

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

CMS CEP COR LTD., and CMS CEP COR AMERICAS LLC,
Petitioner,

v.

SANDVIK INTELLECTUAL PROPERTY AB,
Patent Owner.

Patent No. 9,827,568

Inter Partes Review No. IPR2024-01380

DECLARATION OF HARRI KYTÖMAA, PH.D.

I, Harri Kytömaa, Ph.D, make this declaration in connection with the proceeding identified above.

I. INTRODUCTION

1. I have been retained by counsel for Patent Owner, Sandvik Intellectual Property AB (“Sandvik”) as a technical expert in connection with the proceeding identified above. I submit this declaration in support of Patent Owner’s Non-Contingent Motion to Amend for *Inter Partes* Review of United States Patent No. 9,827,568 (“the ‘568 patent”).

2. Exponent is being paid at an hourly rate for my work on this matter. I have no personal or financial stake or interest in the outcome of the present proceeding.

II. QUALIFICATIONS

3. In this section, I summarize my educational background, experience, career history, publications, and other relevant qualifications. A detailed description of my professional qualifications, including a list of publications, awards, and professional activities, is contained in my curriculum vitae, attached as Exhibit 2002.

4. I am a Licensed Professional Engineer in the states of Texas, Louisiana, Oklahoma, Arkansas, Alabama, California, Washington, Michigan, Florida, Maine, New Jersey, New York, and Massachusetts.

5. In 1979, I graduated with a Bachelor of Science degree (First Class with Honors) in Engineering Science from Durham University. Subsequently, I attended the California Institute of Technology (“Caltech”) where I received a Master of Science degree in Mechanical Engineering in 1982, as well as my Ph.D., also in Mechanical Engineering, in 1987.

6. My Ph.D. thesis research at Caltech focused on the dynamics of particle flows. As part of my research, I designed and constructed a two-story experimental facility and designed and built a custom hopper to contain and dispense solid materials and a gate valve to control their flow. During my tenure as a graduate student at Caltech, I was also a teaching assistant of Caltech undergraduate and graduate-level mechanical engineering courses.

7. I was a member of the faculty at The Massachusetts Institute of Technology (“MIT”) from 1986 to 1994 in the Mechanical Engineering department. From 1986 to 1990, I was an Assistant Professor, and from 1990 to 1994, I was an Associate Professor. I was Head of MIT’s Fluid Mechanics Laboratory in the Department of Mechanical Engineering from 1990 to 1994. As a Professor at MIT, my responsibilities also included teaching undergraduate and graduate level courses. I taught the capstone mechanical engineering design course that included machine design, experimental methods courses, and courses in thermal sciences. Some of my research at MIT focused on comminution and

methods of efficient particle size reduction through crushing, for example. Such methods are energy intensive and, in an effort to render these more efficient, my work addressed ways of segregating particles by their size. I designed and constructed a test section in which mixtures of particulate materials of different sizes were submerged in water and were dynamically fluidized with sudden upward jets of water to separate them by size. Another part of my research studied the behavior of dense granular and particulate materials. For this work, I designed and built a shear cell that was driven by a bearing-supported shaft, a gear box, and an electric motor.

8. While a Professor at MIT, I also spent some of my time on engineering consulting in the oil and gas industry. This work included developing the use of acoustic telemetry in drilling and downhole applications by sending sound waves through drilling muds (dense suspensions of solids). This work contributed to Measurement-While-Drilling (MWD) techniques, an enabling technology for directional drilling. In this consulting capacity, I also developed concepts for downhole rotating valves that were driven by a shaft to create pressure pulses.

9. While at MIT, I also published articles about my research work in peer-reviewed journals. I was awarded the ASME Lewis F. Moody Award for my

work on dense suspensions of solids and served as Workshop Group Leader for the U.S. National Science Foundation.

10. I joined Failure Analysis Associates in 1994 as a full-time employee with the title of Managing Engineer. The firm was renamed Exponent in 1998. In that same year, I became the Director of the Thermal Science practice, a position that I held until October 1, 2016. I am currently Corporate Vice President of Exponent. My responsibilities with Exponent include providing scientific and engineering consulting services as a mechanical engineer.

11. At Exponent, I have continued to work on mechanical and machine design. Examples of past projects include working on coal handling equipment including crushers associated with coal mining and coal fired power plants, fasteners (such as threaded components and rivets), manufacturing techniques (casting, forging, welded and riveted assemblies), mechanical seal designs, bearing design and performance, shaft misalignment, eccentric shaft motion and vibration. These have often been in the context of rotating equipment such as aircraft engines, compressors, turbines and pumps.

12. I have also worked and testified on intellectual property matters involving machine design of heavy mechanical equipment, such as large valves, aircraft engines and downhole tools, as well as smaller equipment, such as fire-fighting nozzles and various kinds of mechanical fasteners.

13. I am an active member of several professional organizations including the American Society of Mechanical Engineers (“ASME”) and the American Society of Chemical Engineers (“AIChE”). In January 2016, I was elected Fellow of the ASME in recognition for the contributions I have made to the profession.

14. As noted above, attached as Appendix A is a copy of my *curriculum vitae*.

III. MATERIALS CONSIDERED

15. In preparing this declaration, I have reviewed, among other things, the following materials:

- The ’568 patent (Ex. 1001);
- The Petition for *Inter Partes* Review of the ’568 patent to which my declaration related (“Petition”) and Exhibits thereto, with particular attention to the Exhibits set forth below;
- The prosecution history of the ’568 patent (Ex. 1001-1, “’568 prosecution history”);
- The Expert Declaration by David G. Smith that accompanies the Petition (Ex. 1002, “Smith”);
- U.S. Patent No. 4,410,143 issued to Polinski (Ex. 1015, “Polinski”);
- U.S. Patent No. 6,270,026 issued to Piepho (Ex. 1016, “Piepho”);
- U.S. Patent No. 4,060,205 issued to Pollak (Ex. 1017, “Pollak”);

- U.S. Patent No. 2,764,437 issued to A.G. Bratt (Ex. 1034, “Bratt”);
- The Decision on Institution (“Institution Decision”) dated March 18, 2025.
- Deposition Transcript of David Smith, (Ex. 2006);
- Declaration of David G. Smith in Support of Petition for *Inter Partes* Review of U.S. Patent 11,014,090 (Ex. 2007)
- Merriam-Webster’s Collegiate Dictionary, 11th ed. (2012) (definition of “end”) (Ex. 2008);
- Sandvik CH440 Webpage at <https://www.rockprocessing.sandvik/en/products/stationary-crushers/stationary-cone-crushers/ch440-cone-crusher/> (accessed on June 23, 2025) (Ex. 2009);
- CMS Cepcor Webpage at <https://www.cmscepcor.com/us/crusher-parts/brands/sandvik-hydrocone-superior/ch-series/ch440/> (accessed on June 23, 2025) (Ex. 2010);
- CMS Cepcor Webpage at <https://www.cmscepcor.com/us/crusher-parts/brands/sandvik-hydrocone-superior/> (accessed on June 23, 2025)(Ex. 2011)
- Richard G. Budynas & J. Keith Nisbett, *Shigley’s Mechanical Engineering Design*, Ninth Edition (2011) (Ex. 2012)

- John H. Bickford, *An Introduction to the Design and Behavior of Bolted Joints*, 3rd ed. (1995) (Ex. 2013)
- Robert C. Juvinall & Kurt M. Marshek, *Fundamentals of Machine Component Design*, 3rd Edition (2000) (Ex. 2014)

IV. DEFINITIONS AND STANDARDS

16. Although I am not a lawyer and will not provide legal opinions, I have been advised to apply certain legal standards, such as relating to claim construction and obviousness, in forming my opinions. I have been informed and understand that claims are construed from the perspective of one of ordinary skill in the art at the time of the claimed invention. For the purposes of this Declaration, I have been informed that the time of the claimed invention is August 2, 2012, the earliest effective filing date for the '568 patent, corresponding to when European Patent Application No. 12179089 was filed.

17. I have further been informed, that during *inter partes* review, claims are to be construed using the same standard applied in district court. This standard is sometimes referred to as the *Phillips* standard. I understand that, under this standard, a claim term presumptively receives its plain and ordinary meaning to a person of ordinary skill in the art. I have been further informed that claim construction begins with the language of the claims, the specification, and the

prosecution history, but that extrinsic evidence, including dictionary definitions and expert testimony, may also be considered.

18. I have also been informed and understand that the subject matter of a patent claim is obvious if the differences between the subject matter of the claim and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the subject matter pertains. I have also been informed that the framework for determining obviousness involves considering the following factors: (i) the scope and content of the prior art; (ii) the differences between the prior art and the claimed subject matter; (iii) the level of ordinary skill in the art; and (iv) any objective evidence of non-obviousness. With respect to the objective evidence of non-obviousness, I understand that they may show that a claimed invention would not have been obvious to a POSITA. Such objective evidence may include evidence of copying by a patent challenger or third parties, praise and commercial success of the claimed invention, and unexpected results. I further understand that there must be a relationship, or nexus, between any such evidence and the claimed invention.

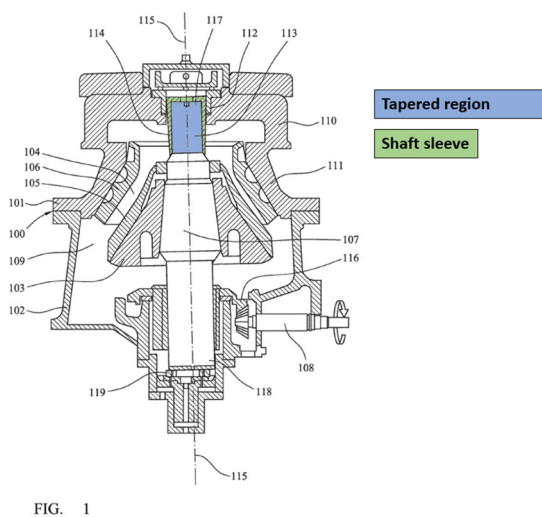
19. I understand that the claimed subject matter would have been obvious to one of ordinary skill in the art if, for example, it results from the combination of known elements according to known methods to yield predictable results, the

simple substitution of one known element for another to obtain predictable results, use of a known technique to improve similar devices in the same way or applying a known technique to a known device ready for improvement to yield predictable results. I have also been informed that the analysis of obviousness may include recourse to logic, judgment and common sense available to the person of ordinary skill in the art that does not necessarily require explication in any reference.

V. THE '568 PATENT

A. Overview of the '568 patent

20. The '568 patent is directed to “a sleeve for a main shaft of a gyratory crusher that enables convenient attachment and detachment at the shaft so as to be quickly and conveniently assembled and disassembled.” (Ex. 1001, 1:66–2:2.) As illustrated in FIG. 1 of the '568 patent below, a shaft body of main shaft 107 includes a tapered region, upper conical portion 113. (*Id.*, 3:65–66.) The upper conical portion 113 is fit with a wear sleeve 114. (*Id.*, 4:4–12.)



(*Id.*, FIG. 1 (annotated).)

21. FIG. 2 of the '568 patent, shown below, illustrates additional details with respect to the tapered region 113 and the sleeve 114 fit to tapered region 113.

