permeability reflect the extent to which the diamond grains have bonded and formed large diamond grains thereby displacing the metal catalyst in the diamond matrix. *See,*

[3] Coercivity is the measurement of the magnetizing force required to return the magnetizing of PCD back to zero. *See* Order No. 23, at 27. Coercivity may be correlated with the average distance or "mean free path" between neighboring diamond grains of the PCD. JX-0002 at 5:40-49, 5:61-6:3. Thus, coercivity reflects how tightly the diamond grains are bonded together. *Id*.

[4] Electrical conductivity measures how conductive a PCD is, which is associated with both the amount of metal-solvent catalyst in the diamond microstructure and the continuity of the catalyst mesh between the diamond grains. JX-0002 at 4:41-49, 9:32-34. A PCD having a higher degree of diamond-to-diamond bonding has more pinched-off metal catalyst pathways and thus exhibits a lower average electrical conductivity. *Id*. at 4:41-49, 5:61-6:3, 7:53-8:5, 9:32-34, 9:63-10:3.

[5] Specific magnetic saturation represents a state in which an increase in the magnetizing force does not result in an increase in the magnetization of the material. *See* Order No. 23, at 29-30. Specific magnetic saturation is correlated with the amount of the metal-solvent catalyst in the PCD. JX-0002 at 5:35-39, 5:49-51.

[6] Specific permeability measures the ratio of specific magnetic saturation to coercivity. *See* JX-0002 at 4:47-49; Order No. 23, at 29.

e.g., '502 patent (JX-0003) at 3:65-4:12, 4:58-5:7. The specification of the '565 patent provides a similar disclosure regarding those properties but further teaches that electrical conductivity also reflects the extent to which the diamond grains have bonded and displaced the metal catalyst. *See*, *e.g*, JX-0002 at 4:34-54, 5:32-39, 22:44-47 ("Sensitivity of electrical conductivity measurements of PDC diamond tables of a given PCD microstructure may provide an excellent method for estimation and imaging of metal content in the diamond table.").[7]

Asserted claims such as claim 1 of the'565 patent and claim 15 of the '502 patent also require that the PDC satisfy specific parameters that are used for measuring cutting performance. The claimed performance parameters are G-ratio[8] and thermal stability.[9] The specifications correlate the increased cutting performance with the improved microstructure. *See, e.g.*, JX-0003 at 4:54-57 ("By maintaining the metal-solvent catalyst content below about 7.5 wt %, the PCD may exhibit a desirable thermal stability suitable for subterranean drilling applications."), 5:63-6:38; *see also* JX-0002 at 22:51-62 ("In fact, relatively lowered metal-solvent content in the PDC appears to substantially influence cutting performance. Therefore, it follows that the

[7] The specifications connect the claimed numerical thresholds for the magnetic and electrical properties to the improved process of making the PDC using a higher sintering pressure. *See* Table 1 of both patents (magnetic properties); JX-0002 at 4:58-64 (electrical conductivity).

[8] G-ratio is a measure of wear resistance that uses a vertical turret lathe (VTL) test to replicate drilling conditions by grinding the PDC against a large, rotating rock cylinder using a coolant. Tr. (Bertagnolli) at 75:17-77:22; Tr. (German) at 141:25-142:5; 7:13-14. It is measured as the ratio of the volume of workpiece cut to the volume of PCD worn away during a cutting process. JX-0002 at 7:2-5.

[9] Thermal Stability is a "dry VTL" measurement since it does not use a coolant. Tr. (German) at 158:24-159:12; JX-0003 at 6:14-38. It is "evaluated by measuring the distance cut in a workpiece prior to catastrophic failure, without using coolant, in a vertical lathe test (e.g., vertical turret lathe or a vertical boring mill)." JX-0002 at 7:24-28.

electrical conductivity, also dependent on metal-solvent catalyst content, may also be used as a quality characteristic for evaluating PDC cutting performance.”).

In short, both patents describe a problem solved by the inventors as providing an improved PDC. The invention, meanwhile, is described in terms reflecting its structure, including its microstructure quantified by various measurements (*e.g.*, grain size, coercivity, magnetic saturation).

II. THE ID’S SECTION 101 FINDINGS

The ID’s analysis focused on the ’565 patent and found the asserted claims of both the ’565 patent and ’502 patent ineligible under section 101 for the same reasons. At the first step of the two-part eligibility test, the ID observed the asserted claims of the ’565 patent “recite compositions of matter that are not found in nature.” ID at 102. The ID then continued by grouping claim features of the ’565 patent into categories and considering whether those categories are directed to a “result or effect.”

Specifically, the ID observed that the claims recite “certain structural and design features (for example, a particular grain size and a catalyst), performance measures (G-Ratio in claim 1 and its dependent claims and thermal stability in claim 18), and side effects (the various electrical and magnetic parameters).” *Id*. at 104; *see also id.* at 100. The ID found the structural and design features are “not problematic” under *Alice* but the performance measure and side effects “are problematic.” ID at 104-105. The ID explained that the performance measures are problematic because they “incorporate the goal or result of a particular measure of wear resistance (*i.e*., G-Ratio) or thermal resilience (*i.e*., thermal stability), however achieved.” *Id*. at 105. The ID explained that the side effect features (*i.e*., the various electrical and magnetic parameters) are problematic because they are “an indirect measure of the effectiveness of other design choices and manufacturing variables” and “imperfect proxies for unclaimed features.” *Id*.

at 103, 105. The ID also explained: "A low electrical conductivity is not a desirable feature as such; it is just a result of other desirable features." *Id*. at 103.

The ID found that the claims of the '565 and '502 patents also fail *Alice* step two because they "invoke[] well-understood, routine, [and] conventional components to apply the abstract idea[s]" recited in the claims. *Id.* at 110.

On review, the Majority affirms the ID and clarifies the identification of the abstract idea. The Majority finds that the asserted claims are directed to the abstract idea of "PDCs that achieve the claimed performance measures and desired magnetic and electrical results, which the specifications claim are derived from enhanced diamond-to-diamond bonding."

For the reasons explained below, I dissent from the Commission's decision to affirm the ID's section 101 determination.

III. DISCUSSION

A. Patent-Eligibility under Section 101

Section 101 of the Patent Act defines the subject matter eligible for patent protection. It provides:

> Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title.

35 U.S.C. § 101. It has long been established that the expansive language of § 101 provides a broad scope for patent eligibility. *See Diamond v. Chakrabarty*, 447 U.S. 303, 308 (1980).

Within § 101's expansive language, the Supreme Court has recognized "an important implicit exception: Laws of nature, natural phenomena, and abstract ideas are not patentable." *Ass'n for Molecular Pathology v. Myriad Genetics, Inc.,* 569 U.S. 576, 589 (2013). The Court has described the concern that drives this exclusionary principle as one of pre-emption. "Laws of nature, natural phenomena, and abstract ideas are . . . the basic tools of scientific and technological work." *Id*. "[M]onopolization of those tools through the grant of a patent might tend to impede innovation more than it would tend to promote it," thereby thwarting the primary object of the patent laws. *Mayo Collaborative Servs. v. Prometheus Labs., Inc.,* 566 U.S. 66, 71 (2012).

At the same time, the Court has cautioned lower tribunals to "tread carefully in construing this exclusionary principle lest it swallow all of patent law." *Alice Corp. Pty. Ltd. v. CLS Bank Int'l*, 573 U.S. 208, 217 (2014). At some level, "all inventions . . . embody, use, reflect, rest upon, or apply laws of nature, natural phenomena, or abstract ideas." *Id*. Thus, an invention is not rendered ineligible for patent protection simply because it involves an abstract concept. *Id*. (citing *Diamond v. Diehr,* 450 U.S. 175, 187 (1981)). "'[A]pplication[s]' of such concepts 'to a new and useful end' . . . remain eligible for patent protection." *Alice*, 573 U.S. at 217 (citing *Gottschalk v. Benson,* 409 U.S. 63, 67 (1972)).

With these concerns in mind, Supreme Court precedent articulates a two-step framework for distinguishing patents that claim laws of nature, natural phenomena, or abstract ideas from those that claim patent-eligible applications of those concepts. *First*, a court must "determine whether the claims at issue are directed to [a] patent-ineligible concept[]." *Alice*, 573 U.S. at 217. *Second*, if the claims are directed to a patent-ineligible concept, the court must then determine whether there are additional elements of the claim that contain an "inventive concept" sufficient to "transform" the claimed matter into a patent-eligible application. *Id.* at 217-218.

B. Application of *Alice* Step One

The ID's step-one abstractness determination turns on grouping the claim features into categories and considering whether those individual categories are directed to a "result or effect." As explained below, the "problematic" results and effects which the ID identifies (*i.e.*, the measurements of PDC properties) are not the sort of results Federal Circuit caselaw has called into question. Rather, the specifications (and other record evidence) indicate that they are measurements that reflect structure of a composition of matter. When the claim elements are considered as whole, I do not believe that any of the asserted claims are directed to an abstract idea.

1. The Asserted Claims Are Directed To A Composition of Matter

One only need to look at the language of the claims to observe that they are directed to measurable composition of matter for which eligibility should be routine. The claims recite, *inter alia*, a "polycrystalline diamond compact" comprising a "polycrystalline diamond table" with a "catalyst occupying at least a portion of the interstitial regions" wherein an "unleached portion" of the table includes certain measurable properties. All of the asserted claims recite specific ranges of average diamond "grain size" and measurable magnetic properties related to the diamond structure. Asserted claims also include specific ranges for "average electrical conductivity," "G-Ratio" (*e.g.*, at least about 4.0 x 106), "thermal stability" (*e.g.*, at least of about 1300 m), and the "lateral dimension of the polycrystalline diamond table."

The specifications provide further insight into the nature of the claims. The specifications describe "nucleation and growth" of diamond between diamond particles during the sintering process, which impacts the structure of the PCD at the microscopic level by forming big diamond grains that pinch-off cobalt between diamond particles. JX-0002 at 7:53-61. The specifications disclose that the claimed average grain size is a structural threshold with the size being 50 μm or less, or 30 μm or less. *See id.* at 5:8-18. The specifications further disclose that the claimed magnetic and electrical properties reflect the microstructure of the PCD. *See, e.g.,* JX-0003 at 3:65-4:12 (embodiments exhibit enhanced diamond-to-diamond bonding and the magnetic properties reflect nucleation and growth of diamond particles); JX-0003 at 5:22-27

("The PCD defined collectively by the bonded diamond grains and the metal-solvent catalyst may exhibit . . . a coercivity of about 115 Oe or more and a metal-solvent catalyst content of less than about 7.5 wt % as indicated by a specific magnetic saturation of about 15 G·cm^3/g or less."); JX-0002 at 5:32-39 ("Many physical characteristics of the PCD may be determined by measuring certain magnetic and electrical properties of the PCD because the metal-solvent catalyst may be ferromagnetic."); JX-0002 at 22:44-47 ("Sensitivity of electrical conductivity measurements of PDC diamond tables of a given PCD microstructure may provide an excellent method for estimation and imaging of metal content in the diamond table.").

For example, as the specifications explain, measured coercivity is a corollary of "[t]he mean free path between neighboring diamond grains," which in turn is "indicative of the extent of diamond-to-diamond bonding." JX-0002 at 5:40-48. Similarly, specific magnetic saturation is indicative of "the amount of the metal-solvent catalyst present." *Id*. at 5:35-39. Electrical conductivity as disclosed in the '565 patent measures how conductive a PCD is, which is associated with both the amount of metal-solvent catalyst in the diamond microstructure and the continuity of the catalyst mesh between the diamond grains. *Id*. at 4:41-49, 5:64-6:3, 9:32-34, 15:26-31.

The specifications further disclose that the improved PCD results in increased cutting performance, which is measured by G-ratio and thermal stability. *See, e.g.,* JX-0003 at 4:54-57, 5:63-6:38; *see also* JX-0002, 4:1-4, 15:49-61, 22:51-62. The specifications associate the claimed G-ratio and thermal stability measurements with the PCD microstructure. *Id*.

Thus, it is undisputed that the specifications associate the claimed properties with the PCD structure. In fact, the Majority agrees that "[a]s for the electrical and magnetic properties of a PCD, there is no dispute that the presence of cobalt or other metal-solvent catalyst in the PCD is measurable." However, the Majority does not explain their conclusion that the claimed properties do not define a "specific microstructure." That conclusion seems inconsistent with the intrinsic evidence and the Majority's concession that the electrical and magnetic properties reflect the presence of cobalt or other metal-solvent catalyst in the PCD.[10]

Labeling certain claim elements merely as "performance standards," "results," "side effects," or "not a design choice," in my view, fails to appreciate that the claimed parameters are concrete, objective measurements for defining the invention and which reflect the diamond microstructure. Many properties of patented materials could be described the same way. As is often the case in materials science and chemistry, intrinsic properties like density, pH, conductivity, and melting point result from other design choices, such as the choice of chemical inputs, processing parameters, and finishing steps. The claimed PDC involves a composition of matter that the inventors characterized based on *what it is*. That a particular material property of this composition of matter "results" from other design choices does not render it abstract.[11]

2. The Precedent Cited By Majority Does Not Support Finding The Claims Ineligible As Directed To An Abstract Idea

Given that the abstract idea exception is a narrow, court-made exception to the language of § 101, we should tread carefully before extending the exception beyond the subject matter that the courts themselves have identified as being abstract. A manufactured composition of matter is

[10] Similarly, the Majority's analysis under *Alice* step 2 finding the claimed properties to be "results-oriented" and "conventional" rests on the same conclusion. If the properties reflect structure, they are not results-oriented or conventional claim elements.

[11] The Majority cites USS's expert testimony where he agreed the claimed properties are the result of the sintering conditions and input materials that went into manufacturing the PDC. *See* Tr. (German) at 1338:24-1339:4. The testimony is not inconsistent with the intrinsic evidence that those properties reflect the structure of the PDC. The idea that properties of a material may result from manufacturing conditions is unremarkable.

a class of invention that has historically been patent eligible. *See, e.g.*, *Chakrabarty*, 447 U.S. at 308-09 (explaining that the Patent Act of 1793 defined statutory subject matter as "any new and useful art, machine, manufacture, or composition of matter, or any new or useful improvement [thereof]"); *Diehr*, 450 U.S. at 184 n.8 (observing that "[i]ndustrial processes" and "new machines and new compositions of matter" have "historically been eligible to receive the protection of our patent laws"); *see also Nat. Alternatives Int'l, Inc. v. Creative Compounds, LLC*, 918 F.3d 1338, 1347-49 (Fed. Cir. 2019) (holding product claims to dietary supplement to be eligible). The ID and Majority have identified no case, nor do the Respondents cite any, where a claim to a composition of matter has been deemed ineligible as an abstract idea.

The ID and Majority cite as support several Federal Circuit decisions involving claims for processing information using software on generic computer components – the "familiar class of claims" that often receive eligibility scrutiny under the *Alice* line of cases.[12] *See Elec. Power Group LLC v. Alstom S.A.*, 830 F.3d 1350, 1353 (Fed. Cir. 2016). I believe the reliance on those cases is misplaced. The "results" or "effects" which the Majority identifies (*i.e.*, the measurement of PDC properties) as problematic are *not* the sort of results that have been called into question in the software functionality computer cases.

Rather, those cases stand for the principle that "information as such is an intangible," and

[12] The generic computer functionality cases cited by the ID and Majority include: *Apple, Inc. v. Ameranth, Inc.*, 842 F.3d 1229 (Fed. Cir. 2016) (claims related to software for information management and the result of generating menus on a display); *Free Stream Media Corp. v. Alphonso Inc*., 996 F.3d 1355 (Fed. Cir. 2021) (claims related to software for gathering information and providing the result of target advertisements to a mobile device user); *Elec. Power Group LLC v. Alstom S.A*., 830 F.3d 1350 (Fed. Cir. 2016) (claims related to software for monitoring an electrical grid); *Interval Licensing LLC v. AOL, Inc.*, 896 F.3d 1335 (Fed. Cir. 2018) (claims related to software for information acquisition, organization, and display); *Yu v. Apple Inc.*, 1 F.4th 1040 (Fed. Cir. 2021) (claims related to processing information to produce a digital image); *ChargePoint, Inc. v. SemaConnect, Inc.*, 920 F.3d 759 (Fed. Cir. 2019) (claims related to functionality of communicating over a generic network).

hence abstract. *Id.*; *SAP America, Inc. v. Investpic, LLC*, 898 F.3d 1161, 1167 (Fed. Cir. 2018). Therefore, "merely presenting the *results* of abstract processes of collecting and analyzing information, without more . . . is abstract." *Elec. Power Group*, 830 F.3d at 1354 (emphasis added). As the Federal Circuit has explained, ineligible patents "claiming only a result" of an abstract process and which lack specificity must be "contrast[ed]" with eligible patents claiming "physical-realm improvements." *SAP America*, 898 F.3d at 1167. The claimed PDC is a "physical-realm" improvement defined by specific, measurable parameters.

The Majority opinion cites *Alice* and *Yu v. Apple Inc.*, 1 F.4th 1040 (Fed. Cir. 2021), to argue that the fact that asserted claims involve physical phenomena is "beside the point." Specifically, the quote from *Alice* cited by the Majority includes the statement that "[t]he fact that a computer 'necessarily exist[s] in the physical, rather than purely conceptual, realm,' is beside the point." 573 U.S. at 224. That statement merely stands for the common-sense proposition that the claimed methods are not patent eligible just because they operate in the tangible world. This makes sense because generic computers used to perform software functionality steps are tangible objects. But taking *Alice's* unremarkable statement and applying it to the improved composition of matter at issue here to find it abstract is not supported by the decision.