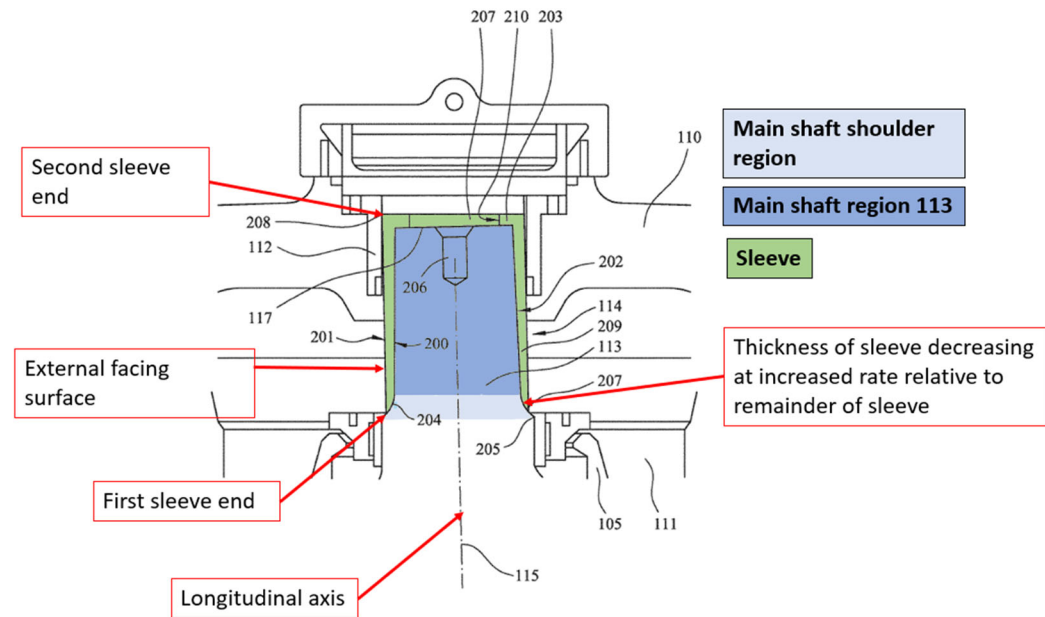


FIG. 2

(*Id.*, FIG. 2 (annotated).)

22. As disclosed in the '568 patent, sleeve 114 includes an external facing surface 201 and an internal facing surface 200, the orientation of faces 201, 200 being relative to the longitudinal axis 115 extending through shaft region 113 and sleeve 114. (*Id.*, 4:13–16.) Internal facing surface 200 is secured in direct contact against an external facing surface 202 of conical region 113. (*Id.*, 4:17–18.) The internal facing surface 200 of sleeve 114 tapers inwardly towards longitudinal axis

115 from a first end 207 of the sleeve 114. (*Id.*, 4:19–20.) The first end 207 of sleeve 114 is positioned below a second end 208 of the sleeve 114 within the crusher during normal use. (*Id.*, 4:21–22; FIG. 2.)

23. The external facing surface 201 of sleeve 114 is aligned parallel with axis 115 such that the sleeve 114, when viewed externally, has a cylindrical geometry. (*Id.*, 4:26–29; FIGS. 1–2.) The annular axial wall 209 of sleeve 114 that is defined between internal facing surface 200 and external facing surface 201 has a thickness that tapers and decreases the full axial length of sleeve 114 from the second (upper) end 208 of the sleeve 114 to the first (lower) end 207 of the sleeve 114. (*Id.*, 4:29–33; 2:37–39; FIGS 1–2.) Additionally, the thickness of the axial wall 209 decreases at a uniform rate along the axial length of axial wall 209 except for at a region proximal to the first, lower, end 207 of sleeve 114, at which the rate of thickness decline increases.

VI. THE SUBSTITUTE CLAIMS ARE SUPPORTED BY THE ORIGINAL DISCLOSURES AND DO NOT INTRODUCE NEW MATTER

24. The '568 patent issued from U.S. App. No. 14/418,535 (Ex. 2004, the “'535 application”), filed on January 30, 2015. The '535 application is a national stage entry of PCT/EP2013/062861 (Ex. 2005), filed on June 20, 2013, which claims priority to EP Application No. 12179089.3 (Ex. 2003), filed August 2, 2012. As set forth below, Sandvik submits that the originally filed disclosure (Exs.

2003 & 2004) supports each substitute claim and makes clear that no new matter has been introduced. 37 C.F.R. §§ 42.121(a)(2)(ii) and (b)(1). The left column of the chart below shows the substitute independent claim in comparison to the challenged independent claim, with added recitations underlined and deleted recitations with strikethroughs. The right column shows exemplary support in the original disclosure—first with respect to the recitations of the challenged independent claims and then for the newly added recitations.

Substitute Independent Claim	Support in the EP Application No. 12179089.3 (Ex. 2003) and '535 Application (Ex. 2004)
[11pre] Claim 11. A gyratory crusher comprising: [11a] a main shaft including a shaft body having a first end for positioning at a lower region of the crusher and a second end for positioning at an upper region of the crusher relative to the first end, a thickness of the shaft body being tapered in an axial direction of the main shaft at a <u>tapered</u> region of the second end so as to <u>taper and</u> decrease in cross-sectional area; and [11b] a sleeve fitted over the tapered region at the second end of the main shaft, the sleeve including an elongate axial wall extending around a longitudinal axis of the sleeve, the axial wall having an internal facing surface for positioning in contact with an outward facing surface of the main shaft, and an external facing surface relative to the longitudinal axis, the axial wall extending between the	<u>'568 patent claim 1</u> Exs. 2003 & 2004: 3:12–23; 4:23–29; FIGS. 1–2. [11a] “a thickness of the shaft body being tapered in an axial direction of the main shaft at a <u>tapered</u> region of the second end so as to <u>taper and</u> decrease in cross-sectional area” Exs. 2003 & 2004: 3:5; 6:1–3; FIG. 1–2. [11b] “the axial wall extending between the internal and external facing surfaces, the axial wall having a first <u>sleeve</u> end for positioning at a lower region of the main shaft, and a second <u>sleeve</u> end for positioning at an upper region of the main shaft relative to the lower region” Exs. 2003 & 2004: 3:1–3; 6:14–20; 6:24–27; FIG. 2.

internal and external facing surfaces, the axial wall having a first <u>sleeve end</u> for positioning at a lower region of the main shaft and a second <u>sleeve end</u> for positioning at an upper region of the main shaft relative to the lower region, [11c] wherein a thickness of the axial wall at a region between the first and second <u>sleeve ends tapers and</u> decreases in a direction from the second <u>sleeve end</u> to the first <u>sleeve end</u>, [11d] in the axial direction the internal facing surface at said region between the first and second <u>sleeve ends</u> extending transverse to the longitudinal axis so as to taper inwardly towards the longitudinal axis <u>of the sleeve</u> in the direction from the first <u>sleeve end</u> to the second <u>sleeve end</u>, and [11e] wherein the external facing surface from the first sleeve end to the second sleeve end is parallel to the longitudinal axis of the sleeve such that the external facing surface of the sleeve when viewed externally has a cylindrical geometry.	[11c] “a thickness of the axial wall at a region between the first and second <u>sleeve ends tapers and</u> decreases in a direction from the second <u>sleeve end</u> to the first <u>sleeve end</u>” Exs. 2003 & 2004: 3:19–21; 6:24–27; FIG. 2. [11d] “in the axial direction the internal facing surface at said region between the first and second <u>sleeve ends</u> extending transverse to the longitudinal axis so as to taper inwardly towards the longitudinal axis <u>of the sleeve</u> in the direction from the first <u>sleeve end</u> to the second <u>sleeve end</u>” Exs. 2003 & 2004: 3:1–3; 6:18–20; FIG. 2. [11e] “wherein the external facing surface from the first sleeve end to the second sleeve end is parallel to the longitudinal axis of the sleeve such that the external facing surface of the sleeve when viewed externally has a cylindrical geometry.” Exs. 2003 & 2004: 6:14-24; FIGS. 1–2.
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The chart below shows the exemplary support for the substitute dependent claims.

Substitute Dependent Claims	Support in the '535 Application (Ex. 2004) and EP Application No. 12179089.3 (Ex. 2003).
Claim 12 (corresponding to claim 2)	“wherein the region over which the thickness of the axial wall <u>tapers and</u> decreases extends <u>substantially</u> the full axial length of the sleeve” Exs. 2003 & 2004: 3:19–21; 25–26; 6:24–27; FIGS. 1–2.

Claim 13 (corresponding to claim 3)	Exs. 2003 & 2004: 3:28–30.
Claim 14 (corresponding to claim 5)	Exs. 2003 & 2004: 4:1–2.
Claim 15 (corresponding to claim 6)	Exs. 2003 & 2004: 4:2–3.
Claim 16 (corresponding to claim 8)	Exs. 2003 & 2004: 4:4–5.
Claim 17 (corresponding to claim 9)	Exs. 2003 & 2004: 4:10–11.
Claim 18 (corresponding to claim 10) The gyratory crusher as claimed in claim 11, wherein at a ~~curved~~ region <u>proximal to the first sleeve end, the thickness of the axial wall reduces at an increased rate relative to a region of the axial wall proximal to the second sleeve end</u> ~~the internal facing surface is curved radially outward relative to the longitudinal axis in a direction towards the external facing surface such that the axial wall thickness decreases to zero at the curved region.~~ (corresponding to claim 10)	<u>“wherein at a ~~curved~~ region proximal to the first sleeve end, the thickness of the axial wall reduces at an increased rate relative to a region of the axial wall proximal to the second sleeve end”</u> Exs. 2003 & 2004: 4:19–21; 7:1–5; FIG. 2.
Claim 19. The gyratory crusher as claimed in claim 18, wherein the thickness of the axial wall reduces at a uniform rate along an entire axial length of the sleeve other than the region proximal to the first sleeve end.	Exs. 2003 & 2004: 7:18–20; FIG. 2.

VII. THE SUBSTITUTE CLAIMS ARE PATENTABLE OVER THE PRIOR ART OF THE INSTITUTED GROUNDS

25. Substitute independent claim 11, and those claims that depend therefrom, are patentable over the instituted grounds in this trial in my opinion.

B. Claim Construction

26. I understand that Sandvik is requesting that the Board construe the term “end” as an extremity of the sleeve. Substitute claim 11 refers to, inter alia, an

“axial wall [of a sleeve] having a first sleeve end for positioning at a lower region of the main shaft and a second sleeve end for positioning at an upper region of the main shaft relative to the lower region.” My opinion is that the proposed construction is consistent with the claim language, the specification of the ’568 Patent, and dictionary definitions and would be understood as the plain and ordinary meaning of “end” to a POSITA.

27. The claim language support Sandvik’s proposed construction. Substitute claim 11 recites that “the external facing surface from the first sleeve end to the second sleeve end is parallel to the longitudinal axis of the sleeve such that the external facing surface of the sleeve when viewed externally has a cylindrical geometry.” The sleeve would only have a cylindrical geometry when viewed externally if the first sleeve end and the second sleeve end were respective extremities of the sleeve. I understand the dependent claims to be consistent with Sandvik’s proposed construction.

28. The specification of the ’568 Patent also supports Sandvik’s proposed construction. The specification of the ’568 Patent describes that the sleeve has “a thickness that tapers and reduces in a direction from second upper end 208 to first lower end 207.” (Ex. 1001, 4:29–33.) FIG. 2 of the ’568 Patent, in turn, points to the upper extremity of the sleeve for 208 and to the lower extremity of the sleeve for 207.

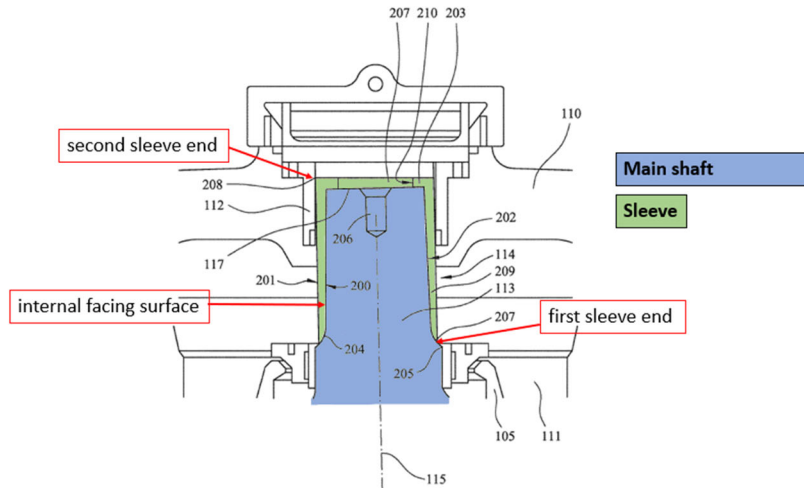


FIG. 2

29. Finally, Merriam-Webster’s Collegiate Dictionary (2012) provides that a definition of end is “the extreme or last part lengthwise: TIP.” (Ex. 2008, 411 (definition 1c).) It is my opinion that this definition is consistent with the use of “end” in the claim language and the specification and supports Sandvik’s construction of “end” as an extremity of the sleeve.