Yu v. Apple is similar to *Alice* and the other cases involving abstract steps performed on generic computer components. The claim at issue in *Yu* involved computing functions – *i.e.*, processing information using conventional components of a digital camera. It is true that the conventional digital camera components operate in the tangible world just like the generic computer referenced in *Alice*. But, similar to the point above with *Alice*, that does not support finding the improved PDC to be abstract.

The Majority opinion's reliance on *American Axle & Mfg., Inc. v. Neapco Holdings LLC*, 967 F.3d 1285, 1302 (Fed. Cir. 2020), is also misplaced. In *American Axle*, the claims at issue recited a manufacturing method directed to the "result" of applying a law of nature – Hook's law. The inventor's own deposition testimony confirmed that the claimed "tuning" element of the method claim merely required the use of Hooke's law. *Id*. at 1294. There was no structural claim at issue nor any specific numerical range to limit the application of Hooke's law. *Id*. at 1295. Notably, the Federal Circuit explained that "[w]hat is missing is any physical structure or steps for achieving the claimed result" of applying natural law. Here, in contrast, the advance of the claimed invention is a *physical structure* described by various measured parameters.[13]

The Majority also relies on the Supreme Court decision in *O'Reilly v. Morse,* 56 U.S. (15 How.) 62 (1853). The claim held ineligible in *O'Reilly* is distinguishable on its face to those at issue in this investigation. The claim in *O'Reilly* was not limited to any particular machinery or other structure and was instead broadly directed to the use of electromagnetism, "however developed," for transmitting information. *Id*. at 112.

The Majority additionally cites as support the Supreme Court decision in *Funk Brothers Seed Co. v. Kalo Inoculant Co.*, 333 U.S. 127 (1948). *Funk Brothers* addressed the eligibility of claims directed to a natural phenomenon, *i.e.*, a mixture of naturally occurring strains of bacteria. *Id*. at 128–30. The Court concluded that this mixture of bacteria strains was not patent eligible because the patentee did not alter the bacteria in any way. *Id*. at 132. In the current investigation, there is no dispute that the asserted claims recite compositions of matter that are

[13] *American Axle* instructs that product claims should be limited to structures specified at some level of concreteness. 967 F.3d at 1302. The parameters recited in the claims, which are objective and measurable, specify structure in a concrete way. *See, e.g,* JX-0002 at 5:32-39; Tr. (German) at 1243:12-23.

not found in nature. ID at 102. Thus, Respondents are not arguing, the Majority does not find, that the asserted claims are directed to a natural phenomenon. Although the claimed bacteria in *Funk Brothers* were naturally occurring organisms, they were certainly not abstract ideas. In my view, *Funk Brothers* does not support finding the claims at issue here are directed to an abstract idea.[14]

Unlike the Majority opinion, I do not see there being any preemption concerns. *ChargePoint, Inc. v. SemaConnect, Inc.,* cited by the Majority, involved claims related to generic network communication functionality applied to any electric vehicle charging station. In finding the claims directed to an abstract idea, the Court explained that communication over a network is a "building block of the modern economy" and that claim 1 would broadly "preempt the use of any networked charging stations." 920 F.3d at 769, 773.

In contrast to *ChargePoint*, there is no evidence that the asserted claims would broadly preempt all PDCs. In fact, the evidence indicates that PDC manufacturers are capable of manufacturing PDCs that do not read on the asserted claims. For example, during the pendency of this investigation, SF Diamond developed A-Series redesign products, which the ID found to

[14] I also do not believe that *Le Roy v. Tatham*, 55 U.S. 156 (1852), supports the Majority's decision today. *Le Roy* found the claim at issue eligible. *Le Roy* stands for the proposition that an application of a law of nature to a new and useful end may be deserving of patent protection.

Further, *Certain Light-Emitting Diode Products, Fixtures, and Components Thereof,* Inv. No. 337-TA-1213, cited by the ID and Majority is also distinguishable. There, the claim was directed to energy efficiency of lighting devices having a wall plug efficiency of at least 85 lumens/watt "however achieved." Final ID at 22 (Aug. 25, 2021), *aff'd by* Comm'n Op. (Jan. 14, 2022). The asserted claim recited only one structure, and only in the most generic terms: a "solid state light emitter." Final ID at 22. It was indisputably a conventional component performing conventional function of producing light when supplied with electricity. *Id*. at 25. In contrast, in the current investigation the asserted claims are structurally defined with concrete, measurable parameters.

be non-infringing. *See* ID at 39-43, 55, 68, 160. Further, the specifications disclose polycrystalline diamond in Tables II-III that have magnetic properties outside the claimed ranges. *See, e.g.*, JX-0002 at tbls.II-III.[15]

The Majority opinion criticizes the patentee for not incorporating manufacturing steps or equipment into the asserted claims. However, it is well-understood that product claims, unlike product-by-process claims, do not need to recite a method of achieving the claimed product. *See Vanguard Prods. Corp. v. Parker Hannifin Corp.*, 234 F.3d 1370, 1372 (Fed. Cir. 2000) ("The method of manufacture, even when cited as advantageous, does not of itself convert product claims into claims limited to a particular process."). The Patent Act includes provisions for challenging eligible patent claims drafted in an overly broad fashion (section 112), that lack novelty (section 102), and that involve the combination of familiar elements according to known methods yielding predictable results (section 103). *See Diehr*, 450 U.S. at 188-90 ("The question therefore of whether a particular invention is novel is wholly apart from whether the invention falls into a category of statutory subject matter."); *Data Engine Techs. LLC v. Google LLC*, 906 F.3d 999, 1011 (Fed. Cir. 2018) ("The eligibility question is not whether anyone has ever used tabs to organize information. That question is reserved for §§ 102 and 103.").

The outcome in this case – finding claims reciting a specific, definable composition of

[15] As support for preemption, the Majority opinion identifies two infringing products that it finds were sintered at a pressure less than 7.5 GPa. Whether *two* infringing PDC products practice an unclaimed cell pressure parameter – especially when the record demonstrates that there are non-infringing PDCs available – does not in my view demonstrate monopolizing a "building block" of the economy or "basic tools of scientific and technological work." *See Alice*, 573 U.S. at 216-217; *compare* CX-0383C (listing all tested products), with ID at 10-11 (listing only the accused products). If claims do not preempt a "building block" of human ingenuity or "basic tools of scientific and technological work," than breadth of claiming is addressed by other statutory provisions. *See infra*.

matter as ineligible – suggests that the ID and Majority have strayed from the preemption concerns that motivate the judicial exception to patent eligibility. The claims at issue here are far removed from the concern expressed in *Alice* whereby a claim states an abstract idea while adding the words "apply it with a computer." 573 U.S. at 223.

For all the reasons explained above, I find that the asserted claims are not directed to an abstract idea, but instead to eligible subject matter. Because I believe the claims are not directed to an abstract idea, there is no need to proceed to *Alice* step two.

Because that I would reverse the ID's section 101 findings, I would also reverse the ID's finding of no violation in this investigation for the asserted claims that were not otherwise found invalid under section 102.[16] Specifically, I would find a violation based on infringement of claims 1, 2, 11, 15, and 21 of the '502 patent.

[16] I would affirm the ID's conclusion that USS established the economic prong of the domestic industry requirement for the '565 patent and the '502 patent under subsections (A), (B), and (C) of 337(a)(3). I would, however, not adopt all of the ID's subsidiary findings on the economic prong, such as ID's findings excluding administrative overhead investments and costs associated with "indirect labor." *See* ID at 147, 152.

US010508502B2

(12) **United States Patent**
Bertagnolli et al.

(10) **Patent No.: US 10,508,502 B2**
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(54) **POLYCRYSTALLINE DIAMOND COMPACT**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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See application file for complete search history.

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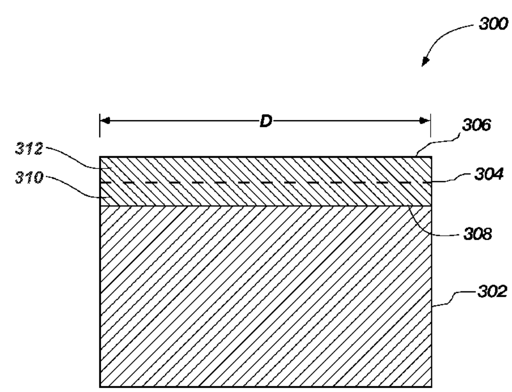
(57) **ABSTRACT**

In an embodiment, a method of fabricating a polycrystalline diamond compact is disclosed. The method includes sintering a plurality of diamond particles in the presence of a metal-solvent catalyst to form a polycrystalline diamond body; leaching the polycrystalline diamond body to at least partially remove the metal-solvent catalyst therefrom, thereby forming an at least partially leached polycrystalline diamond body; and subjecting an assembly of the at least partially leached polycrystalline diamond body and a cemented carbide substrate to a high-pressure/high-temperature process at a pressure to infiltrate the at least partially leached polycrystalline diamond body with an infiltrant. The pressure of the high-pressure/high-temperature process is less than that employed in the act of sintering of the plurality of diamond particles.

28 Claims, 12 Drawing Sheets



Related U.S. Application Data

continuation of application No. 13/623,764, filed on Sep. 20, 2012, now Pat. No. 8,616,306, which is a continuation of application No. 12/690,998, filed on Jan. 21, 2010, now Pat. No. 8,297,382, which is a continuation-in-part of application No. 12/244,960, filed on Oct. 3, 2008, now Pat. No. 7,866,418.

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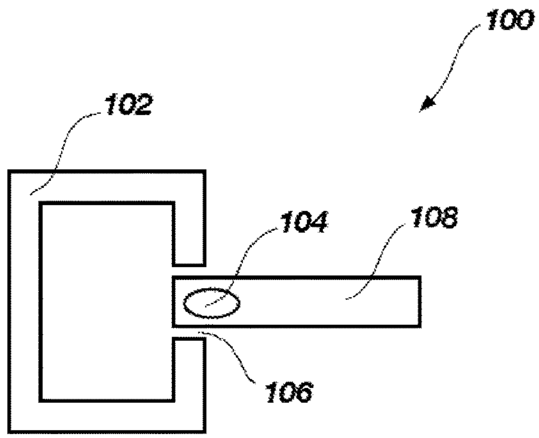

100
102
104
108
106

FIG. 1A

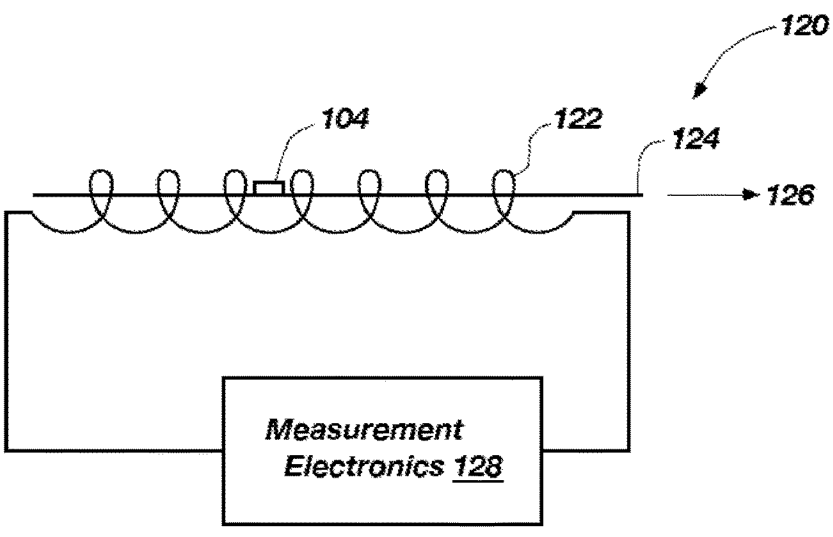

120
104
122
124
126
Measurement
Electronics 128

FIG. 1B

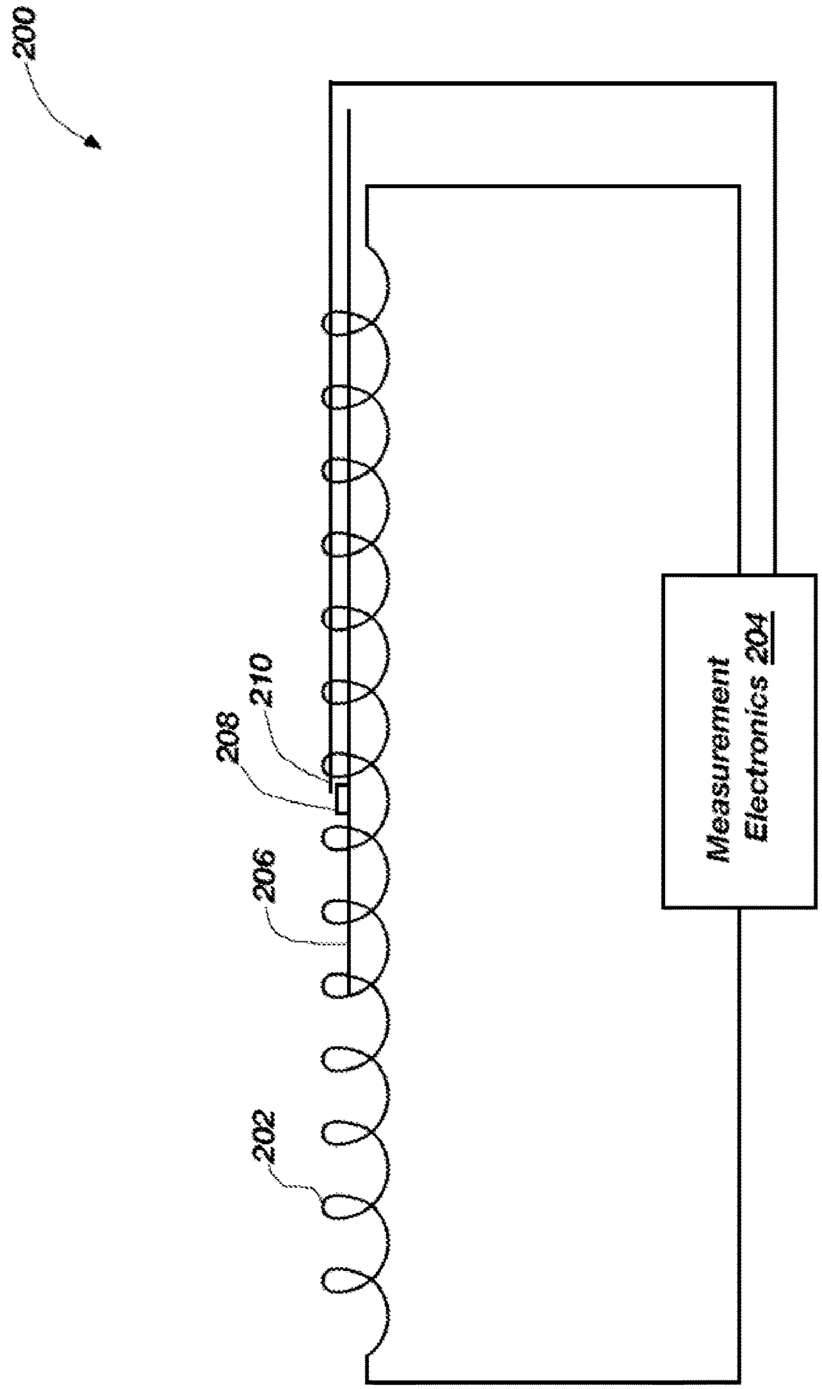


FIG. 2

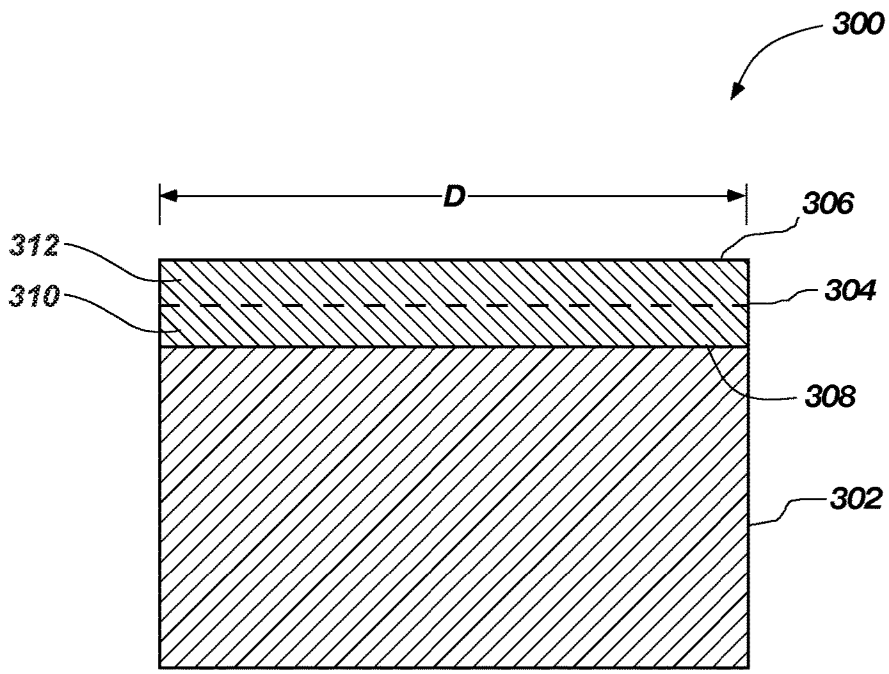


FIG. 3A

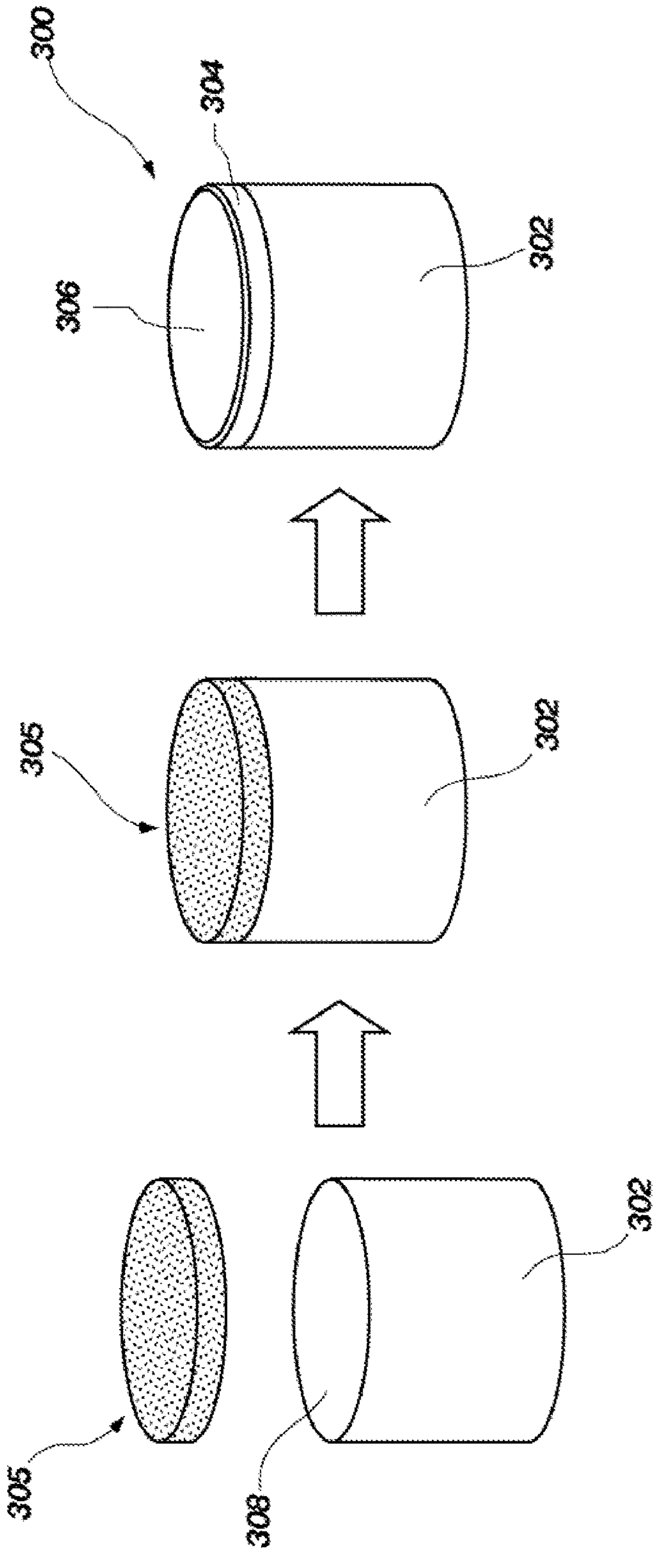


FIG. 3B

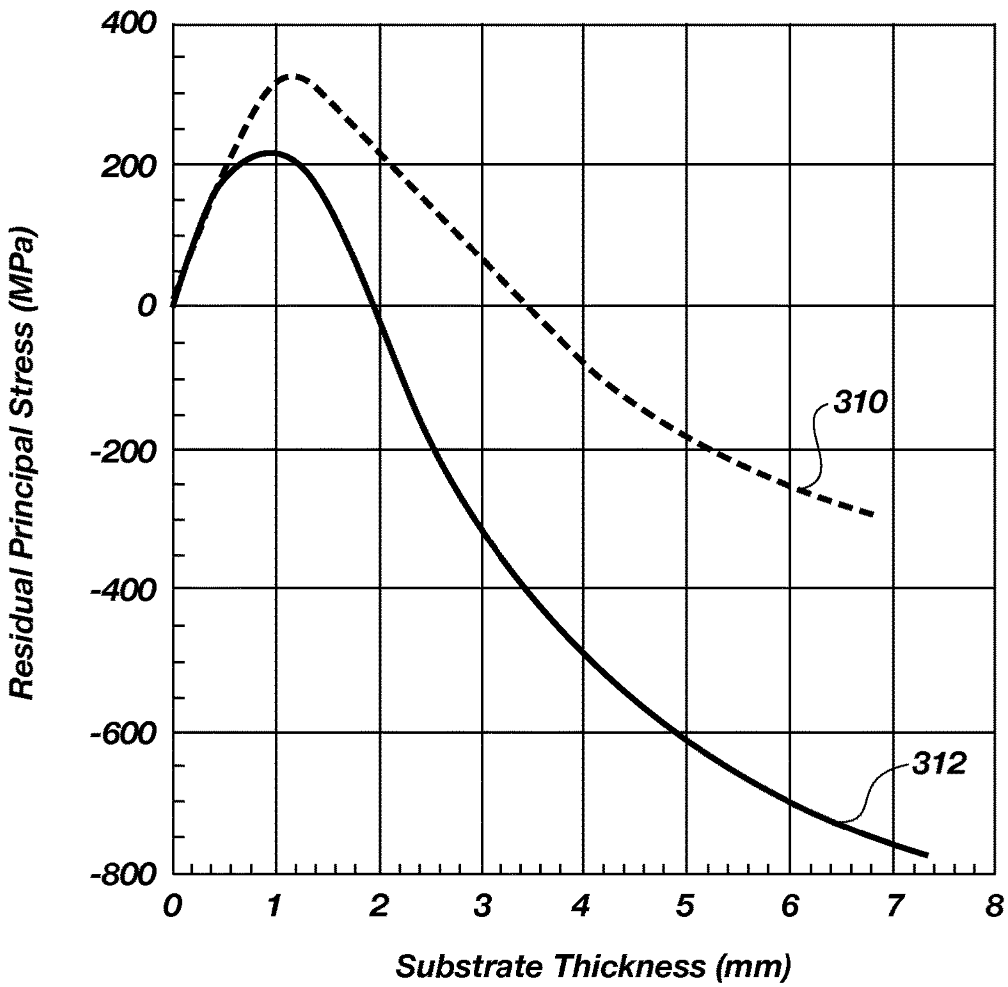
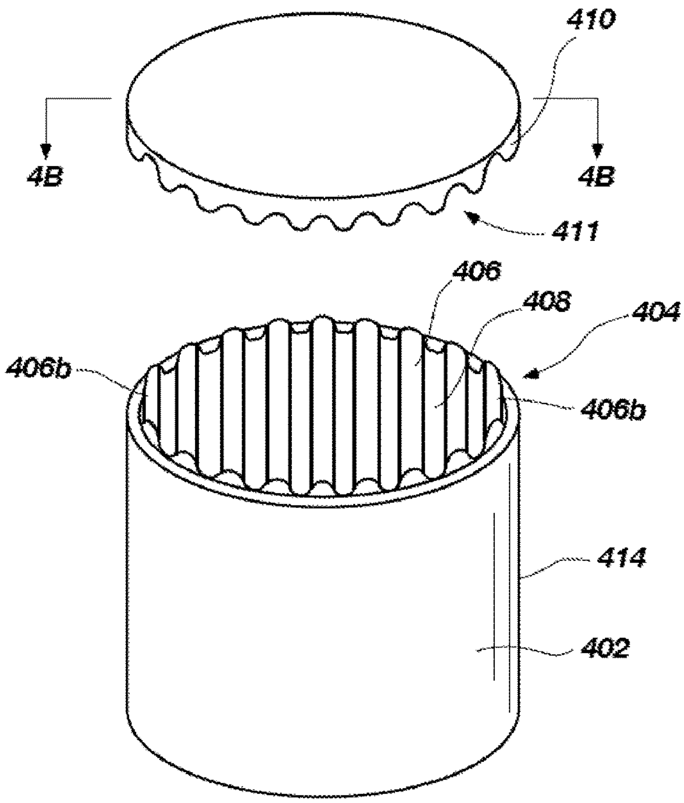

400
200
0
-200
-400
-600
-800
Residual Principal Stress (MPa)
0
1
2
3
4
5
6
7
8
Substrate Thickness (mm)
310
312

FIG. 3C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4B
4B
411
406
408
404
406b
406b
414
402

FIG. 4A

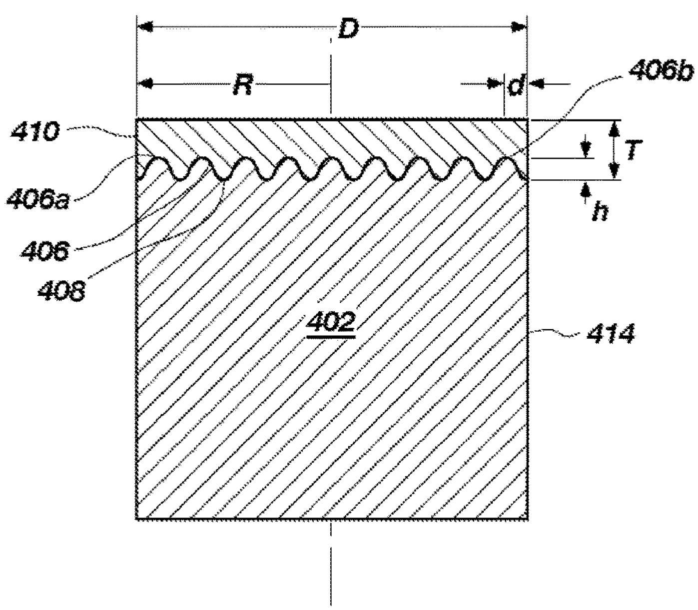
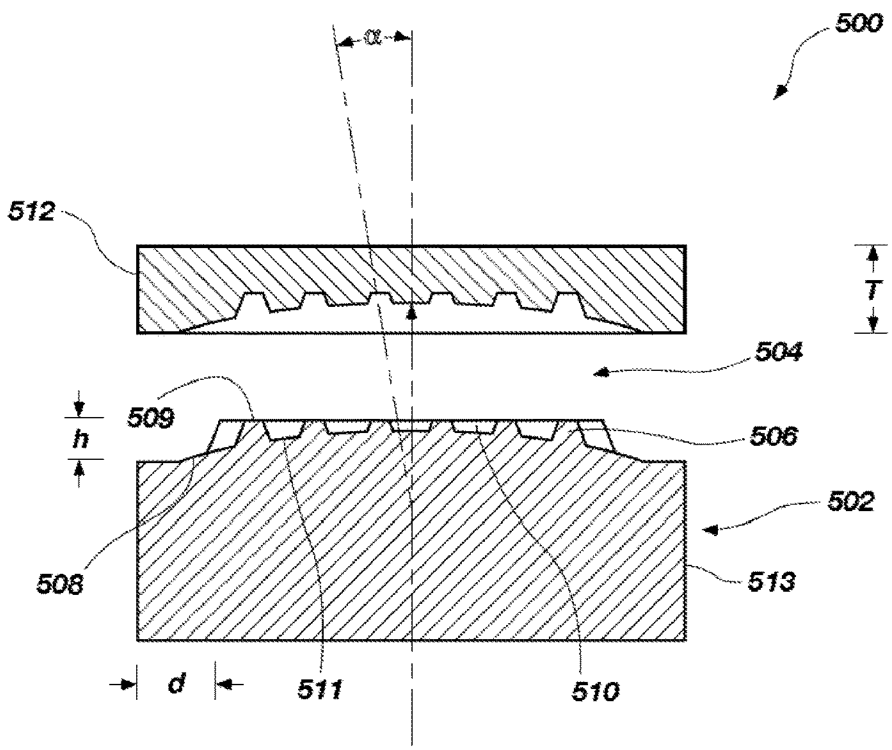
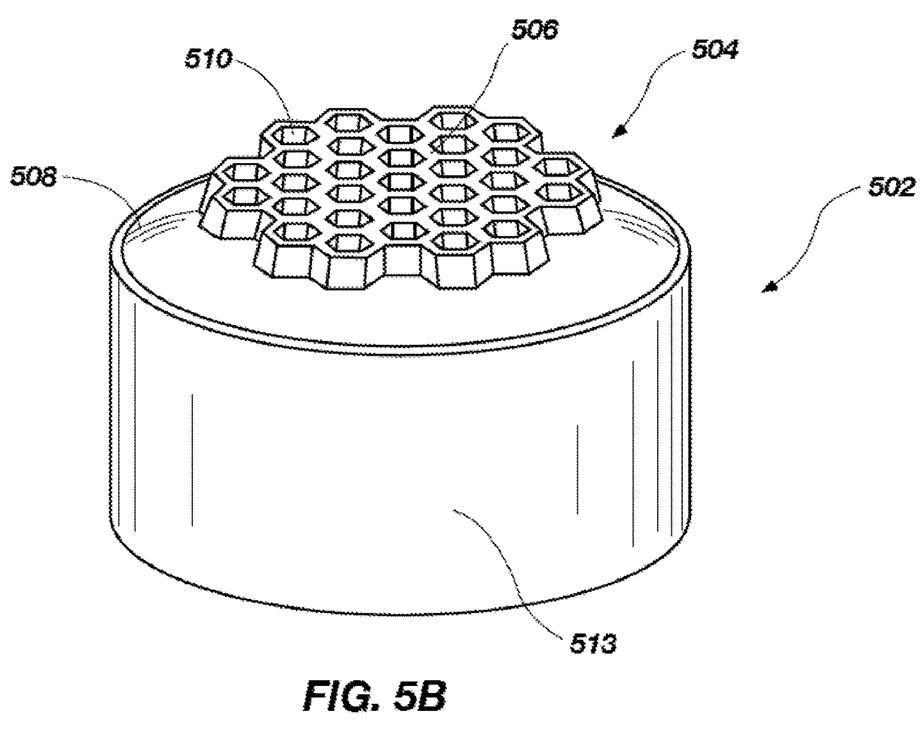