C. Level Of A Person Of Ordinary Skill In The Art

30. Mr. Smith states that “a person having ordinary skill in the art would be a person who has a bachelor’s degree in mechanical engineering or a related field and at least two years of experience with industrial equipment design and development. A POSITA may also have a combination of more formal education and less work experience or a combination of less/different formal education and more work experience.” (Ex. 1002, ¶ 30.) Mr. Smith also testified that the two years of experience is not limited to rock crushers and that “industrial equipment”

is a “broad category.” (*See* Ex. 2006, 38:25–39:24.) For the purposes of this Declaration, I do not object to Mr. Smith’s position on the level of skill in the art.

31. I meet and exceed the defined level of skill of a person of ordinary skill in the art of mechanical design and the field of comminution in the following ways: First, I have a B.Sc. in Engineering Science, and an M.S. and Ph.D. in Mechanical Engineering. While obtaining my doctorate, I engaged in the design and fabrication of equipment for the handling of bulk solid materials, which is relevant to crushers. For example, I designed and constructed a custom hopper to contain and dispense solid materials. During that time, I also taught undergraduate and graduate-level mechanical engineering courses. After I obtained my PhD, I was a Professor in Mechanical engineering at MIT. There, I taught the MIT capstone mechanical engineering design course that included machine design, experimental method courses, as well as courses in thermal sciences. Second, much of my research at MIT focused on bulk solids including comminution, how bulk solids respond to compression and methods of efficient particle size reduction through crushing. I have published multiple peer reviewed engineering papers on the subject. Third, I have engaged in the practice of mechanical engineering for decades. At Exponent, where I am a Corporate Vice President, I have worked on mechanical and machine design, including fasteners (such as threaded components and rivets), manufacturing techniques (casting, forging, welded and riveted

assemblies), mechanical seal designs (gaskets and seals), bearing design and performance, shaft misalignment, eccentric shaft motion and vibration. These have often been in the context of rotating equipment such as downhole rock drilling tools, as well as pumps, turbines and compressors. Some of this work has involved the failure of metal components through various mechanisms including metal fatigue of engineered components that experienced excessive vibrations and oscillatory stresses. I have also worked on coal handling equipment such as ball mills and crushers associated with coal mining and coal fired power plants.

32. Indeed, while Mr. Smith has testified that he does not have two years of experience with rock crushers (Ex. 2011, 39:8–10), I do have experience with rock crushers and I have published in the field of comminution. (Ex. 2002, 3–14.) Finally, I am a licensed professional mechanical engineer in the following 13 states: California, Massachusetts, Louisiana, Maine, Michigan, Washington, New York, Arkansas, Alabama, Oklahoma, New Jersey, Florida and Texas.

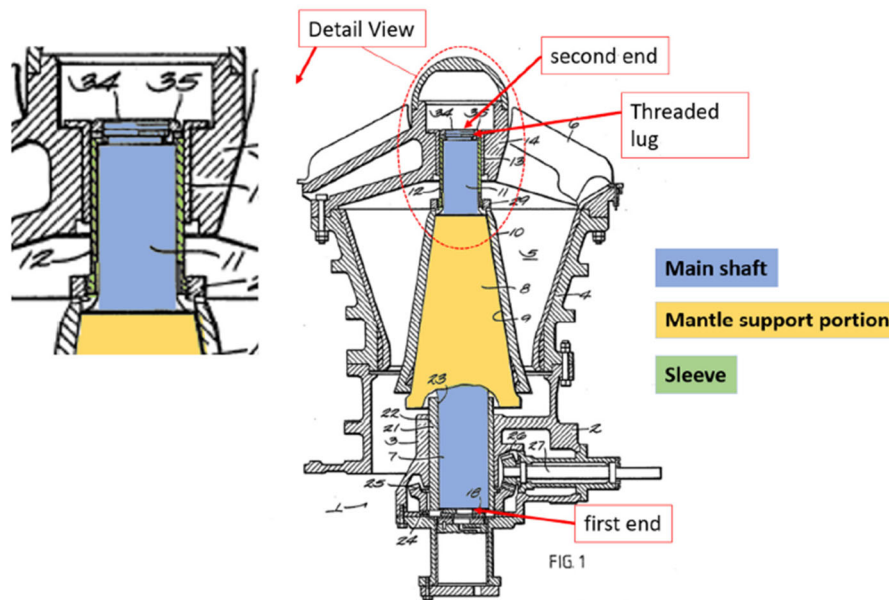
33. I will describe *infra* why the substitute claims would not have been obvious to a POSITA. At this point, I would add that the level of skill set forth by Mr. Smith supports the patentability of the substitute claims. To reach the substitute claims, a POSITA would have to modify Polinski and Piepho in a number of ways. Such modifications, aside from being unsupported by the disclosures of the references, would have been beyond the level of skill of a

POSITA, especially given that Mr. Smith testified elsewhere that “rock crushers are fairly complex machines” and their successful design requires understanding of a number of fields, such as “tribology, fracture mechanics, and fluid mechanics.” (Ex. 1002, ¶ 27.).

D. Summary Of The References

1. Polinski (Ex. 1015)

34. Polinski discloses a gyratory crusher and corresponding gyratory crusher shaft and bearing sleeve arrangement. (Ex. 1015, 1:44–47.) As illustrated in annotated Figure 1 of Polinski (below), the shaft includes a first end positioned near the bottom of the crusher and a second end positioned near the top of the crusher. (*Id.*, FIG. 1.) Above the cylindrical journal 11, shaft 7 includes a threaded lug 34 that extends to the second (top) end and is adapted to receive a sleeve nut 35 of a bearing sleeve 12. (*Id.*, 3:15–48.) The shaft further includes a mantle support portion 8 inserted into a conically shaped bore of a crusher mantle 10 and a cylindrical journal 11 fit with a corresponding bearing sleeve 12 (in green). (*Id.* 2:32–47.)



(Id., FIG. 1 (annotated).)

35. Polinski teaches that conventional gyratory crusher shafts often attach a crusher mantle (such as crusher mantle 10 in Figure 1 above) directly to the main shaft using threads cut into the main shaft. (*Id.*, 1:10–20.) Polinski teaches that such threads, which form geometrical discontinuities, should be eliminated from high stress regions of the shaft. (*See id.*) Specifically, with reference to the use of threads cut into the shaft to secure the crusher mantle, Polinski provides:

While this type of arrangement [threads cut into the shaft] has proven to be satisfactory for most crusher installations, experience has indicated that the relatively abrupt changes in the cross-sectional area of the shaft above and below the threaded section have resulted in high local stress concentrations in these regions of the shaft. **These stress concentrations are in addition to the *substantial stresses* generated by the *cyclic bending loads* applied to the shaft by the mantle during operation of the crusher. The result has been the development of *fatigue cracks* or fractures in the threaded section of the shaft as**

well as immediately above and below it where the highest stresses occur due to the abrupt changes in the cross-sectional area of the shaft. Over a period of time the cracks continue to grow and ultimately render the shaft unserviceable requiring that the crusher be taken out of service and the shaft replaced before crushing operations can be resumed.¹ (*Id.*, 1:20–37.)

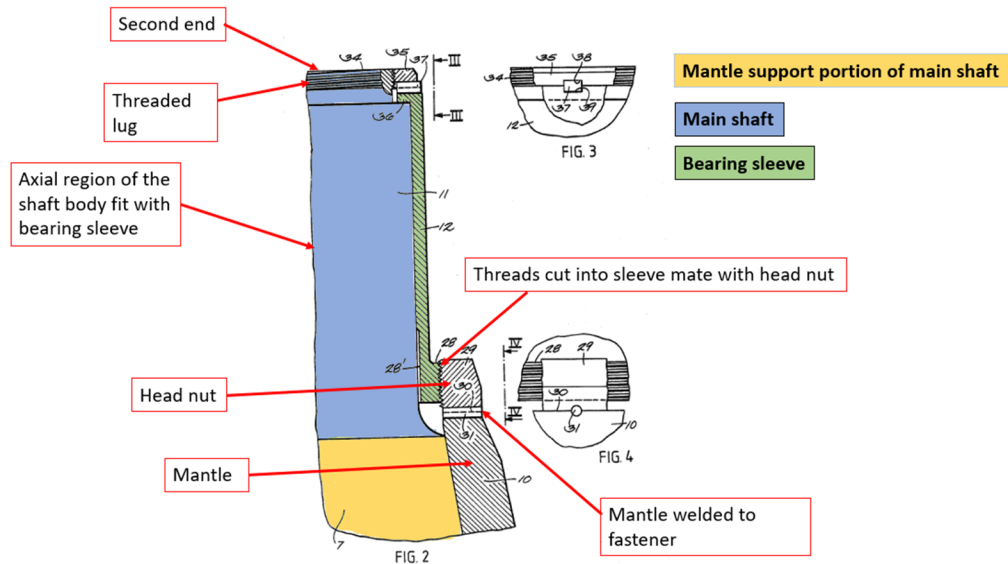
36. Polinski is directed to mitigating failure in gyratory crusher shafts by eliminating geometrical discontinuities from high-stress regions of the shaft. (*Id.*, 1:61–67.) Specifically, Polinski provides that:

[T]he invention contemplates an arrangement wherein abrupt structural discontinuities in the normally high-stressed regions of the main shaft have been essentially eliminated [by instead cutting threads into the sleeve] to minimize the development of fatigue fractures in the shaft while at the same time providing an arrangement which can be easily maintained and repaired in the field. (*Id.*)

37. To that end, Figure 2 of Polinski, below, illustrates the above discussed threads cut into a sleeve 12 as opposed to the shaft. Polinski provides that “the bearing sleeve 12 extends generally coextensively with the bearing journal 11 and includes an externally threaded annular shoulder 28 about its lower periphery threadably receiving a head nut 29.” (*Id.*, 2:67–68; 3:1–9.) “The head nut 29 abuts the upper edge 30 of the mantle 10 to secure it to the tapered portion of the main shaft 7, and at least one rod or dowel 31 is welded in a corresponding pair of semi-circular keyways in the head nut and the mantle to prevent rotation between these members after the head nut is secured in position.” (*Id.*, 3:3–9.)

¹ In this Declaration, all emphases have been added unless otherwise noted.

Accordingly, geometrical discontinuities are “essentially eliminated” from the high-stress bearing journal 11 of shaft 7. (*Id.*, 1:61–67.) The geometrical discontinuities are instead included in the bearing sleeve 12 to reduce fatigue crack initiation in the shaft 7. (*Id.*)



(*Id.*, FIG. 2.)

38. Polinski does not disclose that journal 11 (to which sleeve 12 is mounted) includes a taper extending from the second end of the shaft 7. Polinski also does not disclose that sleeve 12 includes a taper. Polinski also fails to disclose or suggest that the external facing surface from the end of the sleeve to the second end of the sleeve is parallel to the longitudinal axis of the sleeve.