D
R
d
406b
410
T
406a
h
406
408
402
414

FIG. 4B



500
α
512
T
504
509
h
506
502
508
513
d
511
510

FIG. 5A



506
510
504
508
502
513

FIG. 5B

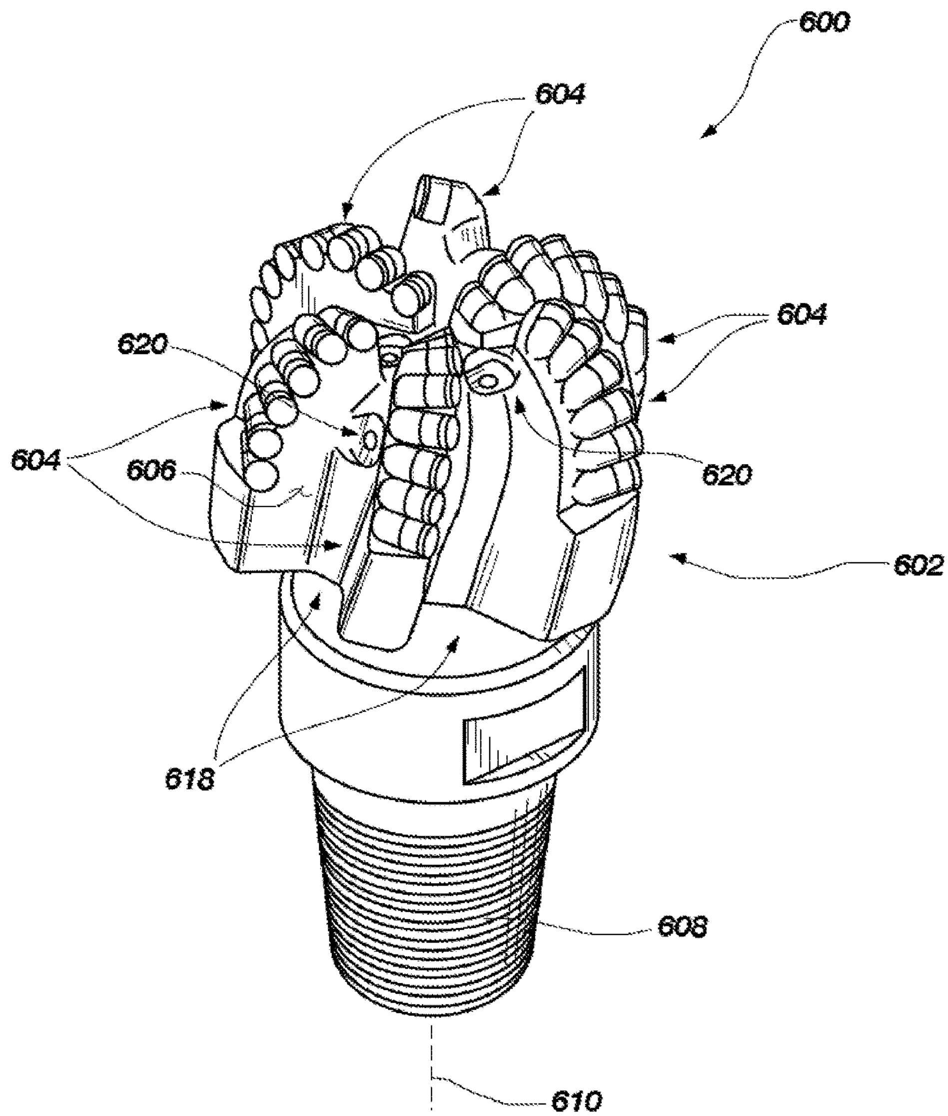
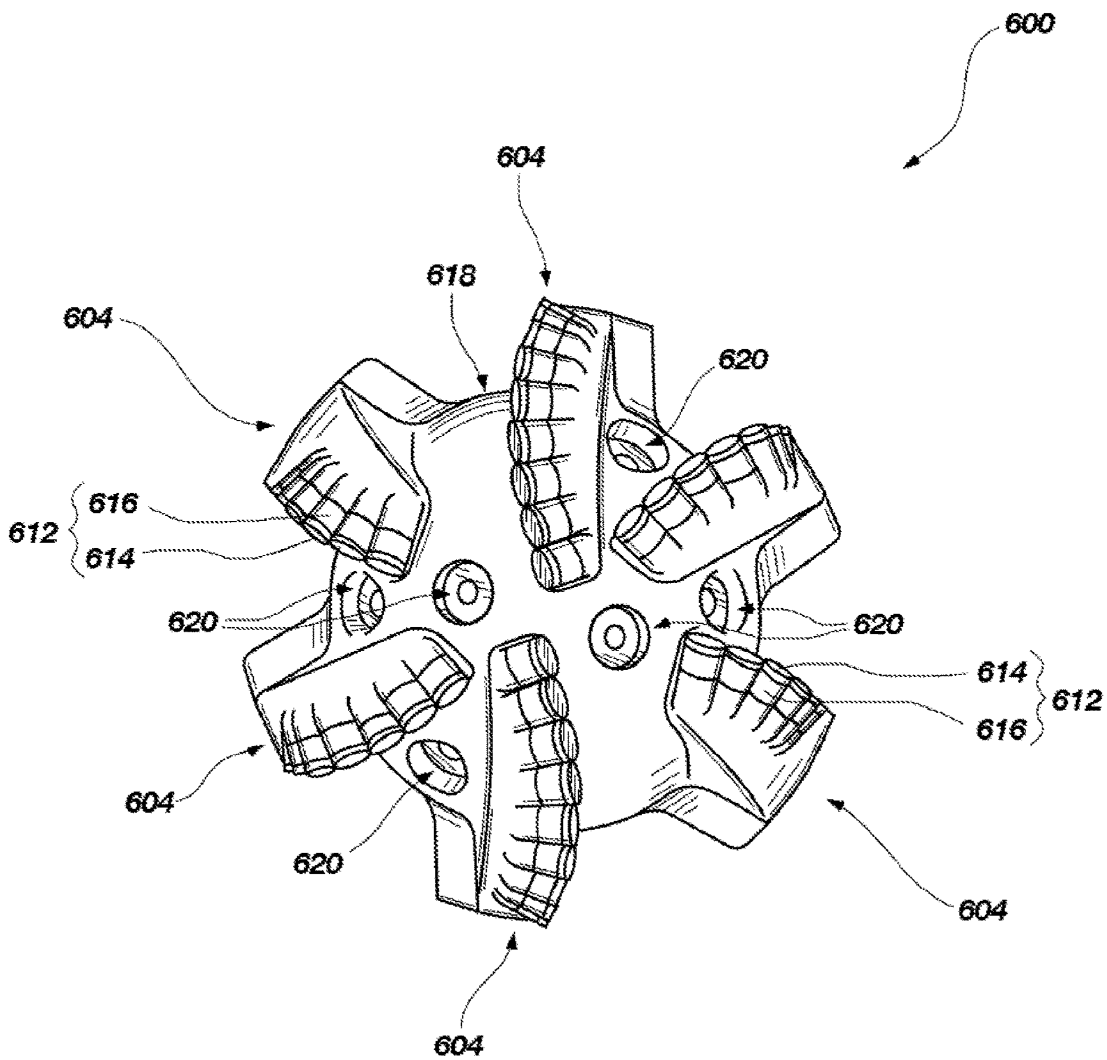


FIG. 6A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604
618
604
620
616
612
614
620
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614
612
616
604
620
604
604

FIG. 6B

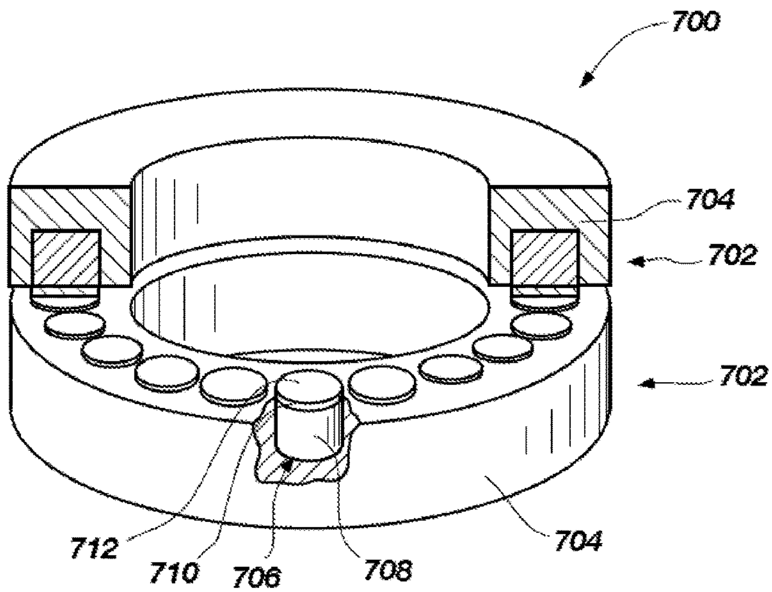

FIG. 7

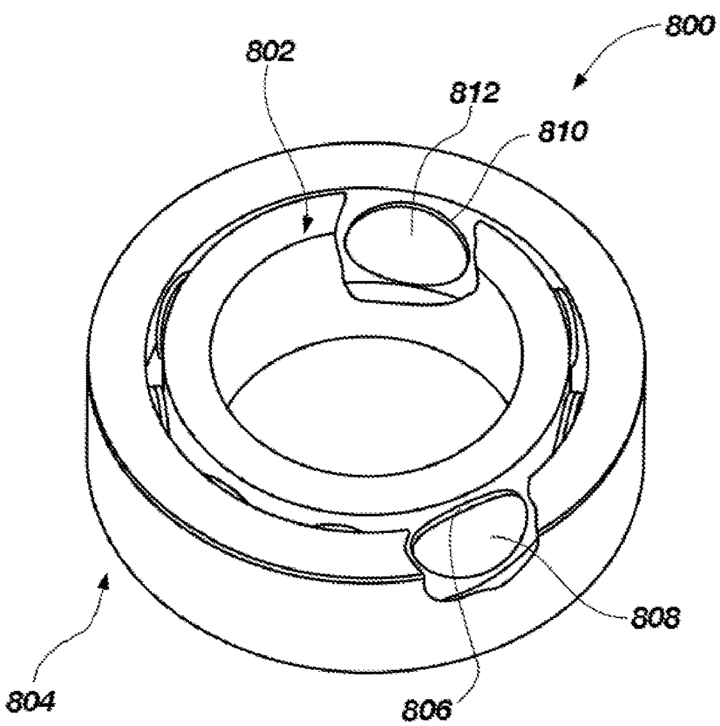

FIG. 8

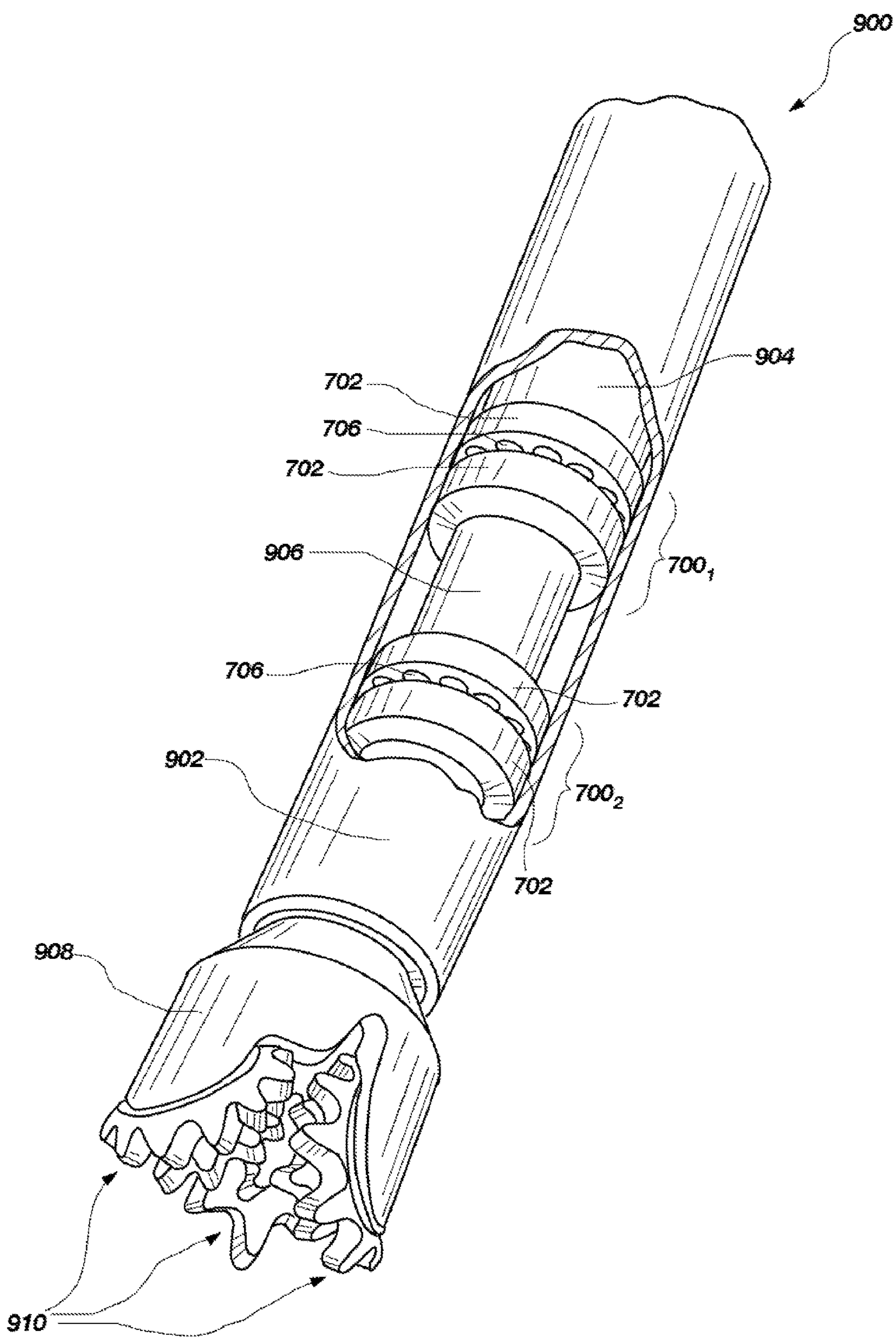

FIG. 9

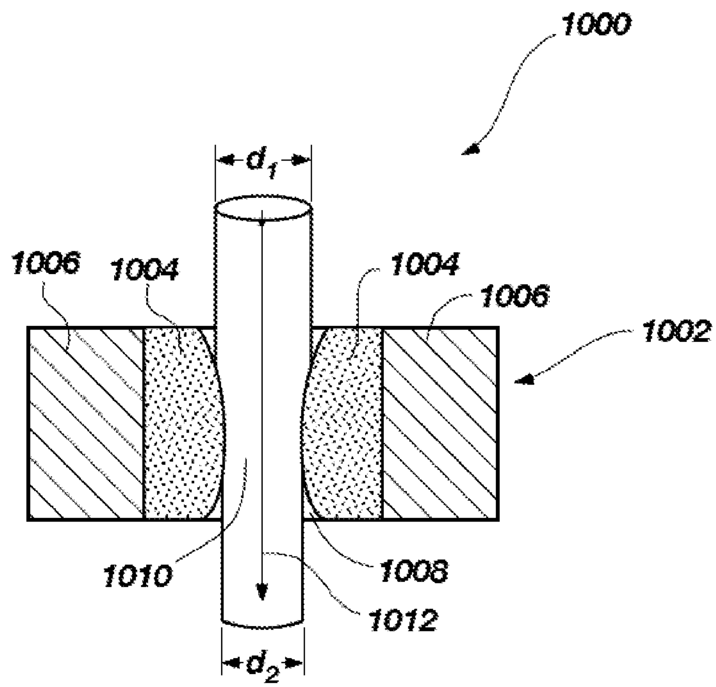

FIG. 10

POLYCRYSTALLINE DIAMOND COMPACT

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 13/789,099 filed on 7 Mar. 2013, which is a continuation of U.S. application Ser. No. 13/623,764 filed on 20 Sep. 2012 (now U.S. Pat. No. 8,616,306 issued on 31 Dec. 2013), which is a continuation of U.S. patent application Ser. No. 12/690,998 filed on 21 Jan. 2010 (now U.S. Pat. No. 8,297,382 issued on 30 Oct. 2012), which is a continuation-in-part of U.S. patent application Ser. No. 12/244,960 filed on 3 Oct. 2008 (now U.S. Pat. No. 7,866,418 issued on 11 Jan. 2011), the disclosure of each of which is incorporated herein, in its entirety, by this reference.

BACKGROUND

Wear-resistant, superabrasive compacts are utilized in a variety of mechanical applications. For example, polycrystalline diamond compacts ("PDCs") are used in drilling tools (e.g., cutting elements, gage trimmers, etc.), machining equipment, bearing apparatuses, wire-drawing machinery, and in other mechanical apparatuses.

PDCs have found particular utility as superabrasive cutting elements in rotary drill bits, such as roller cone drill bits and fixed-cutter drill bits. A PDC cutting element typically includes a superabrasive diamond layer commonly referred to as a diamond table. The diamond table may be formed and bonded to a substrate using a high-pressure, high-temperature ("HPHT") process. The PDC cutting element may also be brazed directly into a preformed pocket, socket, or other receptacle formed in a bit body of a rotary drill bit. The substrate may often be brazed or otherwise joined to an attachment member, such as a cylindrical backing. A rotary drill bit typically includes a number of PDC cutting elements affixed to the bit body. A stud carrying the PDC may also be used as a PDC cutting element when mounted to a bit body of a rotary drill bit by press-fitting, brazing, or otherwise securing the stud into a receptacle formed in the bit body.

Conventional PDCs are normally fabricated by placing a cemented carbide substrate into a container with a volume of diamond particles positioned adjacent to the cemented carbide substrate. A number of such cartridges may be loaded into an HPHT press. The substrates and volume of diamond particles are then processed under HPHT conditions in the presence of a catalyst material that causes the diamond particles to bond to one another to form a matrix of bonded diamond grains defining a polycrystalline diamond ("PCD") table that is bonded to the substrate. The catalyst material is often a metal-solvent catalyst (e.g., cobalt, nickel, iron, or alloys thereof) that is used for promoting intergrowth of the diamond particles. For example, a constituent of the cemented carbide substrate, such as cobalt from a cobalt-cemented tungsten carbide substrate, liquefies and sweeps from a region adjacent to the volume of diamond particles into interstitial regions between the diamond particles during the HPHT process. The cobalt acts as a catalyst to promote intergrowth between the diamond particles, which results in formation of bonded diamond grains.

Because of different coefficients of thermal expansion and modulus of elasticity between the PCD table and the cemented carbide substrate, residual stresses of varying magnitudes may develop within different regions of the PCD table and the cemented carbide substrate. Such residual stresses may remain in the PCD table and cemented carbide substrate following cooling and release of pressure from the HPHT process. These complex stresses may be concentrated near the PCD table/substrate interface. Residual stresses at the interface between the PCD table and cemented carbide substrate may result in premature failure of the PDC upon cooling or during subsequent use under thermal stresses and applied forces.

In order to help reduce de-bonding of the PCD table from the cemented carbide substrate, some PDC designers have made the interfacial surface of the cemented carbide substrate that bonds to the PCD table significantly nonplanar. For example, various nonplanar substrate interfacial surface configurations have been proposed and/or used, such as a plurality of spaced protrusions, a honeycomb-type protrusion pattern, and a variety of other configurations.

SUMMARY

Embodiments of the invention relate to PCD exhibiting enhanced diamond-to-diamond bonding. In an embodiment, PCD includes a plurality of diamond grains defining a plurality of interstitial regions. A metal-solvent catalyst occupies at least a portion of the plurality of interstitial regions. The plurality of diamond grains and the metal-solvent catalyst collectively may exhibit a coercivity of about 115 Oersteds ("Oe") or more and a specific magnetic saturation of about 15 Gauss·cm^3/grams ("G·cm^3/g") or less.

In an embodiment, PCD includes a plurality of diamond grains defining a plurality of interstitial regions. A metal-solvent catalyst occupies the plurality of interstitial regions. The plurality of diamond grains and the metal-solvent catalyst collectively may exhibit a specific magnetic saturation of about 15 G·cm^3/g or less. The plurality of diamond grains and the metal-solvent catalyst define a volume of at least about 0.050 cm^3.

In an embodiment, a method of fabricating PCD includes enclosing a plurality of diamond particles that exhibit an average particle size of about 30 μm or less, and a metal-solvent catalyst in a pressure transmitting medium to form a cell assembly. The method further includes subjecting the cell assembly to a temperature of at least about 1000° C. and a pressure in the pressure transmitting medium of at least about 7.5 GPa to form the PCD.

In an embodiment, a PDC includes a PCD table bonded to a substrate. At least a portion of the PCD table may comprise any of the PCD embodiments disclosed herein. In an embodiment, the substrate includes an interfacial surface that is bonded to the polycrystalline diamond table and exhibits a substantially planar topography. According to an embodiment, the interfacial surface may include a plurality of protrusions, and a ratio of a surface area of the interfacial surface in the absence of the plurality of provisions to a surface area of the interfacial surface with the plurality of protrusions is greater than about 0.600.

In an embodiment, a method of fabricating a PDC includes enclosing a combination in a pressure transmitting medium to form a cell assembly. The combination includes a plurality of diamond particles that exhibit an average particle size of about 30 μm or less positioned at least proximate to a substrate having an interfacial surface that is substantially planar. The method further includes subjecting the cell assembly to a temperature of at least about 1000° C. and a pressure in the pressure transmitting medium of at least about 7.5 GPa to form a PCD table adjacent to the substrate.

Further embodiments relate to applications utilizing the disclosed PCD and PDCs in various articles and apparatuses, such as rotary drill bits, bearing apparatuses, wire-drawing dies, machining equipment, and other articles and apparatuses.

Features from any of the disclosed embodiments may be used in combination with one another, without limitation. In addition, other features and advantages of the present disclosure will become apparent to those of ordinary skill in the art through consideration of the following detailed description and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings illustrate several embodiments of the invention, wherein identical reference numerals refer to identical elements or features in different views or embodiments shown in the drawings.

FIG. **1**A is a schematic diagram of an example of a magnetic saturation apparatus configured to magnetize a PCD sample approximately to saturation.

FIG. **1**B is a schematic diagram of an example of a magnetic saturation measurement apparatus configured to measure a saturation magnetization of a PCD sample.

FIG. **2** is a schematic diagram of an example of a coercivity measurement apparatus configured to determine coercivity of a PCD sample.

FIG. **3**A is a cross-sectional view of an embodiment of a PDC including a PCD table formed from any of the PCD embodiments disclosed herein.

FIG. **3**B is a schematic illustration of a method of fabricating the PDC shown in FIG. **3**A according to an embodiment.

FIG. **3**C is a graph of residual principal stress versus substrate thickness that was measured in a PCD table of a PDC fabricated at a pressure above about 7.5 GPa and a PCD table of a conventionally formed PDC.

FIG. **4**A is an exploded isometric view of a PDC comprising a substrate including an interfacial surface exhibiting a selected substantially planar topography according to an embodiment.

FIG. **4**B is an assembled cross-sectional view of the PDC shown in FIG. **4**A taken along line **4**B-**4**B.

FIG. **5**A is cross-sectional view of a PDC comprising a substrate including an interfacial surface exhibiting a selected substantially planar topography according to yet another embodiment.

FIG. **5**B is an isometric view of the substrate shown in FIG. **5**A.

FIG. **6**A is an isometric view of an embodiment of a rotary drill bit that may employ one or more of the disclosed PDC embodiments.

FIG. **6**B is a top elevation view of the rotary drill bit shown in FIG. **6**A.

FIG. **7** is an isometric cutaway view of an embodiment of a thrust-bearing apparatus that may utilize one or more of the disclosed PDC embodiments.

FIG. **8** is an isometric cutaway view of an embodiment of a radial bearing apparatus that may utilize one or more of the disclosed PDC embodiments.

FIG. **9** is a schematic isometric cutaway view of an embodiment of a subterranean drilling system including the thrust-bearing apparatus shown in FIG. **7**.

FIG. **10** is a side cross-sectional view of an embodiment of a wire-drawing die that employs a PDC fabricated in accordance with the principles described herein.

DETAILED DESCRIPTION

Embodiments of the invention relate to PCD that exhibits enhanced diamond-to-diamond bonding. It is currently believed by the inventors that as the sintering pressure employed during the HPHT process used to fabricate such PCD is moved further into the diamond-stable region away from the graphite-diamond equilibrium line, the rate of nucleation and growth of diamond increases. Such increased nucleation and growth of diamond between diamond particles (for a given diamond particle formulation) may result in PCD being formed exhibiting one or more of a relatively lower metal-solvent catalyst content, a higher coercivity, a lower specific magnetic saturation, or a lower specific permeability (i.e., the ratio of specific magnetic saturation to coercivity) than PCD formed at a lower sintering pressure. Embodiments also relate to PDCs having a PCD table comprising such PCD, methods of fabricating such PCD and PDCs, and applications for such PCD and PDCs in rotary drill bits, bearing apparatuses, wire-drawing dies, machining equipment, and other articles and apparatuses.

PCD Embodiments

According to various embodiments, PCD sintered at a pressure of at least about 7.5 GPa may exhibit a coercivity of 115 Oe or more, a high-degree of diamond-to-diamond bonding, a specific magnetic saturation of about 15 $G \cdot cm^3/g$ or less, and a metal-solvent catalyst content of about 7.5 weight % ("wt %") or less. The PCD includes a plurality of diamond grains directly bonded together via diamond-to-diamond bonding (e.g., sp^3 bonding) to define a plurality of interstitial regions. At least a portion of the interstitial regions or, in some embodiments, substantially all of the interstitial regions may be occupied by a metal-solvent catalyst, such as iron, nickel, cobalt, or alloys of any of the foregoing metals. For example, the metal-solvent catalyst may be a cobalt-based material including at least 50 wt % cobalt, such as a cobalt alloy.

The diamond grains may exhibit an average grain size of about 50 μm or less, such as about 30 μm or less or about 20 μm or less. For example, the average grain size of the diamond grains may be about 10 μm to about 18 μm and, in some embodiments, about 15 μm to about 18 μm. In some embodiments, the average grain size of the diamond grains may be about 10 μm or less, such as about 2 μm to about 5 μm or submicron. The diamond grain size distribution of the diamond grains may exhibit a single mode, or may be a bimodal or greater grain size distribution.

The metal-solvent catalyst that occupies the interstitial regions may be present in the PCD in an amount of about 7.5 wt % or less. In some embodiments, the metal-solvent catalyst may be present in the PCD in an amount of about 3 wt % to about 7.5 wt %, such as about 3 wt % to about 6 wt %. In other embodiments, the metal-solvent catalyst content may be present in the PCD in an amount less than about 3 wt %, such as about 1 wt % to about 3 wt % or a residual amount to about 1 wt %. By maintaining the metal-solvent catalyst content below about 7.5 wt %, the PCD may exhibit a desirable level of thermal stability suitable for subterranean drilling applications.

Many physical characteristics of the PCD may be determined by measuring certain magnetic properties of the PCD because the metal-solvent catalyst may be ferromagnetic. The amount of the metal-solvent catalyst present in the PCD may be correlated with the measured specific magnetic saturation of the PCD. A relatively larger specific magnetic saturation indicates relatively more metal-solvent catalyst in the PCD.

The mean free path between neighboring diamond grains of the PCD may be correlated with the measured coercivity of the PCD. A relatively large coercivity indicates a relatively smaller mean free path. The mean free path is representative of the average distance between neighboring diamond grains of the PCD, and thus may be indicative of the extent of diamond-to-diamond bonding in the PCD. A relatively smaller mean free path, in well-sintered PCD, may indicate relatively more diamond-to-diamond bonding.

As merely one example, ASTM B886-03 (2008) provides a suitable standard for measuring the specific magnetic saturation and ASTM B887-03 (2008) e1 provides a suitable standard for measuring the coercivity of the PCD. Although both ASTM B886-03 (2008) and ASTM B887-03 (2008) e1 are directed to standards for measuring magnetic properties of cemented carbide materials, either standard may be used to determine the magnetic properties of PCD. A KOERZIMAT CS 1.096 instrument (commercially available from Foerster Instruments of Pittsburgh, Pa.) is one suitable instrument that may be used to measure the specific magnetic saturation and the coercivity of the PCD.

Generally, as the sintering pressure that is used to form the PCD increases, the coercivity may increase and the magnetic saturation may decrease. The PCD defined collectively by the bonded diamond grains and the metal-solvent catalyst may exhibit a coercivity of about 115 Oe or more and a metal-solvent catalyst content of less than about 7.5 wt % as indicated by a specific magnetic saturation of about 15 $G\cdot cm^3/g$ or less. In a more detailed embodiment, the coercivity of the PCD may be about 115 Oe to about 250 Oe and the specific magnetic saturation of the PCD may be greater than 0 $G\cdot cm^3/g$ to about 15 $G\cdot cm^3/g$. In an even more detailed embodiment, the coercivity of the PCD may be about 115 Oe to about 175 Oe and the specific magnetic saturation of the PCD may be about 5 $G\cdot cm^3/g$ to about 15 $G\cdot cm^3/g$. In yet an even more detailed embodiment, the coercivity of the PCD may be about 155 Oe to about 175 Oe and the specific magnetic saturation of the PCD may be about 10 $G\cdot cm^3/g$ to about 15 $G\cdot cm^3/g$. The specific permeability (i.e., the ratio of specific magnetic saturation to coercivity) of the PCD may be about 0.10 $G\cdot cm^3/g\cdot Oe$ or less, such as about 0.060 $G\cdot cm^3/g\cdot Oe$ to about 0.090 $G\cdot cm^3/g\cdot Oe$. Despite the average grain size of the bonded diamond grains being less than about 30 μm in some embodiments, the metal-solvent catalyst content in the PCD may be less than about 7.5 wt % resulting in a desirable thermal stability.

In one embodiment, diamond particles having an average particle size of about 18 μm to about 20 μm are positioned adjacent to a cobalt-cemented tungsten carbide substrate and subjected to an HPHT process at a temperature of about 1390° C. to about 1430° C. and a pressure of about 7.8 GPa to about 8.5 GPa. The PCD so-formed as a PCD table bonded to the substrate may exhibit a coercivity of about 155 Oe to about 175 Oe, a specific magnetic saturation of about 10 $G\cdot cm^3/g$ to about 15 $G\cdot cm^3/g$, and a cobalt content of about 5 wt % to about 7.5 wt %.

In one or more embodiments, a specific magnetic saturation constant for the metal-solvent catalyst in the PCD may be about 185 $G\cdot cm^3/g$ to about 215 $G\cdot cm^3/g$. For example, the specific magnetic saturation constant for the metal-solvent catalyst in the PCD may be about 195 $G\cdot cm^3/g$ to about 205 $G\cdot cm^3/g$. It is noted that the specific magnetic saturation constant for the metal-solvent catalyst in the PCD may be composition dependent.

Generally, as the sintering pressure is increased above 7.5 GPa, a wear resistance of the PCD so-formed may increase. For example, the G_{ratio} may be at least about 4.0×10^6, such as about 5.0×10^6 to about 15.0×10^6 or, more particularly, about 8.0×10^6 to about 15.0×10^6. In some embodiments, the G_{ratio} may be at least about 30.0×10^6. The G_{ratio} is the ratio of the volume of workpiece cut to the volume of PCD worn away during the cutting process. An example of suitable parameters that may be used to determine a G_{ratio} of the PCD are a depth of cut for the PCD cutting element of about 0.254 mm, a back rake angle for the PCD cutting element of about 20 degrees, an in-feed for the PCD cutting element of about 6.35 mm/rev, a rotary speed of the workpiece to be cut of about 101 rpm, and the workpiece may be made from Barre granite having a 914 mm outer diameter and a 254 mm inner diameter. During the G_{ratio} test, the workpiece is cooled with a coolant, such as water.

In addition to the aforementioned G_{ratio}, despite the presence of the metal-solvent catalyst in the PCD, the PCD may exhibit a thermal stability that is close to, substantially the same as, or greater than a partially leached PCD material formed by sintering a substantially similar diamond particle formulation at a lower sintering pressure (e.g., up to about 5.5 GPa) and in which the metal-solvent catalyst (e.g., cobalt) is leached therefrom to a depth of about 60 μm to about 100 μm from a working surface thereof. The thermal stability of the PCD may be evaluated by measuring the distance cut in a workpiece prior to catastrophic failure, without using coolant, in a vertical lathe test (e.g., vertical turret lathe or a vertical boring mill). An example of suitable parameters that may be used to determine thermal stability of the PCD are a depth of cut for the PCD cutting element of about 1.27 mm, a back rake angle for the PCD cutting element of about 20 degrees, an in-feed for the PCD cutting element of about 1.524 mm/rev, a cutting speed of the workpiece to be cut of about 1.78 m/sec, and the workpiece may be made from Barre granite having a 914 mm outer diameter and a 254 mm inner diameter. In an embodiment, the distance cut in a workpiece prior to catastrophic failure as measured in the above-described vertical lathe test may be at least about 1300 m, such as about 1300 m to about 3950 m.

PCD formed by sintering diamond particles having the same diamond particle size distribution as a PCD embodiment of the invention, but sintered at a pressure of, for example, up to about 5.5 GPa and at temperatures in which diamond is stable may exhibit a coercivity of about 100 Oe or less and/or a specific magnetic saturation of about 16 $G\cdot cm^3/g$ or more. Thus, in one or more embodiments of the invention, PCD exhibits a metal-solvent catalyst content of less than 7.5 wt % and a greater amount of diamond-to-diamond bonding between diamond grains than that of a PCD sintered at a lower pressure, but with the same precursor diamond particle size distribution and catalyst.

It is currently believed by the inventors that forming the PCD by sintering diamond particles at a pressure of at least about 7.5 GPa may promote nucleation and growth of diamond between the diamond particles being sintered so that the volume of the interstitial regions of the PCD so-formed is decreased compared to the volume of interstitial regions if the same diamond particle distribution was sintered at a pressure of, for example, up to about 5.5 GPa and at temperatures where diamond is stable. For example, the diamond may nucleate and grow from carbon provided by dissolved carbon in metal-solvent catalyst (e.g., liquefied cobalt) infiltrating into the diamond particles being sintered, partially graphitized diamond particles, carbon from a substrate, carbon from another source (e.g., graphite particles and/or fullerenes mixed with the diamond particles), or combinations of the foregoing. This nucleation and growth of diamond in combination with the sintering pressure of at least about 7.5 GPa may contribute to the PCD so-formed having a metal-solvent catalyst content of less than about 7.5 wt %.

FIGS. **1**A, **1**B, and **2** schematically illustrate the manner in which the specific magnetic saturation and the coercivity of the PCD may be determined using an apparatus, such as the KOERZIMAT CS 1.096 instrument. FIG. **1**A is a schematic diagram of an example of a magnetic saturation apparatus **100** configured to magnetize a PCD sample to saturation. The magnetic saturation apparatus **100** includes a saturation magnet **102** of sufficient strength to magnetize a PCD sample **104** to saturation. The saturation magnet **102** may be a permanent magnet or an electromagnet. In the illustrated embodiment, the saturation magnet **102** is a permanent magnet that defines an air gap **106**, and the PCD sample **104** may be positioned on a sample holder **108** within the air gap **106**. When the PCD sample **104** is lightweight, it may be secured to the sample holder **108** using, for example, double-sided tape or other adhesive so that the PCD sample **104** does not move responsive to the magnetic field from the saturation magnet **102** and the PCD sample **104** is magnetized at least approximately to saturation.

Referring to the schematic diagram of FIG. **1**B, after magnetizing the PCD sample **104** at least approximately to saturation using the magnetic saturation apparatus **100**, a magnetic saturation of the PCD sample **104** may be measured using a magnetic saturation measurement apparatus **120**. The magnetic saturation measurement apparatus **120** includes a Helmholtz measuring coil **122** defining a passageway dimensioned so that the magnetized PCD sample **104** may be positioned therein on a sample holder **124**. Once positioned in the passageway, the sample holder **124** supporting the magnetized PCD sample **104** may be moved axially along an axis direction **126** to induce a current in the Helmholtz measuring coil **122**. Measurement electronics **128** are coupled to the Helmholtz measuring coil **122** and configured to calculate the magnetic saturation based upon the measured current passing through the Helmholtz measuring coil **122**. The measurement electronics **128** may also be configured to calculate a weight percentage of magnetic material in the PCD sample **104** when the composition and magnetic characteristics of the metal-solvent catalyst in the PCD sample **104** are known, such as with iron, nickel, cobalt, and alloys thereof. Specific magnetic saturation may be calculated based upon the calculated magnetic saturation and the measured weight of the PCD sample **104**.

The amount of metal-solvent catalyst in the PCD sample **104** may be determined using a number of different analytical techniques. For example, energy dispersive spectroscopy (e.g., EDAX), wavelength dispersive x-ray spectroscopy (e.g., WDX), Rutherford backscattering spectroscopy, or combinations thereof may be employed to determine the amount of metal-solvent catalyst in the PCD sample **104**.

If desired, a specific magnetic saturation constant of the metal-solvent catalyst content in the PCD sample **104** may be determined using an iterative approach. A value for the specific magnetic saturation constant of the metal-solvent catalyst in the PCD sample **104** may be iteratively chosen until a metal-solvent catalyst content calculated by the analysis software of the KOERZIMAT CS 1.096 instrument using the chosen value substantially matches the metal-solvent catalyst content determined via one or more analytical techniques, such as energy dispersive spectroscopy, wavelength dispersive x-ray spectroscopy, or Rutherford backscattering spectroscopy.

FIG. **2** is a schematic diagram of a coercivity measurement apparatus **200** configured to determine a coercivity of a PCD sample. The coercivity measurement apparatus **200** includes a coil **202** and measurement electronics **204** coupled to the coil **202**. The measurement electronics **204** are configured to pass a current through the coil **202** so that a magnetic field is generated. A sample holder **206** having a PCD sample **208** thereon may be positioned within the coil **202**. A magnetization sensor **210** configured to measure a magnetization of the PCD sample **208** may be coupled to the measurement electronics **204** and positioned in proximity to the PCD sample **208**.

During testing, the magnetic field generated by the coil **202** magnetizes the PCD sample **208** at least approximately to saturation. Then, the measurement electronics **204** apply a current so that the magnetic field generated by the coil **202** is increasingly reversed. The magnetization sensor **210** measures a magnetization of the PCD sample **208** resulting from application of the reversed magnetic field to the PCD sample **208**. The measurement electronics **204** determine the coercivity of the PCD sample **208**, which is a measurement of the strength of the reversed magnetic field at which the magnetization of the PCD sample **208** is zero.