2. Piepho (Ex. 1016)

39. Piepho discloses a main shaft for a coal pulverizer having a portion of the shaft coated with a material to mitigate fretting wear and fatigue failure. (Ex. 1016, 2:15–25.) Piepho discloses that conventional coal pulverizer shafts are known to fail due to stress concentrations in the shaft, fretting wear, and cyclic bending loads. (*Id.*, 1:45–65.) Specifically, Piepho explains:

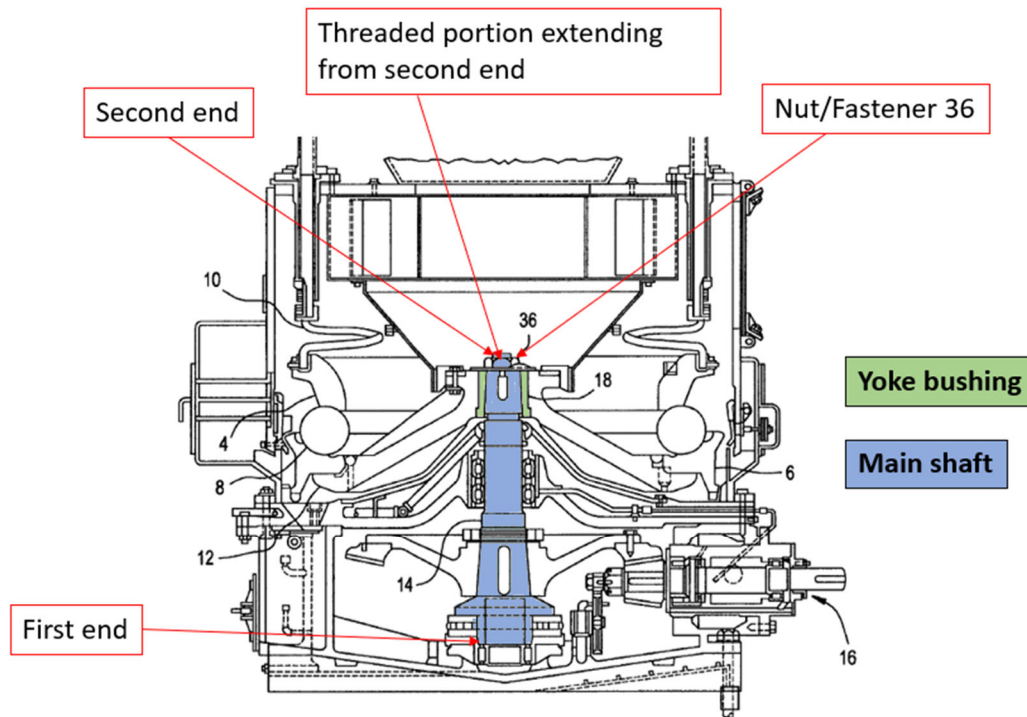
The pulverizer design generates cyclic or alternating type bending loads in the top end of the main shaft. Because the loads are cyclic, rubbing or fretting corrosion will occur. Also of concern is fatigue failure when stress concentration, cyclic loading and fretting corrosion are combined. (*Id.*, 1:53–58.)

40. Piepho further provides that various remedial efforts have failed to correct main shaft failure in coal pulverizers:

[T]here have been many attempts to correct main shaft failure frequency such as employing an anti-seize compound at the taper joint, using a bushing with a undercut center portion, using full contact bushings with no undercut center portion, shot peening, and nitriding as a surface hardening process. Remedial efforts notwithstanding, even carefully fitted taper joints, when subjected to cyclic bending forces often exhibit vulnerability to fatigue failure of shafts because of fretting and strain produced within the assembly. (*Id.*, 1:66–67; 2:1–8.)

41. To that end, Piepho is directed to techniques for mitigating shaft failure. Specifically, Piepho provides that “[t]he present invention resides in an improved main shaft for a coal pulverizer to reduce shaft failure due to fretting induced bending fatigue,” as described further below. (*Id.*, 2:56–58.)

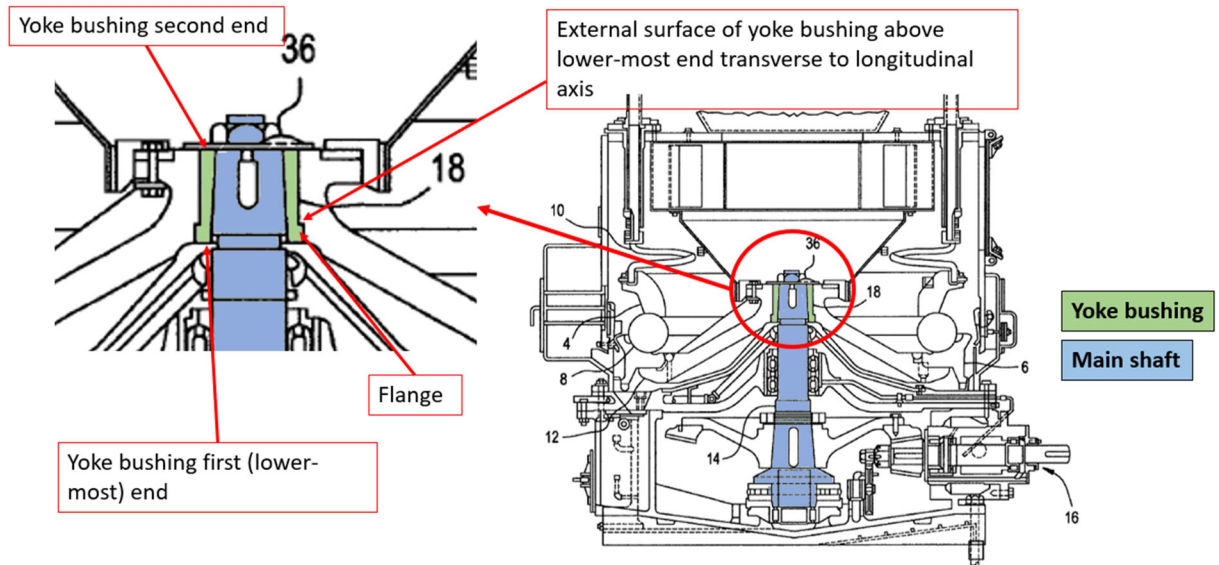
42. Figure 1 of Piepho, shown below, illustrates a conventional B&W type EL ball and race pulverizer in which the purported invention of Piepho may be used.



(*Id.*, FIG. 1 (annotated).)

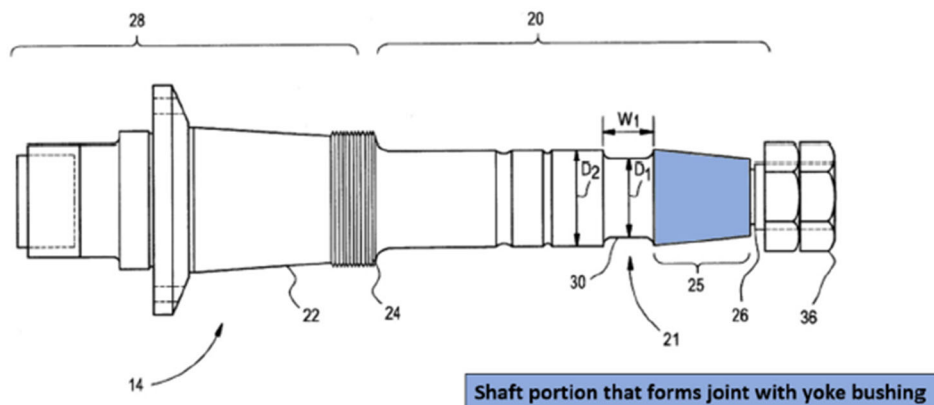
43. As shown in Figure 1 above, the B&W type EL ball and race coal pulverizer includes a main shaft fit into a bore of a yoke bushing. Piepho discloses a flange extending from the lowermost end of a yoke bushing 18. The external facing surface from the first end of the yoke bushing 18 (the lower-most end) to the second end of the yoke bushing 18 (the top-most end) is not parallel to a longitudinal axis of the yoke bushing 18. The external surface of the yoke bushing

18 is at least partially transverse to the longitudinal axis of the yoke bushing 18 at the flange extending from the first end, as illustrated in FIG. 1 of Piepho below.

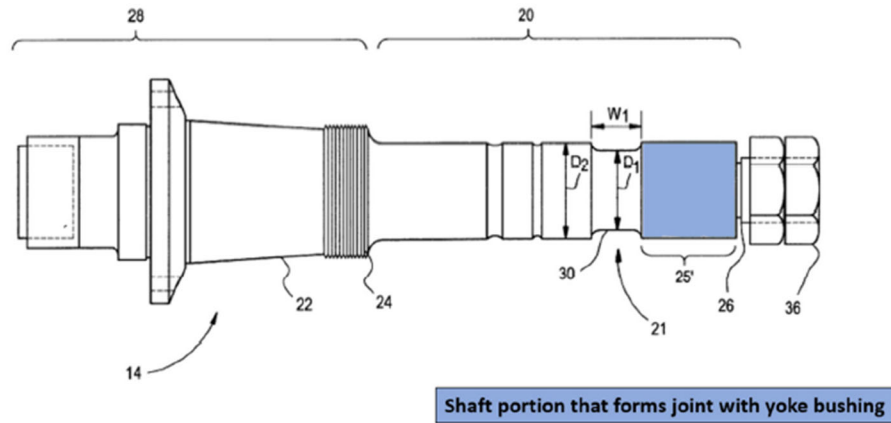


(*Id.*, FIG. 1 (annotated).)

44. The main shaft of Piepho, which may be incorporated into a coal pulverizer, such as the one depicted in Figure 1, is illustrated in Figures 3 and 4 of Piepho, shown below. (*Id.*, 2:47–51.)



(*Id.*, FIG. 3 (annotated).)



(*Id.*, FIG. 4 (annotated).)

45. The portion of the shaft that is configured to be fit with a yoke bushing (item 18 highlighted in Figure 1 above) when assembled into a coal pulverizer is labeled 25 and is highlighted above in Figures 3 and 4. As illustrated, the portion of the shaft that is configured to be fit with a yoke bushing does not extend from the second (top) end of the shaft. Instead, a cylindrical portion labeled 26 extends from the second end of the shaft to the portion labeled 25 configured to be fit with a yoke bushing. The cylindrical portion 26 would be threaded such that a corresponding fastener component 36 can be attached to secure the yoke depicted in Figure 1, shown above, to the shaft. (*See id.*, FIGS. 1, 4.)

46. Piepho further explains that “[t]he fit or joint between the yoke bushing (18) and upper taper (25) is an interference type fit. This type [of] fit generates a stress concentration or a stress multiplier. This stress concentration

increases when the interference fit increases and will also increase when the length of the yoke bushing is increased.” (*Id.*, 3:6–11.)

47. As discussed above, Piepho teaches that stress concentrations, in combination with fretting wear and bending fatigue, can result in failure of coal pulverizer shafts. For instance, with reference to the shafts depicted in Figures 3 and 4, Piepho teaches:

The pulverizer operation generates cyclic or alternate type bending loads in the top end (20) of the main shaft (14). Shaft failures occur, most likely the result of deterioration of the finely machined shaft (14) surfaces within the joint between the shaft (25) and the bore of the yoke (12). This deterioration may be caused by cyclic movement between the respective surfaces of the shaft and the yoke bore. This movement results from bending of the shaft which produces differing stress fields in the shaft (14) and the yoke (12). This movement gives rise to a progressive form of damage known as fretting. (*Id.*, 3:12–22.)