Embodiments of Methods for Fabricating PCD

The PCD may be formed by sintering a mass of a plurality of diamond particles in the presence of a metal-solvent catalyst. The diamond particles may exhibit an average particle size of about 50 μm or less, such as about 30 μm or less, about 20 μm or less, about 10 μm to about 18 μm or, about 15 μm to about 18 μm. In some embodiments, the average particle size of the diamond particles may be about 10 μm or less, such as about 2 μm to about 5 μm or submicron.

In an embodiment, the diamond particles of the mass of diamond particles may comprise a relatively larger size and at least one relatively smaller size. As used herein, the phrases "relatively larger" and "relatively smaller" refer to particle sizes (by any suitable method) that differ by at least a factor of two (e.g., 30 μm and 15 μm). According to various embodiments, the mass of diamond particles may include a portion exhibiting a relatively larger size (e.g., 30 μm, 20 μm, 15 μm, 12 μm, 10 μm, 8 μm) and another portion exhibiting at least one relatively smaller size (e.g., 6 μm, 5 μm, 4 μm, 3 μm, 2 μm, 1 μm, 0.5 μm, less than 0.5 μm, 0.1 μm, less than 0.1 μm). In one embodiment, the mass of diamond particles may include a portion exhibiting a relatively larger size between about 10 μm and about 40 μm and another portion exhibiting a relatively smaller size between about 1 μm and 4 μm. In some embodiments, the mass of diamond particles may comprise three or more different sizes (e.g., one relatively larger size and two or more relatively smaller sizes), without limitation.

It is noted that the as-sintered diamond grain size may differ from the average particle size of the mass of diamond particles prior to sintering due to a variety of different physical processes, such as grain growth, diamond particle fracturing, carbon provided from another carbon source (e.g., dissolved carbon in the metal-solvent catalyst), or combinations of the foregoing. The metal-solvent catalyst (e.g., iron, nickel, cobalt, or alloys thereof) may be provided in particulate form mixed with the diamond particles, as a thin foil or plate placed adjacent to the mass of diamond particles, from a cemented carbide substrate including a metal-solvent catalyst, or combinations of the foregoing.

In order to efficiently sinter the mass of diamond particles, the mass may be enclosed in a pressure transmitting medium, such as a refractory metal can, graphite structure, pyrophyllite, combinations thereof, or other suitable pressure transmitting structure to form a cell assembly. Examples of suitable gasket materials and cell structures for use in manufacturing PCD are disclosed in U.S. Pat. No. 6,338,754 and U.S. patent application Ser. No. 11/545,929, each of which is incorporated herein, in its entirety, by this reference. Another example of a suitable pressure transmitting material is pyrophyllite, which is commercially available from Wonderstone Ltd. of South Africa. The cell assembly, including the pressure transmitting medium and mass of diamond particles therein, is subjected to an HPHT process using an ultra-high pressure press at a temperature of at least about 1000° C. (e.g., about 1100° C. to about 2200° C., or about 1200° C. to about 1450° C.) and a pressure in the pressure transmitting medium of at least about 7.5 GPa (e.g., about 7.5 GPa to about 15 GPa, about 9 GPa to about 12 GPa, or about 10 GPa to about 12.5 GPa) for a time sufficient to sinter the diamond particles together in the presence of the metal-solvent catalyst and form the PCD comprising bonded diamond grains defining interstitial regions occupied by the metal-solvent catalyst. For example, the pressure in the pressure transmitting medium employed in the HPHT process may be at least about 8.0 GPa, at least about 9.0 GPa, at least about 10.0 GPa, at least about 11.0 GPa, at least about 12.0 GPa, or at least about 14 GPa.

The pressure values employed in the HPHT processes disclosed herein refer to the pressure in the pressure transmitting medium at room temperature (e.g., about 25° C.) with application of pressure using an ultra-high pressure press and not the pressure applied to exterior of the cell assembly. The actual pressure in the pressure transmitting medium at sintering temperature may be slightly higher. The ultra-high pressure press may be calibrated at room temperature by embedding at least one calibration material that changes structure at a known pressure such as, PbTe, thallium, barium, or bismuth in the pressure transmitting medium. Optionally, a change in resistance may be measured across the at least one calibration material due to a phase change thereof. For example, PbTe exhibits a phase change at room temperature at about 6.0 GPa and bismuth exhibits a phase change at room temperature at about 7.7 GPa. Examples of suitable pressure calibration techniques are disclosed in G. Rousse, S. Klotz, A. M. Saitta, J. Rodriguez-Carvajal, M. I. McMahon, B. Couzinet, and M. Mezouar, "Structure of the Intermediate Phase of PbTe at High Pressure," Physical Review B: Condensed Matter and Materials Physics, 71, 224116 (2005) and D. L. Decker, W. A. Bassett, L. Merrill, H. T. Hall, and J. D. Barnett, "High-Pressure Calibration: A Critical Review," J. Phys. Chem. Ref. Data, 1, 3 (1972).

In an embodiment, a pressure of at least about 7.5 GPa in the pressure transmitting medium may be generated by applying pressure to a cubic high-pressure cell assembly that encloses the mass of diamond particles to be sintered using anvils, with each anvil applying pressure to a different face of the cubic high-pressure assembly. In such an embodiment, a surface area of each anvil face of the anvils may be selectively dimensioned to facilitate application of pressure of at least about 7.5 GPa to the mass of diamond particles being sintered. For example, the surface area of each anvil may be less than about 16.0 cm^2, such as less than about 16.0 cm^2, about 8 cm^2 to about 10 cm^2. The anvils may be made from a cobalt-cemented tungsten carbide or other material having a sufficient compressive strength to help reduce damage thereto through repetitive use in a high-volume commercial manufacturing environment. As an alternative to or in addition to selectively dimensioning the surface area of each anvil face, in an embodiment, two or more internal anvils may be embedded in the cubic high-pressure cell assembly to further intensify pressure. For example, the article W. Utsumi, N. Toyama, S. Endo and F. E. Fujita, "X-ray diffraction under ultrahigh pressure generated with sintered diamond anvils," J. Appl. Phys., 60, 2201 (1986) is incorporated herein, in its entirety, by this reference and discloses that sintered diamond anvils may be embedded in a cubic pressure transmitting medium for intensifying the pressure applied by an ultra-high pressure press to a workpiece also embedded in the cubic pressure transmitting medium.

PDC Embodiments and Methods of Fabricating PDCs

Referring to FIG. **3**A, the PCD embodiments may be employed in a PDC for cutting applications, bearing applications, or many other applications. FIG. **3**A is a cross-sectional view of an embodiment of a PDC **300**. The PDC **300** includes a substrate **302** bonded to a PCD table **304**. The PCD table **304** may be formed of PCD in accordance with any of the PCD embodiments disclosed herein. The PCD table **304** exhibits at least one working surface **306** and at least one lateral dimension "D" (e.g., a diameter). Although FIG. **3**A shows the working surface **306** as substantially planar, the working surface **306** may be concave, convex, or another nonplanar geometry. Furthermore, other regions of the PCD table **304** may function as a working region, such as a peripheral side surface and/or an edge. The substrate **302** may be generally cylindrical or another selected configuration, without limitation. Although FIG. **3**A shows an interfacial surface **308** of the substrate **302** as being substantially planar, the interfacial surface **308** may exhibit a selected nonplanar topography, such as a grooved, ridged, or other nonplanar interfacial surface. The substrate **302** may include, without limitation, cemented carbides, such as tungsten carbide, titanium carbide, chromium carbide, niobium carbide, tantalum carbide, vanadium carbide, or combinations thereof cemented with iron, nickel, cobalt, or alloys thereof. For example, in one embodiment, the substrate **302** comprises cobalt-cemented tungsten carbide.

In some embodiments, the PCD table **304** may include two or more layered regions **310** and **312** exhibiting different compositions and/or different average diamond grain sizes. For example, the region **310** is located adjacent to the interface surface **308** of the substrate **302** and exhibits a first diamond grain size, while the region **312** is remote from the substrate **302** and exhibits a second average diamond grain size that is less than that of the first average diamond grain size. For example, the second average diamond grain size may be about 90% to about 98% (e.g., about 90 to about 95%) of the first diamond grain size. In another embodiment, the second average diamond grain size may be greater than that of the first average diamond grain size. For example, the first average diamond grain size may be about 90% to about 98% (e.g., about 90 to about 95%) of the second diamond grain size.

As an alternative to or in addition to the first and second regions exhibiting different diamond grain sizes, in an embodiment, the composition of the region **310** may be different than that of the region **312**. The region **310** may include about 15 wt % or less of a tungsten-containing material (e.g., tungsten and/or tungsten carbide) interspersed between the diamond grains to improve toughness, while the region **312** may be substantially free of tungsten. For example, the tungsten-containing material may be present in the region **310** in an amount of about 1 wt % to about 10 wt %, about 5 wt % to about 10 wt %, or about 10 wt %.

FIG. **3**B is a schematic illustration of an embodiment of a method for fabricating the PDC **300** shown in FIG. **3**A. Referring to FIG. **3**B, a mass of diamond particles **305** having any of the above-mentioned average particle sizes and distributions (e.g., an average particle size of about 50 μm or less) is positioned adjacent to the interfacial surface **308** of the substrate **302**. As previously discussed, the substrate **302** may include a metal-solvent catalyst. The mass of diamond particles **305** and substrate **302** may be subjected to an HPHT process using any of the conditions previously described with respect to sintering the PCD embodiments disclosed herein. The PDC **300** so-formed includes the PCD table **304** that comprises PCD, formed of any of the PCD embodiments disclosed herein, integrally formed with the substrate **302** and bonded to the interfacial surface **308** of the substrate **302**. If the substrate **302** includes a metal-solvent catalyst, the metal-solvent catalyst may liquefy and infiltrate the mass of diamond particles **305** to promote growth between adjacent diamond particles of the mass of diamond particles **305** to form the PCD table **304** comprised of a body of bonded diamond grains having the infiltrated metal-solvent catalyst interstitially disposed between bonded diamond grains. For example, if the substrate **302** is a cobalt-cemented tungsten carbide substrate, cobalt from the substrate **302** may be liquefied and infiltrate the mass of diamond particles **305** to catalyze formation of the PCD table **304**.

In some embodiments, the mass of diamond particles **305** may include two or more layers exhibiting different compositions and/or different average diamond particle sizes. For example, a first layer may be located adjacent to the interface surface **308** of the substrate **302** and exhibit a first diamond particle size, while a second layer may be located remote from the substrate **302** and exhibit a second average diamond particle size that is less than that of the first average diamond particle size. For example, the second average diamond particle size may be about 90% to about 98% (e.g., about 90 to about 95%) of the first diamond particle size. In another embodiment, the second average diamond particle size may be greater than that of the first average diamond particle size. For example, the first average diamond particle size may be about 90% to about 98% (e.g., about 90 to about 95%) of the second diamond particle size.

As an alternative to or in addition to the first and second layers exhibiting different diamond particles sizes, in an embodiment, the composition of the first layer may be different than that of the second layer. The first layer may include about 15 wt % or less of a tungsten-containing material (e.g., tungsten and/or tungsten carbide) mixed with the diamond particles, while the second layer may be substantially free of tungsten. For example, the tungsten-containing material may be present in the first layer in an amount of about 1 wt % to about 10 wt %, about 5 wt % to about 10 wt %, or about 10 wt %.

Employing selectively dimensioned anvil faces and/or internal anvils in the ultra-high pressure press used to process the mass of diamond particles **305** and substrate **302** enables forming the at least one lateral dimension d of the PCD table **304** to be about 0.80 cm or more. Referring again to FIG. **3**A, for example, the at least one lateral dimension "D" may be about 0.80 cm to about 3.0 cm and, in some embodiments, about 1.3 cm to about 1.9 cm or about 1.6 cm to about 1.9 cm. A representative volume of the PCD table **304** (or any PCD article of manufacture disclosed herein) formed using the selectively dimensioned anvil faces and/or internal anvils may be at least about 0.050 cm^3. For example, the volume may be about 0.25 cm^3 to at least about 1.25 cm^3 or about 0.1 cm^3 to at least about 0.70 cm^3. A representative volume for the PDC **300** may be about 0.4 cm^3 to at least about 4.6 cm^3, such as about 1.1 cm^3 to at least about 2.3 cm^3.

In other embodiments, a PCD table according to an embodiment may be separately formed using an HPHT sintering process (i.e., a pre-sintered PCD table) and, subsequently, bonded to the interfacial surface **308** of the substrate **302** by brazing, using a separate HPHT bonding process, or any other suitable joining technique, without limitation. In yet another embodiment, a substrate may be formed by depositing a binderless carbide (e.g., tungsten carbide) via chemical vapor deposition onto the separately formed PCD table.

In any of the embodiments disclosed herein, substantially all or a selected portion of the metal-solvent catalyst may be removed (e.g., via leaching) from the PCD table. In an embodiment, metal-solvent catalyst in the PCD table may be removed to a selected depth from at least one exterior working surface (e.g., the working surface **306** and/or a sidewall working surface of the PCD table **304**) so that only a portion of the interstitial regions are occupied by metal-solvent catalyst. For example, substantially all or a selected portion of the metal-solvent catalyst may be removed from the PCD table **304** of the PDC **300** to a selected depth from the working surface **306**.

In another embodiment, a PCD table may be fabricated according to any of the disclosed embodiments in a first HPHT process, leached to remove substantially all of the metal-solvent catalyst from the interstitial regions between the bonded diamond grains, and subsequently bonded to a substrate in a second HPHT process. In the second HPHT process, an infiltrant from, for example, a cemented carbide substrate may infiltrate into the interstitial regions from which the metal-solvent catalyst was depleted. For example, the infiltrant may be cobalt that is swept-in from a cobalt-cemented tungsten carbide substrate. In one embodiment, the first and/or second HPHT process may be performed at a pressure of at least about 7.5 GPa. In one embodiment, the infiltrant may be leached from the infiltrated PCD table using a second acid leaching process following the second HPHT process.

In some embodiments, the pressure employed in the HPHT process used to fabricate the PDC **300** may be sufficient to reduce residual stresses in the PCD table **304** that develop during the HPHT process due to the thermal expansion mismatch between the substrate **302** and the PCD table **304**. In such an embodiment, the principal stress measured on the working surface **306** of the PDC **300** may exhibit a value of about −345 MPa to about 0 MPa, such as about −289 MPa. For example, the principal stress measured on the working surface **306** may exhibit a value of about −345 MPa to about 0 MPa. A conventional PDC fabricated using an HPHT process at a pressure below about 7.5 GPa may result in a PCD table thereof exhibiting a principal stress on a working surface thereof of about −1724 MPa to about −414 MPa, such as about −770 MPa.

Residual stress may be measured on the working surface **306** of the PCD table **304** of the PDC **300** as described in T. P. Lin, M. Hood, G. A. Cooper, and R. H. Smith, "Residual stresses in polycrystalline diamond compacts," J. Am. Ceram. Soc. 77, 6, 1562-1568 (1994). More particularly, residual strain may be measured with a rosette strain gage bonded to the working surface **306**. Such strain may be measured for different levels of removal of the substrate **302** (e.g., as material is removed from the back of the substrate **302**). Residual stress may be calculated from the measured residual strain data.

FIG. **3**C is a graph of residual principal stress versus substrate thickness that was measured in a PCD table of a PDC fabricated at pressure above about 7.5 GPa in accordance with an embodiment of the invention and a PCD table of a conventionally formed PDC. The substrate of each PDC had a substantially planar interfacial surface. The residual principal stress was determined using the technique described in the article referenced above by Lin et al. Curve **310** shows the measured residual principal stress on a working surface of the PDC fabricated at a pressure above about 7.5 GPa. The PDC that was fabricated at a pressure above about 7.5 GPa had a PCD table thickness dimension of about 1 mm and the substrate had a thickness dimension of about 7 mm and a diameter of about 13 mm. Curve **312** shows the measured residual principal stress on a working surface of a PCD table of a conventionally PDC fabricated at pressure below about 7.5 GPa. The PDC that was fabricated at a pressure below about 7.5 GPa had a PCD table thickness dimension of about 1 mm and the substrate had a thickness dimension of about 7 mm and a diameter of about 13 mm. The highest absolute value of the residual principal stress occurs with the full substrate length of about 7 mm. As shown by the curves **310** and **312**, increasing the pressure employed in the HPHT process used to fabricate a PDC, above about 7.5 GPa may reduce the highest absolute value of the principal residual stress in a PCD table thereof by about 60% relative to a conventionally fabricated PDC. For example, at the full substrate length, the absolute value of the principal residual stress in the PCD table fabricated at a pressure above about 7.5 GPa is about 60% less than the absolute value of the principal residual stress in the PCD table of the conventionally fabricated PDC.