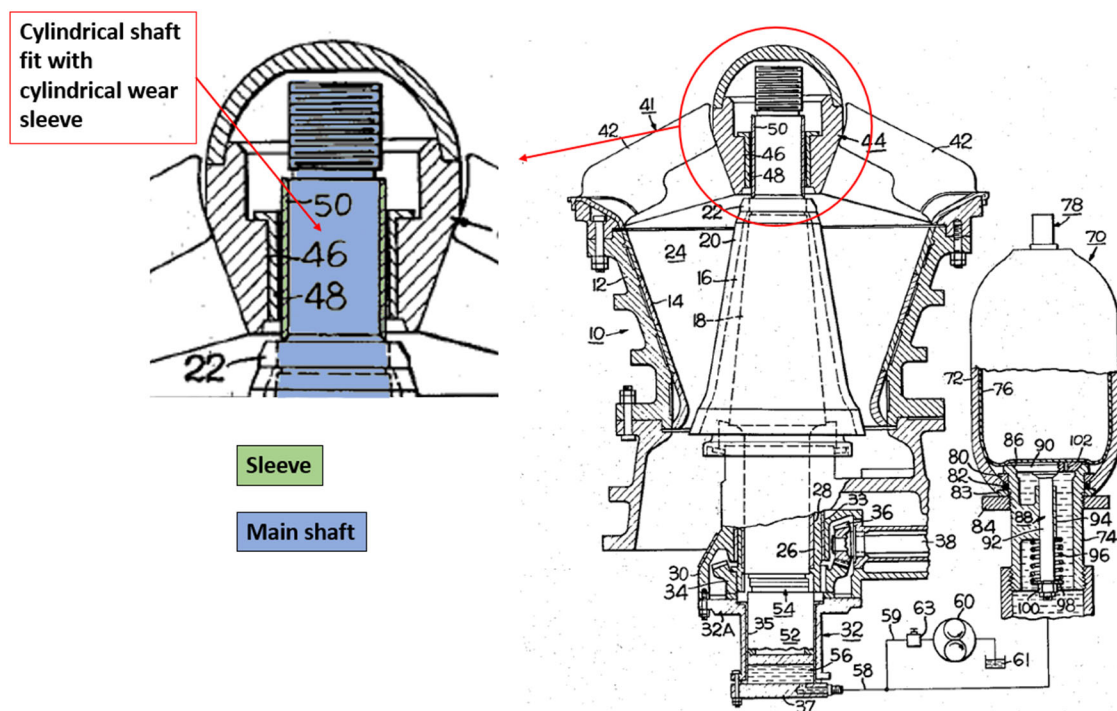
48. To mitigate fretting wear (and bending fatigue), Piepho discloses application of an intervening material between the shaft and yoke bushing to reduce local stresses in the shaft within the joint by reducing the relative movement. (*Id.*, 2:19–25.) For example, Piepho discloses:

The present invention provides an intervening material between the shaft end (25) and the mating bore in yoke bushing (18) fitted within the bore of yoke (12) to prevent fretting damage. (*Id.*, 3:23–26.)

49. Piepho teaches that a suitable intervening material is thermal sprayed ceramic coating such as chrome oxide or a carbide coating like tungsten carbide. (*Id.*, 3:35–45.)

3. Pollak (Ex. 1017)

50. Pollak is directed to a “hydraulic accumulator particularly useful in connection with gyratory crushers.” (Ex. 1017, Abstract.) Pollak discloses that the crusher shaft 18 is provided, as shown below, with “a replaceable wear sleeve 50.” (*Id.*, 4:64–65.) Pollak does not disclose or suggest a tapered shaft region fit with a tapered sleeve.

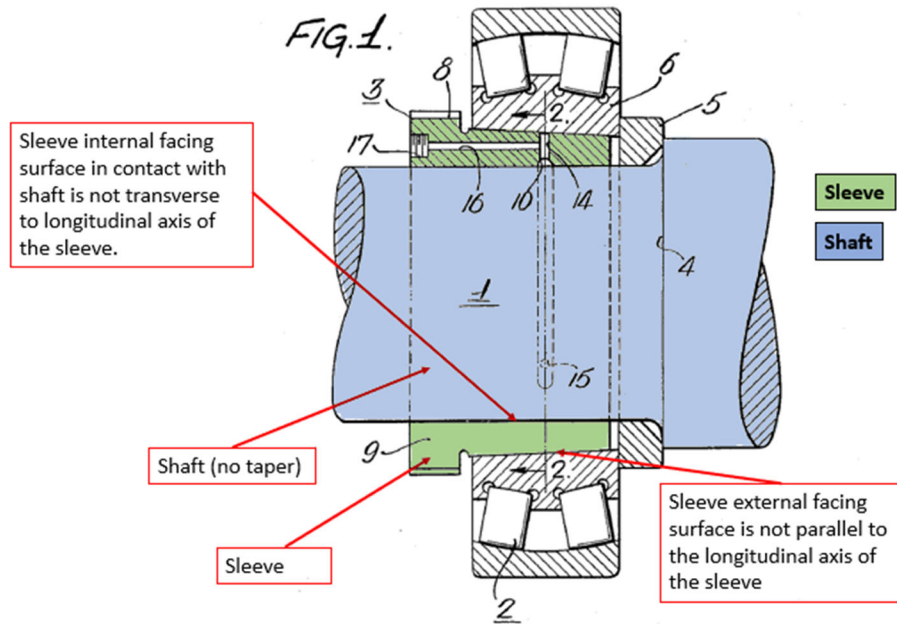


(*Id.*, FIG. 1 (annotated).)

4. Bratt (Ex. 1034)

51. Bratt discloses a cylindrical shaft 1 fit with a sleeve 3. The sleeve 3 has a cylindrical (non-tapered) internal facing surface in contact with an external facing surface of the shaft. (Ex. 1034, FIG. 1) The sleeve 3 has a tapered *external*

facing surface 7 that interfaces with an internal facing surface of a bearing that has a corresponding taper. (*Id.*, 1:47–56, FIG. 1.)



(Ex. 1034, FIG. 1 (annotated).)

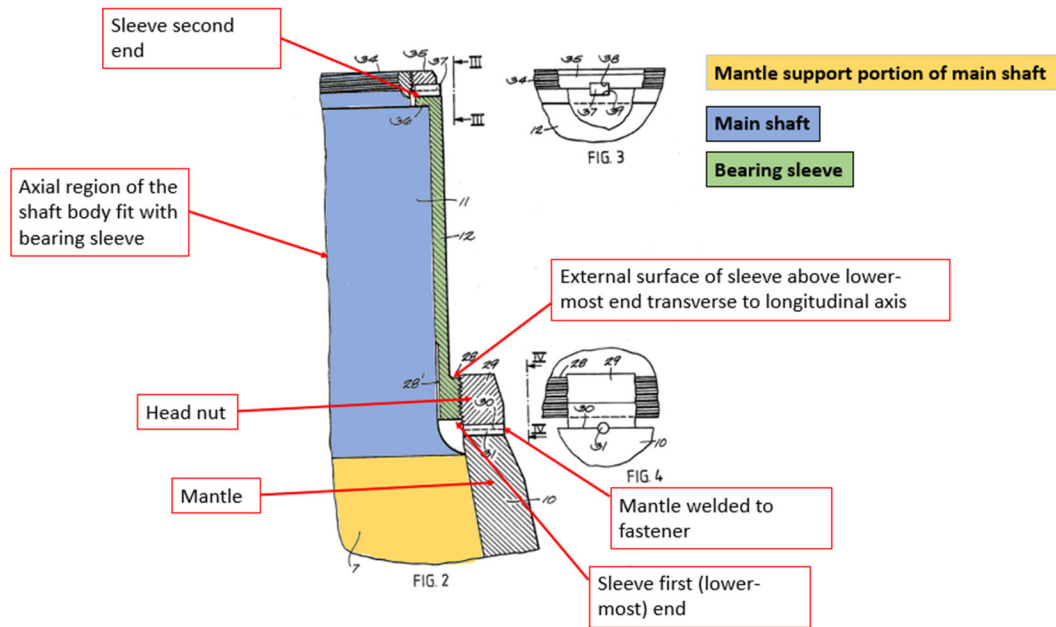
E. Analysis Of Prior Art

1. For substitute claim 11, Polinski and Piepho fail to disclose or suggest that the external facing surface from the first sleeve end to the second sleeve end is parallel to the longitudinal axis of the sleeve such that the external facing surface of the sleeve when viewed externally has a cylindrical geometry as recited in [11e]

52. Polinski and Piepho both lack a shaft sleeve in which the external facing surface from the lower-most end of the sleeve to the top-most end of the sleeve is parallel to a longitudinal axis of the sleeve. The external facing surface of the sleeve disclosed by Polinski, and the yoke bushing disclosed by Piepho, are *not*

parallel to the longitudinal axis of the sleeve. Rather the sleeve disclosed by Polinski, and the yoke bushing disclosed by Piepho, both include structural features (a threaded shoulder and a flange, respectively) that define portions of the external facing surface extending transverse to the longitudinal axis. Thus, as described further below, neither Polinski nor Piepho discloses a sleeve having an external facing surface that is cylindrical when viewed externally, as recited in [11e].

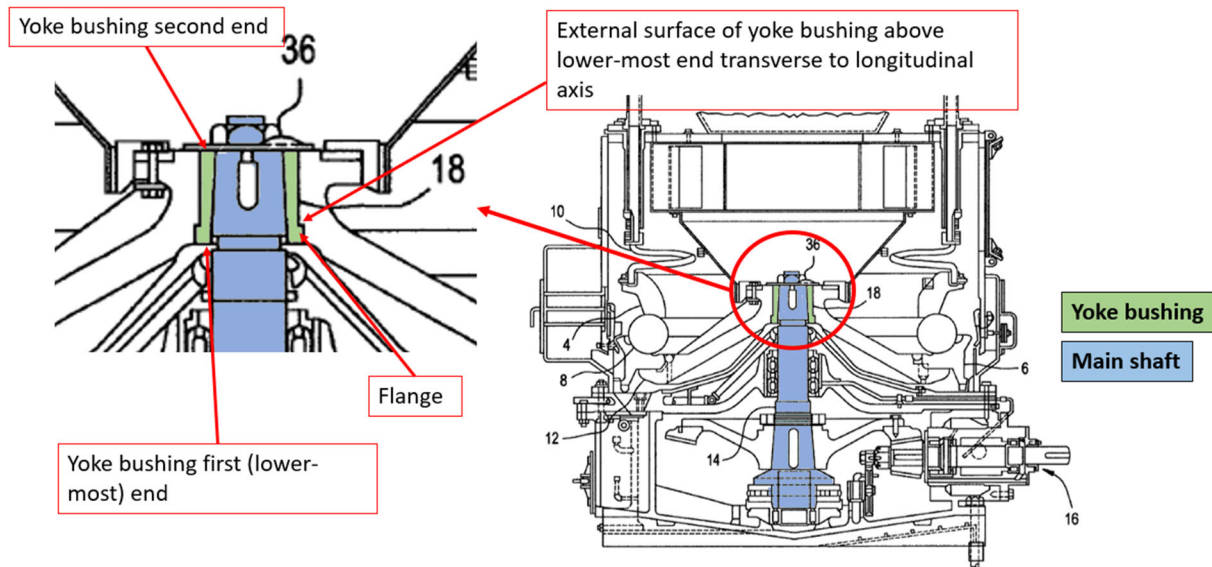
53. As I noted above, Polinski discloses a shaft sleeve 12 (relied on by Petitioner and Mr. Smith for the claimed sleeve) that includes a threaded shoulder 28 extending from the bottom end of the sleeve 12 for securing a mantle 10 to a tapered mantle support portion 8 of the shaft 7. (Ex. 1015, 3:1–8; *see also* Ex. 2006, 54:3–55:4.) Annotated FIG. 2 of Polinski below shows this feature, alongside other relevant features of the shaft, sleeve, and crusher mantle in Polinski.



Ex. 1015, FIG. 2 (annotated).

54. As illustrated, the external facing surface from the first sleeve end (the lower-most end of the sleeve) to the second sleeve end (the top-most end) is not parallel to a longitudinal axis of the sleeve. The external facing surface defined by the threaded shoulder 28 of sleeve 12 is oriented at least partially transverse to the longitudinal axis of the sleeve.

55. Piepho is also deficient. Piepho discloses a flange extending from the lowermost end of a yoke bushing 18, which Petitioner relies on for the sleeve recited in challenged claim 1, shown in annotated FIG. 1 of Piepho below. (Ex. 1016, FIG. 1; *see also* Ex. 2006, 78:6–8 (Petitioner’s expert referring to Piepho’s flange).)



Ex. 1016, FIG. 1 (annotated).

56. The external facing surface from the first end of the yoke bushing 18 (the lower-most end) to the second end of the yoke bushing 18 (the top-most end) is not parallel to a longitudinal axis of the yoke bushing 18. Like the threaded shoulder of Polinski, the flange extending from the bottom end of Piepho's sleeve defines a portion of the external facing surface of the yoke bushing that is oriented at least partially transverse to the longitudinal axis of the yoke bushing.

57. Moreover, a POSITA would not have found it obvious to modify Polinski in view of Piepho to meet [11e], because such a modification would change Polinski's principle of operation. Polinski states that "the present invention relates to gyratory crushers and, in particular, to a main shaft and bearing sleeve arrangement supporting the crusher head or mantle within the crusher." (Ex. 1015,

1:44–47.) As I discussed above, Polinski’s sleeve 12 is configured to secure the crushing mantle 10 to the tapered mantle support portion 8 of the main shaft 7. (Ex. 1015, 3:1–9; *see also* Ex. 2006, 54:3–55:4.) Polinski’s threaded shoulder 28 on the sleeve 12 (for securing the crushing mantle 10 to the tapered portion of the main shaft 7) is core to the purported invention of Polinski, which removes threading from the main shaft and instead secures the mantle using a head nut fastened to the sleeve.

58. Indeed, Mr. Smith testified as follows:

Q. Based on your understanding of Polinski, how does it describe the removal of abrupt structural discontinuities in the normally high stress regions of the main shaft?

A. So based on my understanding, Polinski adds the threads to the lower portion of the sleeve that fits over the shaft. And the mantle attaches to those threads, rather than directly to the shaft.

(Ex. 2006, 53:20–54:2.)

59. To eliminate the threaded shoulder 28 of Polinski’s sleeve would thus change the very principle of operation of Polinski’s purported invention and would not have been obvious to a POSITA. Thus, a POSITA would not be motivated to make such a change.

60. Additionally, a POSITA would not be motivated to modify Polinski to reduce the thickness of the threaded shoulder 28. The increased thickness at the threaded shoulder 28 is used to secure the mantle 10 to a tapered mantle

support portion 8 of the shaft 7. A POSITA would recognize that the threaded shoulder adds significant stiffness to the sleeve where it connects the mantle and would expect that stiffness to be required for load transfer through the joint. Additionally, it is well known that threads reduce the tensile strength of a threaded object relative to the object of the same size. (*See* Ex. 2012, 411.) Reducing the thickness at the threaded shoulder 28 such that the external facing surface of Polinski's sleeve is parallel to its longitudinal axis would significantly increase the likelihood that the sleeve would fail during operation.

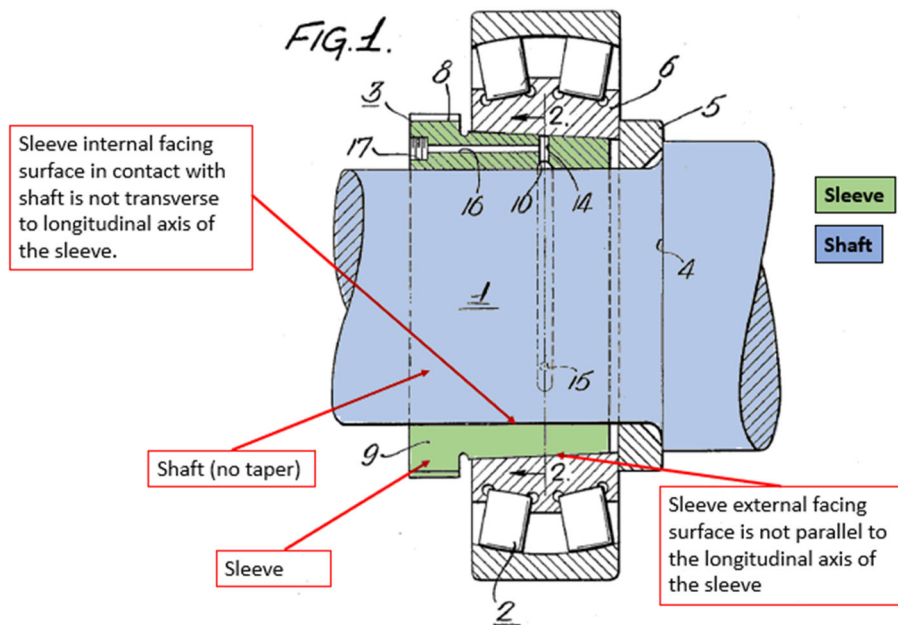
61. If the thickness of the shoulder were reduced to align with the remainder of the sleeve axial wall, the threads in the shoulder 28 would not only reduce the material available to carry stress, but also introduce a stress concentration at the thread runout location (i.e., where the threads end) adding another potential failure location. (*See* Ex. 2012, 444; *see also* Ex. 2013 20–21.) The larger diameter shoulder in Polinski allows for the shoulder to be fully threaded with no thread runout stress concentration. Moreover, removal of the threaded shoulder present in Polinski would result in more of the load in the threaded connection being concentrated on the first engaged thread.

62. The additional material provided by the shoulder 28 relative to the remainder of the sleeve's axial wall is needed to distribute the stresses exerted on the sleeve by the mantle. The design threaded connection geometry to distribute

stress between threads is well understood and is especially useful in cyclic loading scenarios in which fatigue failure is a concern. (*See* Ex. 2014, 412, 450.)

63. Moreover, the additional thickness could not be added to the internal facing surface of Polinski's sleeve. This would render it impossible to mount the sleeve on the shaft. Finally, the threaded shoulder is a core feature of Polinski's disclosure. A POSITA would not have been motivated to remove or change the core feature of Polinski's purported invention. The remaining references in Petition that are applied against the claims are Bratt (Ex. 1034) and Pollak (Ex. 1017). These two references are merely cited for dependent claim limitations associated with claims 9 and 10. Their disclosures cannot undo, in my opinion, that the modification to Polinski would change Polinski's principle of operation.

64. I should add that Bratt has a tapered interference fit joint. Bratt does disclose a sleeve 9 mounted to a shaft 1, as shown in FIG. 1 below.



(Ex. 1034, FIG. 1 (annotated).)

65. But Bratt, in addition to its failure to disclose or suggest a shaft having a tapered region, fails to disclose or suggest “the external facing surface from the first sleeve end to the second sleeve end is parallel to the longitudinal axis of the sleeve such that the external facing surface of the sleeve when viewed externally has a cylindrical geometry,” as required by substitute claim 11. As shown in FIG. 1 of Bratt, the external facing surface (*i.e.*, the surface not in contact with shaft 1) of sleeve 9 is not parallel to the longitudinal axis of the sleeve. Rather, the external facing surface of the sleeve 9 is tapered. Additionally, like the sleeve in Polinski and the yoke bushing in Piepho, the sleeve disclosed by Bratt includes a “terminal flange 8 at its thicker end.” Thus, the sleeve, when viewed externally, does not have a cylindrical geometry. Pollak (Ex. 1017), like Bratt, fails to cure the

deficiencies of Polinski and Piepho and cannot undo that the modification to Polinski would change Polinski's principle of operation.

2. For substitute claim 12, Polinski and Piepho fail to disclose or suggest that “the region over which the thickness of the axial wall tapers and decreases extends the full axial length of the sleeve”

66. Neither Polinski nor Piepho discloses a sleeve in which a thickness of the sleeve's an axial wall tapers and decreases over the full axial length of the sleeve. Polinski's sleeve 12 does not include any taper. Moreover, as I discussed above, Polinski's purported invention does not allow for the thickness of its sleeve to decrease at all the way to the bottom end of the sleeve, because Polinski's sleeve requires a threaded shoulder 28 extending from its bottom end configured to secure a crusher mantle 10 to the mantle support portion 8 of main shaft 7. (Ex. 1015, 3:1–8.)

67. Piepho's yoke bushing 18 does disclose a taper, but the thickness Piepho's yoke bushing does not taper and decrease “the full axial length of the sleeve.” Rather, as I discussed above, Piepho's yoke bushing 18 includes a structural flange at the bottom-most end. The flange supports the yoke 12 of the coal pulverizer. Petitioner and Mr. Smith agree that the flange acts as a structural support. (See Paper 2, 31–32 (Petition referring to Mr. Smith's declaration stating that the flange “provide[s] a shoulder bearing surface which can transmit axial loads.”).)

68. Moreover, a POSITA would not have found it obvious to modify Polinski in view of Piepho to arrive at the limitations of substitute claim 12. Modifying the purported sleeve of Polinski to meet claim 12 would require changing Polinski's sleeve such that the region over which the thickness of the axial wall tapers and decreases extends the full axial length of the sleeve. If Polinski's sleeve were modified to include a taper along its entire length, the thickness of Polinski's sleeve would still be greater at the region associated with the threaded shoulder 28. The thickness of Polinski's sleeve could only decrease along the entire axial length of the sleeve from the second (top-most) sleeve end to the first (lower-most) sleeve end if there was no threaded shoulder 28 for securing the crusher mantle 10 which, as I discussed above, would change the principle of operation of Polinski's purported invention.

69. Similarly, a POSITA looking to Piepho would not be motivated to modify Polinski's sleeve such that the region, over which the thickness of the axial wall tapers and decreases, extends its full axial length in view of the teachings of Piepho. The yoke bushing includes a flange extending from its bottom end. The flange increases the thickness of the yoke bushing and "provide[s] a shoulder bearing surface which can transmit axial loads," thus acting as a structural support for the yoke. (Paper 2, 32.) Removing the flange from the yoke bushing would remove a structural support from the coal pulverizer in Piepho, similar to the way

that removing the threaded shoulder from Polinski would remove a structural support for the crusher mantle. A POSITA would not have found such a modification obvious.

3. Polinski and Piepho fail to disclose or suggest the limitations of substitute claims 13–17

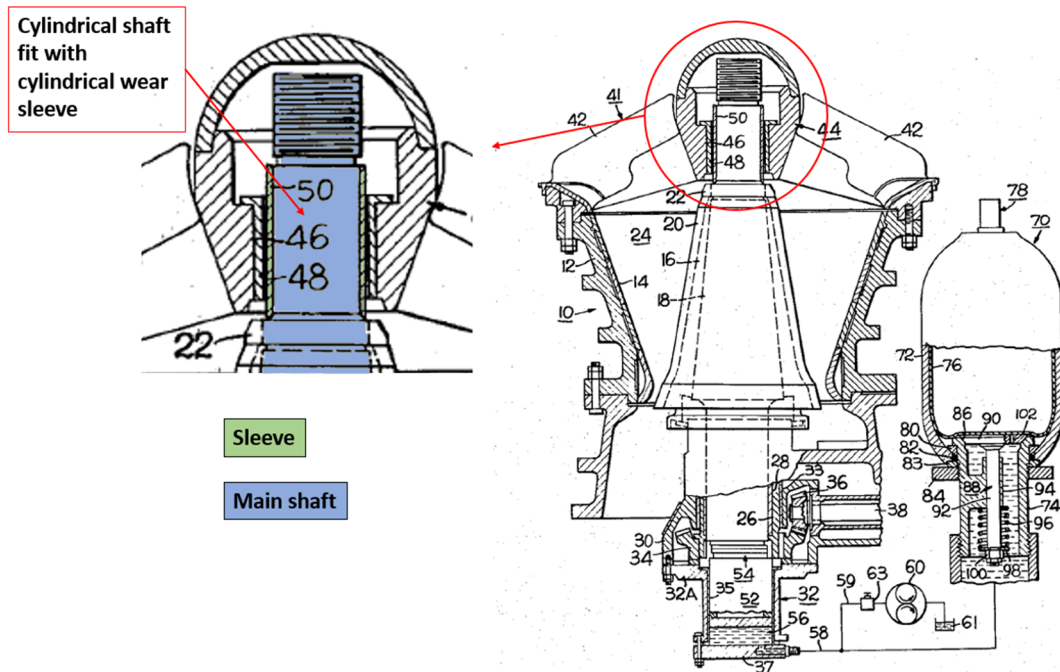
70. Polinski and Piepho fail to disclose or suggest the limitations of substitute claims 13–18 for at least the reasons set forth above based on their respective dependencies.