As discussed above in relation to FIG. **3**C, the application of higher pressure in the HPHT process used to fabricate a PDC may substantially reduce the residual compressive stresses in the PCD table. Typically, high residual compressive stresses in the PCD table are believed desirable to help reduce crack propagation in the PCD table. The inventors have found that the reduced residual compressive stresses in a PCD table of a PDC fabricated in an HPHT process at a pressure of at least about 7.5 GPa may result in detrimental cracking in the PCD table and de-bonding of the PCD table from the substrate upon brazing the substrate to, for example, a carbide extension and/or a bit body of a rotary drill bit depending upon the extent of the nonplanarity of the interfacial surface of the substrate. It is believed by the inventors that when the PDC is fabricated at a pressure of at least about 7.5 GPa, at the brazing temperature, tensile stresses generated in the PCD table due to thermal expansion are greater than if the PCD table had higher residual compressive stresses. Due to the higher tensile stresses at the brazing temperature, hoop stresses generated in the PCD by nonplanar surface features (e.g., protrusions) of the substrate may cause the PCD table to form radially-extending and vertically-extending cracks and/or de-bond from the substrate more frequently than if fabricated at relatively lower pressures. Typically, conventional wisdom taught that a highly nonplanar interfacial surface for the substrate helped prevent de-bonding of the PCD table from the substrate. Thus, in certain embodiments discussed in more detail in FIGS. **3**A-**6**B, the inventors have proceeded contrary to conventional wisdom, which suggested that a highly nonplanar interfacial surface for the substrate promotes bonding. In such embodiments, the topography of the interfacial surface of the substrate may be controlled so that it is still substantially planar and exhibits a nonplanarity that does not exceed a maximum threshold.

Referring again to FIG. **3**A, in an embodiment, the interfacial surface **308** of the substrate **302** may be substantially planar. For example, to the extent that the interfacial surface **308** includes a plurality of protrusions, the protrusions may exhibit an average surface relief height of about 0 to less than about 0.00010 inch, about 0 to about 0.00050 inch, about 0 to about 0.00075 inch, or about 0.000010 inch to about 0.00010 inch. The average surface relief is the height that the protrusions extend above the lowest point of the interfacial surface **308**. A ratio of a surface area of the interfacial surface in the absence of the plurality of protrusions (i.e., a flat interfacial surface) to a surface area of the interfacial surface with the plurality of protrusions is greater than about 0.600. An example of an interfacial surface that is substantially planar is one in which the ratio is greater than about 0.600. For example, the ratio may be about 0.600 to about 0.650, about 0.650 to about 0.725, about 0.650 to about 0.750, about 0.650 to about 0.950, about 0.750 to less than 1.0, or about 0.750 to about 1.0.

FIGS. **4**A-**6**B illustrate embodiments in which the selected substantially planar topography of the interfacial surface of the substrate is controlled to reduce or substantially eliminate cracking in and/or de-bonding of a PCD table of a PDC. FIGS. **4**A and **4**B are exploded isometric and assembled isometric views, respectively, of an embodiment of a PDC **400** comprising a substrate **402** including an interfacial surface **404** exhibiting a selected substantially planar topography. The substrate **402** may be made from the same carbide materials as the substrate **302** shown in FIG. **3**A. The interfacial surface **404** includes a plurality of protrusions **406** spaced from each other and extending substantially transversely to the length of the substrate **402**. The protrusions **406** define a plurality of grooves **408** between pairs of the protrusions **406**. A PCD table **410** may be bonded to the interfacial surface **406**. The PCD table **410** may exhibit some or all of the magnetic, mechanical, thermal stability, wear resistance, size, compositional, diamond-to-diamond bonding, or grain size properties of the PCD disclosed herein and/or the PCD table **304** shown in FIG. **3**A. The PCD table **410** exhibits a maximum thickness "T." Because the PCD table **410** may be integrally formed with the substrate **402** and fabricated from precursor diamond particles, the PCD table **410** may have an interfacial surface **411** that is configured to correspond to the topography of the interfacial surface **404** of the substrate **402**.

A ratio of a surface area of the interfacial surface **404** in the absence of the plurality of protrusions **406** (i.e., a flat interfacial surface) to a surface area of the interfacial surface with the protrusions **406** is greater than about 0.600. For example, the ratio may be about 0.600 to about 0.650, about 0.650 to about 0.725, about 0.650 to about 0.750, about 0.650 to about 0.950, about 0.750 to less than 1.0, or about 0.750 to about 1.0.

The plurality of protrusions **406** exhibits an average surface relief height "h," which is the average height that the protrusions **406** extend above the lowest point of the interfacial surface **404**. For example, h may be greater than 0 to less than about 0.030 inch, greater than 0 to about 0.020 inch, greater than 0 to about 0.015 inch, about 0.0050 inch to about 0.010 inch, or 0.0080 inch to about 0.010 inch. The maximum thickness "T" may be about 0.050 inch to about

0.20 inch, such as about 0.050 inch to about 0.16 inch, about 0.050 inch to about 0.10 inch, about 0.050 inch to about 0.085 inch or about 0.070 inch to about 0.080 inch. The ratio of h/T may be less than about 0.25, such as about 0.050 to about 0.125, about 0.050 to about 0.10, about 0.070 to about 0.090, or about 0.050 to about 0.075.

Referring to FIG. **4**B, the outermost of the protrusions **406** (indicated as **406***a* and **406***b*) may be laterally spaced from an exterior peripheral surface **414** of the substrate **402** by a distance d. When the PDC **400** is substantially cylindrical, a ratio of d to the radius of the PCD table "R" may be about 0.030 to about 1.0, about 0.035 to about 0.080, or about 0.038 to about 0.060.

FIG. **5**A is cross-sectional view of a PDC **500** comprising a substrate **502** including an interfacial surface **504** exhibiting a selected substantially planar topography according to yet another embodiment and FIG. **5**B is an isometric view of the substrate **502**. The substrate **502** may be made from the same carbide materials as the substrate **302** shown in FIG. **3**A. The interfacial surface **504** of the substrate **502** includes a plurality of hexagonal protrusions **506** that extend outwardly from a face **508**. The face **508** may be convex, as in the illustrated embodiment, or substantially planar. Tops **509** of the protrusions **506** may lie generally in a common plane. The plurality of protrusions **506** defines a plurality of internal cavities **510**. A depth of each internal cavity **510** may decrease as they approach the center of the substrate **502**. A bottom **511** of each cavity **510** may follow the profile of the face **508**.

The PDC **500** further includes a PCD table **512** exhibiting a maximum thickness "T," which is bonded to the interfacial surface **504** of the substrate **502**. The thickness of the PCD table **512** gradually increases with lateral distance from the center of the PCD table **512** toward a perimeter **513** of the PDC **500**. The PCD table **512** may be configured to correspond to the topography of the interfacial surface **504** of the substrate **502**. For example, protrusions **513** of the PCD table **512** may fill each of the internal cavities **510** defined by the protrusions **506** of the substrate **502**. The PCD table **512** may exhibit some or all of the magnetic, mechanical, thermal stability, wear resistance, size, compositional, diamond-to-diamond bonding, or grain size properties of the PCD disclosed herein and/or the PCD table **304** shown in FIG. **3**A. The closed features of the hexagonal protrusions **506** include a draft angle α, such as about 5 degrees to about 15 degrees.

A ratio of a surface area of the interfacial surface **504** in the absence of the protrusions **506** (i.e., a flat interfacial surface) to a surface area of the interfacial surface with the protrusions **506** is greater than about 0.600. For example, the ratio may be about 0.600 to about 0.650, about 0.650 to about 0.725, about 0.650 to about 0.750, about 0.650 to about 0.950, about 0.750 to less than 1.0, or about 0.750 to about 1.0.

The plurality of protrusions **506** exhibits an average surface relief height "h," which is the average height that the protrusions **506** extend above the lowest point of the interfacial surface **504**. For example, h may be greater than 0 to less than about 0.030 inch, greater than 0 to about 0.020 inch, greater than 0 to about 0.015 inch, about 0.0050 inch to about 0.010 inch, or 0.0080 inch to about 0.010 inch. The maximum thickness "T" may be about 0.050 inch to about 0.10 inch, such as about 0.050 inch to about 0.085 inch or about 0.070 inch to about 0.080 inch. The ratio of h/T may be less than about 0.25, such as about 0.050 to about 0.125, about 0.050 to about 0.10, about 0.070 to about 0.090, or about 0.050 to about 0.075.

It is noted that the interfacial surface geometries shown in the PDCs **400** and **500** are merely two examples of suitable interfacial surface geometries. Other interfacial surface geometries may be employed that depart from the illustrated interfacial surface geometries shown in the PDCs **400** and **500** of FIGS. **4**A-**5**B.

Working Examples

The following working examples provide further detail about the magnetic properties of PCD tables of PDCs fabricated in accordance with the principles of some of the specific embodiments of the invention. The magnetic properties of each PCD table listed in Tables I-IV were tested using a KOERZIMAT CS 1.096 instrument that is commercially available from Foerster Instruments of Pittsburgh, Pa. The specific magnetic saturation of each PCD table was measured in accordance with ASTM B886-03 (2008) and the coercivity of each PCD table was measured using ASTM B887-03 (2008) e1 using a KOERZIMAT CS 1.096 instrument. The amount of cobalt-based metal-solvent catalyst in the tested PCD tables was determined using energy dispersive spectroscopy and Rutherford backscattering spectroscopy. The specific magnetic saturation constant of the cobalt-based metal-solvent catalyst in the tested PCD tables was determined to be about 201 G·cm^3/g using an iterative analysis as previously described. When a value of 201 G·cm^3/g was used for the specific magnetic saturation constant of the cobalt-based metal-solvent catalyst, the calculated amount of the cobalt-based metal-solvent catalyst in the tested PCD tables using the analysis software of the KOERZIMAT CS 1.096 instrument substantially matched the measurements using energy dispersive spectroscopy and Rutherford spectroscopy.

Table I below lists PCD tables that were fabricated in accordance with the principles of certain embodiments of the invention discussed above. Each PCD table was fabricated by placing a mass of diamond particles having the listed average diamond particle size adjacent to a cobalt-cemented tungsten carbide substrate in a niobium container, placing the container in a high-pressure cell medium, and subjecting the high-pressure cell medium and the container therein to an HPHT process using an HPHT cubic press to form a PCD table bonded to the substrate. The surface area of each anvil of the HPHT press and the hydraulic line pressure used to drive the anvils were selected so that the sintering pressure was at least about 7.8 GPa. The temperature of the HPHT process was about 1400° C. and the sintering pressure was at least about 7.8 GPa. The sintering pressures listed in Table I refer to the pressure in the high-pressure cell medium at room temperature, and the actual sintering pressures at the sintering temperature are believed to be greater. After the HPHT process, the PCD table was removed from the substrate by grinding away the substrate. However, the substrate may also be removed using electro-discharge machining or another suitable method.

TABLE I

Selected Magnetic Properties of PCD Tables Fabricated According to Embodiments of the Invention.

Example	Average Diamond Particle Size (μm)	Sintering Pressure (GPa)	Specific Magnetic Saturation (G · cm^3/g)	Calculated Co wt %	Coercivity (Oe)	Specific Permeability (G · cm^3/g · Oe)
1	20	7.8	11.15	5.549	130.2	0.08564
2	19	7.8	11.64	5.792	170.0	0.06847

TABLE I-continued

Selected Magnetic Properties of PCD Tables Fabricated According to Embodiments of the Invention.

Example	Average Diamond Particle Size (μm)	Sintering Pressure (GPa)	Specific Magnetic Saturation (G · cm³/g)	Calculated Co wt %	Coercivity (Oe)	Specific Permeability (G · cm³/g · Oe)
3	19	7.8	11.85	5.899	157.9	0.07505
4	19	7.8	11.15	5.550	170.9	0.06524
5	19	7.8	11.43	5.689	163.6	0.06987
6	19	7.8	10.67	5.150	146.9	0.07263
7	19	7.8	10.76	5.357	152.3	0.07065
8	19	7.8	10.22	5.087	145.2	0.07039
9	19	7.8	10.12	5.041	156.6	0.06462
10	19	7.8	10.72	5.549	137.1	0.07819
11	11	7.8	12.52	6.229	135.3	0.09254
12	11	7.8	12.78	6.362	130.5	0.09793
13	11	7.8	12.69	6.315	134.6	0.09428
14	11	7.8	13.20	6.569	131.6	0.1003

Table II below lists conventional PCD tables that were fabricated. Each PCD table listed in Table II was fabricated by placing a mass of diamond particles having the listed average diamond particle size adjacent to a cobalt-cemented tungsten carbide substrate in a niobium container, placing container in a high-pressure cell medium, and subjecting the high-pressure cell medium and the container therein to an HPHT process using an HPHT cubic press to form a PCD table bonded to the substrate. The surface area of each anvil of the HPHT press and the hydraulic line pressure used to drive the anvils were selected so that the sintering pressure was about 4.6 GPa. Except for samples 15, 16, 18, and 19, which were subjected to a temperature of about 1430° C., the temperature of the HPHT process was about 1400° C. and the sintering pressure was about 4.6 GPa. The sintering pressures listed in Table II refer to the pressure in the high-pressure cell medium at room temperature. After the HPHT process, the PCD table was removed from the cobalt-cemented tungsten carbide substrate by grinding away the cobalt-cemented tungsten carbide substrate.

TABLE II

Selected Magnetic Properties of Several Conventional PCD Tables.

Example	Average Diamond Particle Size (μm)	Sintering Pressure (GPa)	Specific Magnetic Saturation (G · cm³/g)	Calculated Co wt %	Coercivity (Oe)	Specific Permeability (G · cm³/g · Oe)
15	20	4.61	19.30	9.605	94.64	0.2039
16	20	4.61	19.52	9.712	96.75	0.2018
17	20	4.61	19.87	9.889	94.60	0.2100
18	20	5.08	18.61	9.260	94.94	0.1960
19	20	5.08	18.21	9.061	100.4	0.1814
20	20	5.86	16.97	8.452	108.3	0.1567
21	20	4.61	17.17	8.543	102.0	0.1683
22	20	4.61	17.57	8.745	104.9	0.1675
23	20	5.08	16.10	8.014	111.2	0.1448
24	20	5.08	16.79	8.357	107.1	0.1568

As shown in Tables I and II, the conventional PCD tables listed in Table II exhibit a higher cobalt content therein than the PCD tables listed in Table I as indicated by the relatively higher specific magnetic saturation values. Additionally, the conventional PCD tables listed in Table II exhibit a lower coercivity indicative of a relatively greater mean free path between diamond grains, and thus may indicate relatively less diamond-to-diamond bonding between the diamond grains. Thus, the PCD tables according to examples of the invention listed in Table I may exhibit significantly less cobalt therein and a lower mean free path between diamond grains than the PCD tables listed in Table II.

Table III below lists conventional PCD tables that were obtained from PDCs. Each PCD table listed in Table III was separated from a cobalt-cemented tungsten carbide substrate bonded thereto by grinding.

TABLE III

Selected Magnetic Properties of Several Conventional PCD Tables.

Example	Specific Magnetic Saturation (G · cm³/g)	Calculated Co wt %	Coercivity (Oe)	Specific Permeability (G · cm³/g · Oe)
25	17.23	8.572	140.4	0.1227
26	16.06	7.991	150.2	0.1069
27	15.19	7.560	146.1	0.1040
28	17.30	8.610	143.2	0.1208
29	17.13	8.523	152.1	0.1126
30	17.00	8.458	142.5	0.1193
31	17.08	8.498	147.2	0.1160
32	16.10	8.011	144.1	0.1117

Table IV below lists conventional PCD tables that were obtained from PDCs. Each PCD table listed in Table IV was separated from a cobalt-cemented tungsten carbide substrate bonded thereto by grinding the substrate away. Each PCD table listed in Table IV and tested had a leached region from which cobalt was depleted and an unleached region in which cobalt is interstitially disposed between bonded diamond grains. The leached region was not removed. However, to determine the specific magnetic saturation and the coercivity of the unleached region of the PCD table having metal-solvent catalyst occupying interstitial regions therein, the leached region may be ground away so that only the unleached region of the PCD table remains. It is expected that the leached region causes the specific magnetic saturation to be lower and the coercivity to be higher than if the leached region was removed and the unleached region was tested.

TABLE IV

Selected Magnetic Properties of Several Conventional Leached PCD Tables.

Example	Specific Magnetic Saturation (G · cm³ per gram)	Calculated Co wt %	Coercivity (Oe)	Specific Permeability (G · cm³ per g · Oe)
33	17.12	8.471	143.8	0.1191
34	13.62	6.777	137.3	0.09920
35	15.87	7.897	140.1	0.1133
36	12.95	6.443	145.5	0.0890
37	13.89	6.914	142.0	0.09782
38	13.96	6.946	146.9	0.09503
39	13.67	6.863	133.8	0.1022
40	12.80	6.369	146.3	0.08749

As shown in Tables I, III, and IV, the conventional PCD tables of Tables III and IV exhibit a higher cobalt content therein than the PCD tables listed in Table I as indicated by the relatively higher specific magnetic saturation values. This is believed by the inventors to be a result of the PCD tables listed in Tables III and IV being formed by sintering diamond particles having a relatively greater percentage of fine diamond particles than the diamond particle formulations used to fabricate the PCD tables listed in Table I.

Examples 41-120 tested four different substrate interfacial surface geometries to evaluate the effect of the interfacial surface area of the substrate. Twenty samples of each substrate interfacial surface geometry were tested. All of the PDCs in examples 41-120 were fabricated by placing a mass of diamond particles having an average diamond particle size of about 19 μm adjacent to a cobalt-cemented tungsten carbide substrate in a niobium container, placing the container in a high-pressure cell medium, and subjecting the high-pressure cell medium and the container therein to an HPHT process using an HPHT cubic press to form a PCD table bonded to the substrate. The surface area of each anvil of the HPHT press and the hydraulic line pressure used to drive the anvils were selected so that the sintering pressure was at least about 7.7 GPa. The temperature of the HPHT process was about 1400° C. The sintering pressure of 7.7 GPa refers to the pressure in the high-pressure cell medium at room temperature, and the actual sintering pressure at the sintering temperature of about 1400° C. is believed to be greater.