4. Polinski, Piepho, and Pollak fail to disclose or suggest the limitations of substitute claim 18

71. Polinski, Piepho, and Pollack fail to disclose or suggest that “at a region proximal to the first sleeve end, the thickness of the axial wall reduces at an increased rate relative to a region of the axial wall proximal to the second sleeve end, as required by substitute claim 18. As I discussed above, Polinski does not disclose a tapered sleeve. Although Piepho discloses a tapered yoke bushing, the thickness of the yoke bushing increases near its first end due to the flange. Thus, neither Polinski nor Piepho discloses or suggests that the thickness of the axial wall reduces at an *increased rate* relative to a region of the axial wall proximal to the second sleeve end, as required by substitute claim 18.

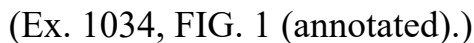
72. Moreover, Pollak, which Petitioner and Mr. Smith rely on for challenged claim 10, does not disclose the limitations of substitute claim 18. At

most, Pollak discloses a sleeve without a taper, having an unlabeled portion that could be a fillet or rounded edge at the bottom end of its sleeve. (Ex. 1017, FIG. 1.)



(*Id.* (annotated))

73. Bratt likewise fails to disclose or suggest that “at a region proximal to the first sleeve end, the thickness of the axial wall reduces at an increased rate relative to a region of the axial wall proximal to the second sleeve end,” as required by substitute claim 18. Bratt discloses a sleeve having an external facing surface that is cylindrical along a first portion and tapered along a second portion. The internal facing surface of the sleeve in Bratt is not tapered. Thus, Bratt necessarily fails to disclose or suggest the limitations of substitute claim 18.



5. Polinski and Piepho fail to disclose or suggest the limitations of substitute claim 19

41

first sleeve end, where the thickness decreases at an increased rate. As discussed above, it would not have been obvious to modify Polinski in view of Piepho to eliminate or change Polinski's threaded shoulder such that the sleeve thickness decreases uniformly along its entire length, because this modification would change Polinski's core principle of operation. For similar reasons, it would not have been obvious to modify Polinski such that the thickness of the axial wall reduces at a uniform rate along most of its axial length, with an increased rate of thickness reduction near the first sleeve end (where the threaded shoulder is located), as required by substitute dependent claim 19. This change would similarly change Polinski's principle of operation. A POSITA would not find such a modification to be obvious.

F. Objective Indicia Of Non-obviousness

76. As discussed above, I have been informed that an evaluation of obviousness requires consideration of any objective evidence of non-obviousness. Such objective evidence of non-obviousness may include copying. As shown below, there is evidence of copying by Petitioner, which supports my opinion that substitute claims 11-20 are non-obviousness.

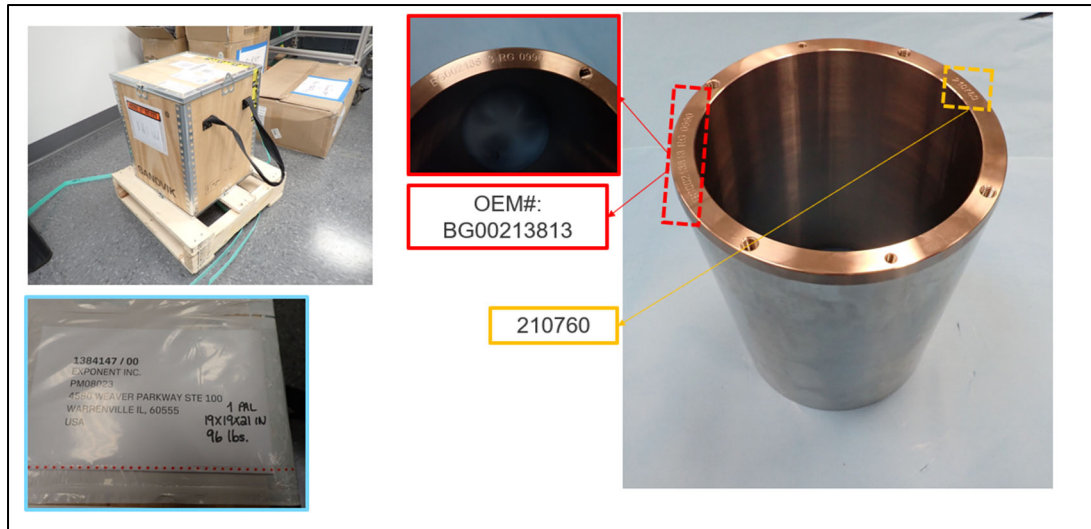
77. Before addressing this evidence, I understand that there must be a nexus between the objective evidence and the claimed invention. Such nexus is presumed when the objective evidence is tied to a specific product and the product

embodies the claimed features and is coextensive with them. The coextensive requirement does not require proof of perfect correspondence between a product and a claim. Rather, it can be met if a product is essentially the claimed invention.

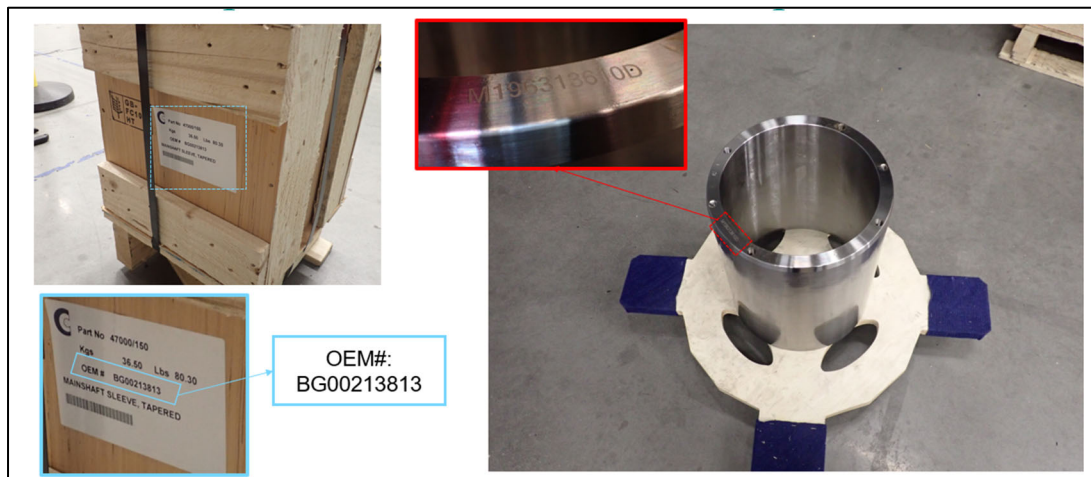
78. Additionally, I understand that nexus can also be established by showing that the objective evidence is a direct result of the unique characteristics of the claimed invention, such as its merits. This is sometimes called nexus in fact.

79. Finally, I understand that copying can be established by evidence showing that Petitioner has access to and has developed a substantially similar product to Sandvik's. As I demonstrate below, Sandvik and Petitioner sell a tapered gyratory crusher main shaft and sleeve that are embodied in the claimed invention and that are essentially the claimed invention, thereby establishing a presumption of nexus. Moreover, the copying is a direct result of the unique characteristics of the claimed invention, particularly with respect to the merits of the sleeve in achieving convenient assembly of the sleeve to the shaft (*see* Ex. 1001, 1:66–2:2), thereby establishing nexus in fact. Finally, Petitioner has access to and has developed a substantially identical product to Sandvik's, thereby establishing evidence of copying that weighs in favor on finding patentability.

80. As shown in the images below, my team at Exponent obtained a sleeve configured for use in Sandvik's CH440 Stationary Cone Crusher from both Sandvik and Petitioner, CMS Cepcor Ltd.



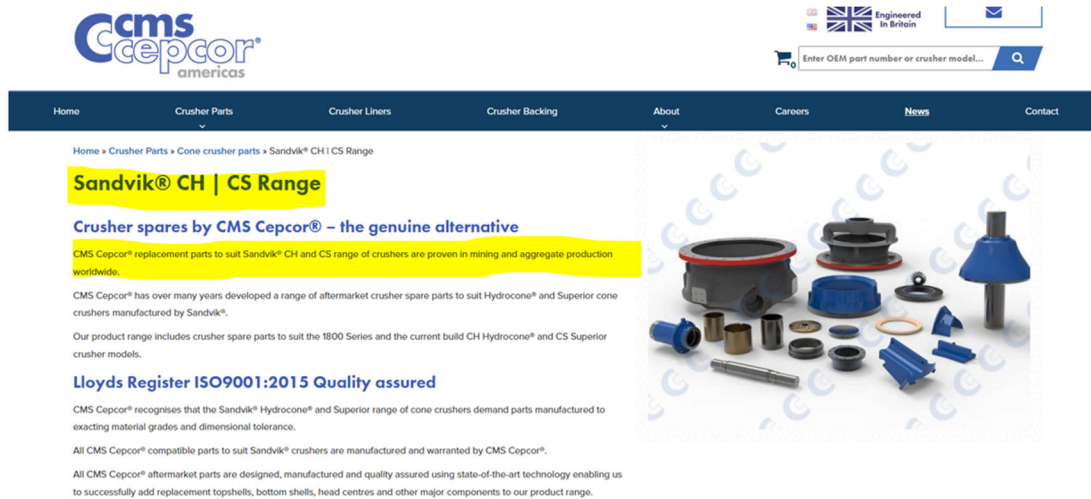
Copying Ex. 1: Sandvik Tapered Mainshaft Sleeve Received by Exponent



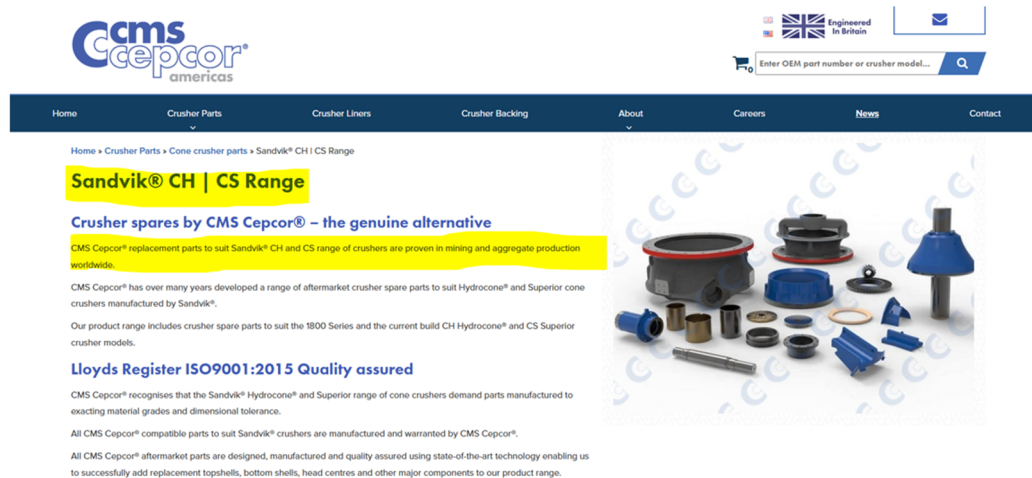
Copying Ex. 2: CMS Tapered Mainshaft Sleeve Shipment Received by Exponent

81. As an initial matter, as shown in the images above, the Original Equipment Manufacturer (OEM) number for the Sandvik sleeve and the CMS sleeve is the same. The matching OEM numbers indicates that CMS is selling selling a one-for-one replacement of the same product as Sandvik. Moreover,

Petitioner's website (Exs. 2010 and 2011) explicitly indicates that Petitioner is selling "all of the replacement parts you need" for Sandvik products. Petitioner indicates that its replacement parts for Sandvik's crushers are "manufactured in consideration of original tolerances," further demonstrating the substantially identical nature of Petitioner's parts to Sandvik's.