The interfacial surface for the substrate in the PDCs of examples 41-60 was a substantially planar interfacial surface having essentially no surface topography other than surface roughness. The interfacial surface for the substrate in the PDCs of examples 61-80 was similar to the interfacial surface **404** shown in FIG. **4**A. The interfacial surface for the substrate in the PDCs of Examples 81-100 was slightly convex with a plurality of radially and circumferentially equally-spaced cylindrical protrusions. The interfacial surface for the substrate in the PDCs of examples 101-120 was similar to the interfacial surface **504** shown in FIGS. **5**A and **5**B.

After fabricating the PDCs of examples 41-120, the substrate of each PDC was brazed to an extension cobalt-cemented tungsten carbide substrate. The braze alloy had a composition of about 25 wt % Au, about 10 wt % Ni, about 15 wt % Pd, about 13 wt % Mn, and about 37 wt % Cu. The brazing process was performed at a brazing temperature of about 1013° C. After the brazing process, the PDCs of examples 41-120 were individually examined using an optical microscope to determine if cracks were present in the PCD tables.

Table V below lists the substrate diameter, surface area of the interfacial surface of the substrates for each type of substrate geometry, the ratio of the interfacial surface area of the substrate to a flat interfacial surface of a substrate with the same diameter, and the number of PDC samples in which the PCD table cracked upon brazing to the extension cobalt-cemented tungsten carbide substrate. As shown in Table V, as the surface area of the interfacial surface of the substrate decreases, the prevalence of the PCD table cracking decreases upon brazing.

TABLE V

Effect of Substrate Interfacial Surface Area on PCD Table Cracking Upon Brazing

Example	Substrate Diameter (in)	Interfacial Surface Area of Substrate (in^2)	Ratio	Number of Samples That Cracked When Brazed
41-60	0.625	0.308	1.0	0
61-80	0.625	0.398	0.772	0
81-100	0.625	0.524	0.588	2 out of 20
101-120	0.625	0.585	0.526	9 out of 20

Embodiments of Applications for PCD and PDCs

The disclosed PCD and PDC embodiments may be used in a number of different applications including, but not limited to, use in a rotary drill bit (FIGS. **6**A and **6**B), a thrust-bearing apparatus (FIG. **7**), a radial bearing apparatus (FIG. **8**), a subterranean drilling system (FIG. **9**), and a wire-drawing die (FIG. **10**). The various applications discussed above are merely some examples of applications in which the PCD and PDC embodiments may be used. Other applications are contemplated, such as employing the disclosed PCD and PDC embodiments in friction stir welding tools.

FIG. **6**A is an isometric view and FIG. **6**B is a top elevation view of an embodiment of a rotary drill bit **600**. The rotary drill bit **600** includes at least one PDC configured according to any of the previously described PDC embodiments. The rotary drill bit **600** comprises a bit body **602** that includes radially and longitudinally extending blades **604** with leading faces **606**, and a threaded pin connection **608** for connecting the bit body **602** to a drilling string. The bit body **602** defines a leading end structure for drilling into a subterranean formation by rotation about a longitudinal axis **610** and application of weight-on-bit. At least one PDC cutting element, configured according to any of the previously described PDC embodiments (e.g., the PDC **300** shown in FIG. **3**A), may be affixed to the bit body **602**. With reference to FIG. **6**B, a plurality of PDCs **612** are secured to the blades **604**. For example, each PDC **612** may include a PCD table **614** bonded to a substrate **616**. More generally, the PDCs **612** may comprise any PDC disclosed herein, without limitation. In addition, if desired, in some embodiments, a number of the PDCs **612** may be conventional in construction. Also, circumferentially adjacent blades **604** define so-called junk slots **618** therebetween, as known in the art. Additionally, the rotary drill bit **600** may include a plurality of nozzle cavities **620** for communicating drilling fluid from the interior of the rotary drill bit **600** to the PDCs **612**.

FIGS. **6**A and **6**B merely depict an embodiment of a rotary drill bit that employs at least one cutting element comprising a PDC fabricated and structured in accordance with the disclosed embodiments, without limitation. The rotary drill bit **600** is used to represent any number of earth-boring tools or drilling tools, including, for example, core bits, roller-cone bits, fixed-cutter bits, eccentric bits, bicenter bits, reamers, reamer wings, or any other downhole tool including PDCs, without limitation.

The PCD and/or PDCs disclosed herein (e.g., the PDC **300** shown in FIG. **3**A) may also be utilized in applications other than rotary drill bits. For example, the disclosed PDC embodiments may be used in thrust-bearing assemblies, radial bearing assemblies, wire-drawing dies, artificial joints, machining elements, and heat sinks.

FIG. **7** is an isometric cutaway view of an embodiment of a thrust-bearing apparatus **700**, which may utilize any of the disclosed PDC embodiments as bearing elements. The thrust-bearing apparatus **700** includes respective thrust-bearing assemblies **702**. Each thrust-bearing assembly **702** includes an annular support ring **704** that may be fabricated from a material, such as carbon steel, stainless steel, or another suitable material. Each support ring **704** includes a plurality of recesses (not labeled) that receive a corresponding bearing element **706**. Each bearing element **706** may be mounted to a corresponding support ring **704** within a corresponding recess by brazing, press-fitting, using fasteners, or another suitable mounting technique. One or more, or all of bearing elements **706** may be configured according to any of the disclosed PDC embodiments. For example, each bearing element **706** may include a substrate **708** and a PCD table **710**, with the PCD table **710** including a bearing surface **712**.

In use, the bearing surfaces **712** of one of the thrust-bearing assemblies **702** bear against the opposing bearing surfaces **712** of the other one of the bearing assemblies **702**. For example, one of the thrust-bearing assemblies **702** may be operably coupled to a shaft to rotate therewith and may be termed a "rotor." The other one of the thrust-bearing assemblies **702** may be held stationary and may be termed a "stator."

FIG. **8** is an isometric cutaway view of an embodiment of a radial bearing apparatus **800**, which may utilize any of the disclosed PDC embodiments as bearing elements. The radial bearing apparatus **800** includes an inner race **802** positioned generally within an outer race **804**. The outer race **804** includes a plurality of bearing elements **806** affixed thereto that have respective bearing surfaces **808**. The inner race **802** also includes a plurality of bearing elements **810** affixed thereto that have respective bearing surfaces **812**. One or more, or all of the bearing elements **806** and **810** may be configured according to any of the PDC embodiments disclosed herein. The inner race **802** is positioned generally within the outer race **804** and, thus, the inner race **802** and outer race **804** may be configured so that the bearing surfaces **808** and **812** may at least partially contact one another and move relative to each other as the inner race **802** and outer race **804** rotate relative to each other during use.

The radial bearing apparatus **800** may be employed in a variety of mechanical applications. For example, so-called "roller cone" rotary drill bits may benefit from a radial bearing apparatus disclosed herein. More specifically, the inner race **802** may be mounted to a spindle of a roller cone and the outer race **804** may be mounted to an inner bore formed within a cone and that such an outer race **804** and inner race **802** may be assembled to form a radial bearing apparatus.

Referring to FIG. **9**, the thrust-bearing apparatus **700** and/or radial bearing apparatus **800** may be incorporated in a subterranean drilling system. FIG. **9** is a schematic isometric cutaway view of a subterranean drilling system **900** that includes at least one of the thrust-bearing apparatuses **700** shown in FIG. **7** according to another embodiment. The subterranean drilling system **900** includes a housing **902** enclosing a downhole drilling motor **904** (i.e., a motor, turbine, or any other device capable of rotating an output shaft) that is operably connected to an output shaft **906**. A first thrust-bearing apparatus $\mathbf{700}_1$ (FIG. **7**) is operably coupled to the downhole drilling motor **904**. A second thrust-bearing apparatus $\mathbf{700}_2$ (FIG. **7**) is operably coupled to the output shaft **906**. A rotary drill bit **908** configured to engage a subterranean formation and drill a borehole is connected to the output shaft **906**. The rotary drill bit **908** is shown as a roller cone bit including a plurality of roller cones **910**. However, other embodiments may utilize different types of rotary drill bits, such as a so-called "fixed cutter" drill bit shown in FIGS. **6**A and **6**B. As the borehole is drilled, pipe sections may be connected to the subterranean drilling system **900** to form a drill string capable of progressively drilling the borehole to a greater depth within the earth.

A first one of the thrust-bearing assemblies **702** of the thrust-bearing apparatus $\mathbf{700}_1$ is configured as a stator that does not rotate and a second one of the thrust-bearing assemblies **702** of the thrust-bearing apparatus $\mathbf{700}_1$ is configured as a rotor that is attached to the output shaft **906** and rotates with the output shaft **906**. The on-bottom thrust generated when the drill bit **908** engages the bottom of the borehole may be carried, at least in part, by the first thrust-bearing apparatus $\mathbf{700}_1$. A first one of the thrust-bearing assemblies **702** of the thrust-bearing apparatus $\mathbf{700}_2$ is configured as a stator that does not rotate and a second one of the thrust-bearing assemblies **702** of the thrust-bearing apparatus $\mathbf{700}_2$ is configured as a rotor that is attached to the output shaft **906** and rotates with the output shaft **906**. Fluid flow through the power section of the downhole drilling motor **904** may cause what is commonly referred to as "off-bottom thrust," which may be carried, at least in part, by the second thrust-bearing apparatus $\mathbf{700}_2$.

In operation, drilling fluid may be circulated through the downhole drilling motor **904** to generate torque and effect rotation of the output shaft **906** and the rotary drill bit **908** attached thereto so that a borehole may be drilled. A portion of the drilling fluid may also be used to lubricate opposing bearing surfaces of the bearing elements **706** of the thrust-bearing assemblies **702**.

FIG. **10** is a side cross-sectional view of an embodiment of a wire-drawing die **1000** that employs a PDC **1002** fabricated in accordance with the teachings described herein. The PDC **1002** includes an inner, annular PCD region **1004** comprising any of the PCD tables described herein that is bonded to an outer cylindrical substrate **1006** that may be made from the same materials as the substrate **302** shown in FIG. **3**A. The PCD region **1004** also includes a die cavity **1008** formed therethrough configured for receiving and shaping a wire being drawn. The wire-drawing die **1000** may be encased in a housing (e.g., a stainless steel housing), which is not shown, to allow for handling.

In use, a wire **1010** of a diameter d_1 is drawn through die cavity **1008** along a wire drawing axis **1012** to reduce the diameter of the wire **1010** to a reduced diameter d_2.

While various aspects and embodiments have been disclosed herein, other aspects and embodiments are contemplated. The various aspects and embodiments disclosed herein are for purposes of illustration and are not intended to be limiting. Additionally, the words "including," "having," and variants thereof (e.g., "includes" and "has") as used herein, including the claims, shall have the same meaning as the word "comprising" and variants thereof (e.g., "comprise" and "comprises").

The invention claimed is:

1. A polycrystalline diamond compact, comprising:

a polycrystalline diamond table, at least an unleached portion of the polycrystalline diamond table including:

a plurality of diamond grains bonded together via diamond-to-diamond bonding to define interstitial regions, the plurality of diamond grains exhibiting an average grain size of about 50 μm or less; and a catalyst including cobalt, the catalyst occupying at least a portion of the interstitial regions;

wherein the unleached portion of the polycrystalline diamond table exhibits a coercivity of about 115 Oe to about 250 Oe;

wherein the unleached portion of the polycrystalline diamond table exhibits a specific permeability less than about 0.10 G·cm^3/g·Oe; and

a substrate bonded to the polycrystalline diamond table along an interfacial surface, the interfacial surface exhibiting a substantially planar topography;

wherein a lateral dimension of the polycrystalline diamond table is about 0.8 cm to about 1.9 cm.

2. The polycrystalline diamond compact of claim **1** wherein the unleached portion of the polycrystalline diamond table exhibits a specific magnetic saturation of about 15 G·cm^3/g or less.

3. The polycrystalline diamond compact of claim **2** wherein:

the specific magnetic saturation is about 10 G·cm^3/g to about 15 G·cm^3/g; and

the unleached portion of the polycrystalline diamond table includes metal-solvent catalyst in an amount of about 3 weight % to about 7.5 weight %.

4. The polycrystalline diamond compact of claim **1** wherein a ratio of a surface area of a planar interfacial surface to a surface area of the substantially planar interfacial surface is greater than about 0.600.

5. The polycrystalline diamond compact of claim **4** wherein the ratio is about 0.600 to about 0.650.

6. The polycrystalline diamond compact of claim **5** wherein a G_{ratio} of the polycrystalline diamond table is at least about 4.0×10^6.

7. The polycrystalline diamond compact of claim **5** wherein the average grain size is about 30 μm or less.

8. The polycrystalline diamond compact of claim **4** wherein the ratio is about 0.750 to less than 1.0.

9. The polycrystalline diamond compact of claim **1** wherein the coercivity is about 115 Oe to about 175 Oe.

10. The polycrystalline diamond compact of claim **1** wherein the unleached portion of the polycrystalline diamond table exhibits a specific magnetic saturation of about 5 G·cm^3/g to about 15 G·cm^3/g.

11. The polycrystalline diamond compact of claim **1** wherein the lateral dimension of the polycrystalline diamond table is about 1.3 cm to about 1.9 cm.

12. The polycrystalline diamond compact of claim **1** wherein the polycrystalline diamond table is formed from only single layer of polycrystalline diamond extending from an upper working surface of the polycrystalline diamond table to the substrate.

13. The polycrystalline diamond compact of claim **1** wherein the polycrystalline diamond table includes:

a first layer including coarse-sized diamond grains exhibiting a first average grain size; and a second layer including fine-sized diamond grains.

14. A rotary drill bit, comprising:

a bit body including a leading end structure configured to facilitate drilling a subterranean formation; and

a plurality of cutting elements mounted to the bit body, at least one of the plurality of cutting elements configured as the polycrystalline diamond compact according to claim **1**.

15. A polycrystalline diamond compact, comprising:

a polycrystalline diamond table, at least an unleached portion of the polycrystalline diamond table including:

a plurality of diamond grains bonded together via diamond-to-diamond bonding to define defining interstitial regions, the plurality of diamond grains exhibiting an average grain size of about 50 μm or less; and

a catalyst including cobalt, the catalyst occupying at least a portion of the interstitial regions;

wherein the unleached portion of the polycrystalline diamond table exhibits:

a coercivity of about 115 Oe to about 250 Oe;

a specific magnetic saturation of about 10 G·cm^3/g to about 15 G·cm^3/g; and

a thermal stability, as determined by a distance cut, prior to failure in a vertical lathe test, of about 1300 m to about 3950 m;

wherein a lateral dimension of the polycrystalline diamond table is about 0.8 cm or more.

16. The polycrystalline diamond compact of claim **15** wherein the unleached portion of the polycrystalline diamond table includes metal-solvent catalyst in an amount of about 3 weight % to about 7.5 weight %.

17. The polycrystalline diamond compact of claim **16** wherein a ratio of a surface area of a planar interfacial surface to a surface area of the substantially planar interfacial surface is greater than about 0.600.

18. The polycrystalline diamond compact of claim **17** wherein the ratio is about 0.600 to about 0.650.

19. The polycrystalline diamond compact of claim **17** wherein the ratio is about 0.750 to less than 1.0.

20. The polycrystalline diamond compact of claim **16** wherein a G_{ratio} of the polycrystalline diamond table is at least about 4.0×10^6.

21. The polycrystalline diamond compact of claim **15** wherein the unleached portion of the polycrystalline diamond table exhibits a specific permeability less than about 0.10 G·cm^3/g·Oe.

22. The polycrystalline diamond compact of claim **15** wherein the polycrystalline diamond table is formed from only single layer of polycrystalline diamond extending from an upper working surface of the polycrystalline diamond table to the substrate.

23. The polycrystalline diamond compact of claim **15** wherein the polycrystalline diamond table includes

a first layer including coarse-sized diamond grains exhibiting a first average grain size; and

a second layer including fine-sized diamond grains.

24. A polycrystalline diamond compact, comprising:

a polycrystalline diamond table, at least an unleached portion of the polycrystalline diamond table including:

a plurality of diamond grains bonded together via diamond-to-diamond bonding to define interstitial regions, the plurality of diamond grains exhibiting an average grain size of about 10 μm to about 18 μm; and

a catalyst including cobalt, the catalyst occupying at least a portion of the interstitial regions;

wherein the unleached portion of the polycrystalline diamond table exhibits a coercivity of about 115 Oe to about 250 Oe;

wherein the unleached portion of the polycrystalline diamond table exhibits a specific permeability of about 0.060 G·cm^3/g·Oe to about 0.090 G·cm^3/g·Oe; and

a substrate bonded to the polycrystalline diamond table along an interfacial surface, the interfacial surface exhibiting a substantially planar topography;

wherein a lateral dimension of the polycrystalline diamond table is about 1.3 cm to about 1.9 cm.

25. The polycrystalline diamond compact of claim **24** wherein:

the specific magnetic saturation is about 10 G·cm^3/g to about 15 G·cm^3/g; and

the unleached portion of the polycrystalline diamond table includes metal-solvent catalyst in an amount of about 3 weight % to about 7.5 weight %.

26. The polycrystalline diamond compact of claim **24** wherein a ratio of a surface area of a planar interfacial surface to a surface area of the substantially planar interfacial surface is greater than about 0.600.

27. The polycrystalline diamond compact of claim **26** wherein the ratio is about 0.600 to about 0.650.

28. The polycrystalline diamond compact of claim **26** wherein the ratio is about 0.750 to less than 1.0.

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UNITED STATES COURT OF APPEALS
FOR THE FEDERAL CIRCUIT

CERTIFICATE OF CONFIDENTIAL MATERIAL

Case Number: 2023-1217

Short Case Caption: US Synthetic Corp. v. ITC

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