(See, e.g., Ex. 2010.)



(See, e.g., Ex. 2011.)

82. The analysis below demonstrates that the Sandvik product (identified in Copying Ex. 1, above) includes each limitation of both original independent claim 1 and substitute claim 11 with the substitute claim limitations underlined below.

A. Sandvik’s product is essentially the invention recited in substitute claim 11

1. Claim limitation [11pre]

83. As agreed by Petitioner, the preamble of challenged claim 1 is not limiting. (Paper 2, (asserting “This preamble is not limiting” with reference to “a gyratory crusher comprising”).) The preamble recited in substitute claim 11 is the same as the preamble of challenged claim 1, and nothing has been added to the body of substitute claim 1 that would render the preamble limiting.

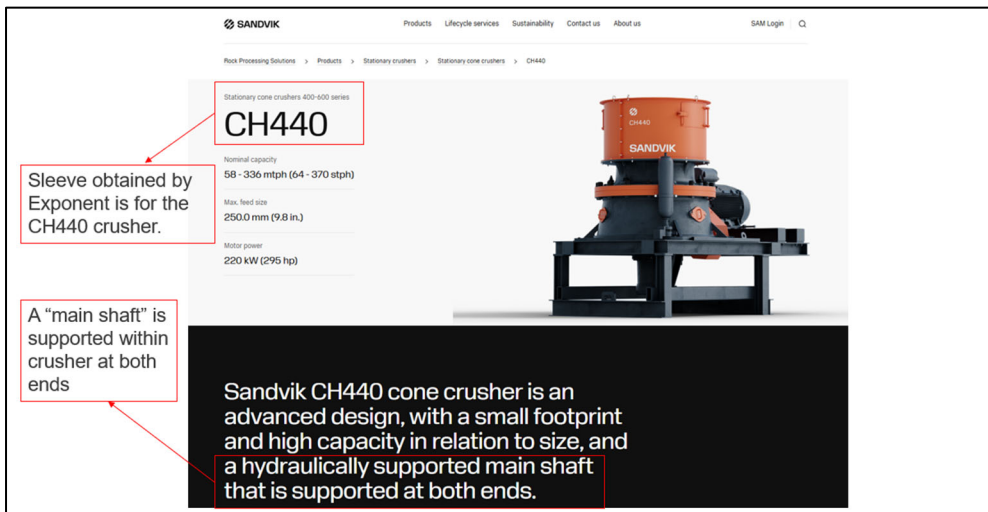
2. Claim limitation [11a]

84. Limitation [11a] recites the following features.

[11a.1] a main shaft including a shaft body having a first end for positioning at a lower region of the crusher and a second end for positioning at an upper region of the crusher relative to the first end,

[11a.2] a thickness of the shaft body being tapered in an axial direction of the main shaft at a tapered region of the second end so as to taper and decrease in cross-sectional area

85. Sandvik sells a corresponding shaft upon which the sleeve identified in Copying Ex. 1 is mounted, as indicated by the excerpted content from Sandvik's website (Ex. 2009), below.



(See, e.g., Ex. 2009.)

86. As indicated above, the “main shaft” is supported “at both ends” within a cone crusher. Thus, the CH440 main shaft is “a main shaft including a shaft body having a first end for positioning at a lower region of the crusher and a second end for positioning at an upper region of the crusher relative to the first end,” as required by [11a.1]. Additionally, the main shaft of the CH440 Stationary Cone Crusher would necessarily include [11a.2]. This is true because the tapered sleeve identified in Copying Ex. 1 above must be fit on a corresponding tapered region of the crusher main shaft. The shaft body would necessarily be tapered to mate with the sleeve of Copying Ex. 1. (See Ex. 2007, 80 (Mr. Smith testifying in the related IPR proceeding that “a bushing that . . . mates with a tapered portion of

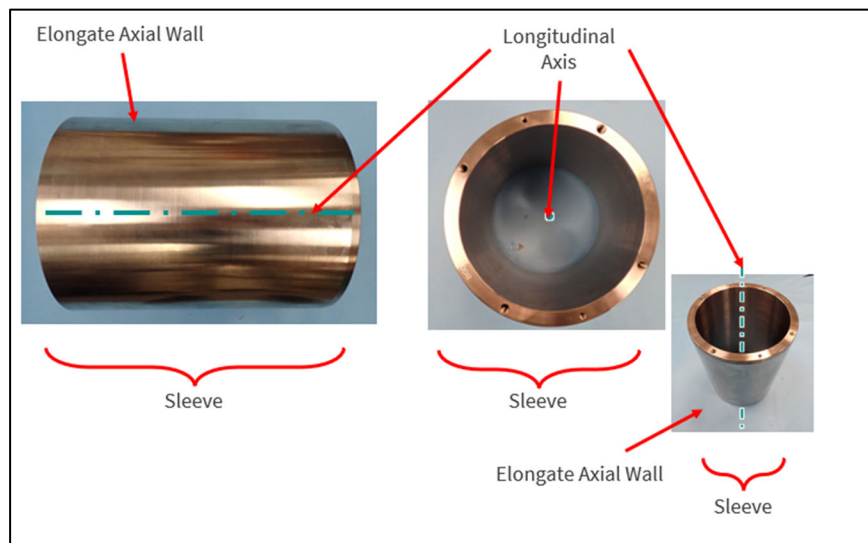
shaft will naturally have a wall thickness that tapers from one end to the other in order to fill the space between the two surfaces.”).) Thus, Sandvik’s product includes the features recited in [11a.1] and [11a.2].

3. Claim limitation [11b]

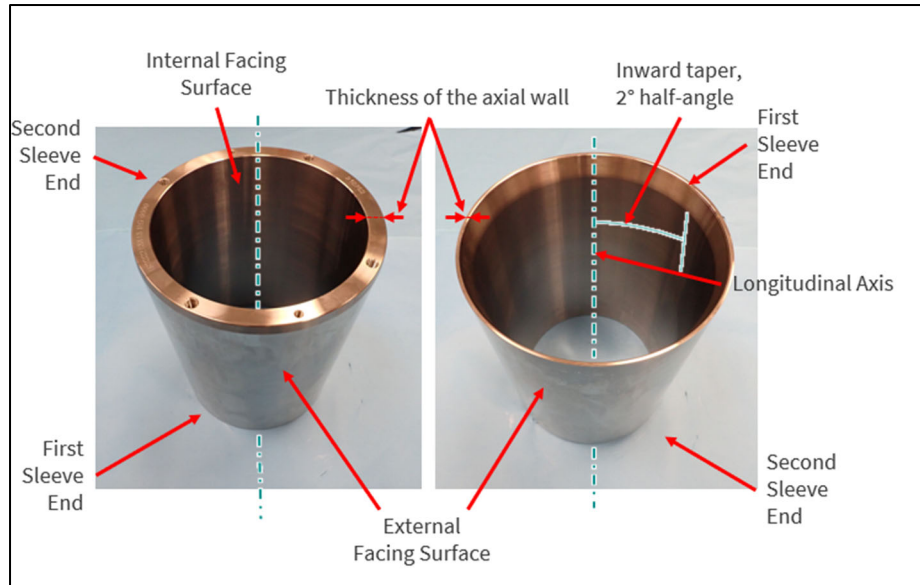
87. Limitation [11b] is broken into its constituent portions [11b.1]-[11b.6] below, and annotated images by my team of the Sandvik CH440 sleeve demonstrating that the Sandvik product includes the recited feature are provided for each respective portion.

88. Limitation [11b.1] recites:

[11b.1] a sleeve fitted over the tapered region at the second end of the main shaft, the sleeve including an elongate axial wall extending around a longitudinal axis of the sleeve



Sandvik CH440 Main Shaft Sleeve

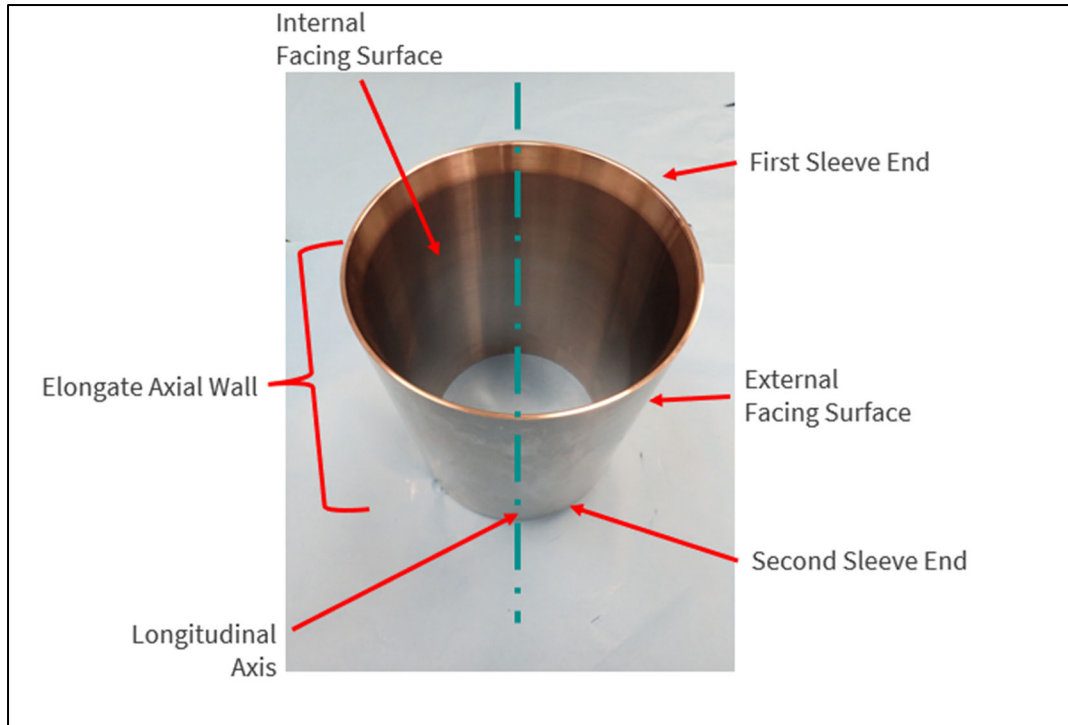


Sandvik CH440 Main Shaft Sleeve

89. The Sandvik CH440 Main Shaft Sleeve includes an elongate axial wall extending around a longitudinal axis of the sleeve. The sleeve includes a tapered internal facing surface and thus, as I discussed above, the sleeve is configured to be fit over a tapered region of the main shaft for the CH440 stationary cone crusher. The shaft sleeve is configured to be positioned on the shaft body such that its second sleeve end relatively closer to the second end of the shaft, which has a relatively smaller diameter due to the taper of the shaft body.

90. Limitation [11b.2] recites:

[11b.2] the axial wall having an internal facing surface for positioning in contact with an outward facing surface of the main shaft

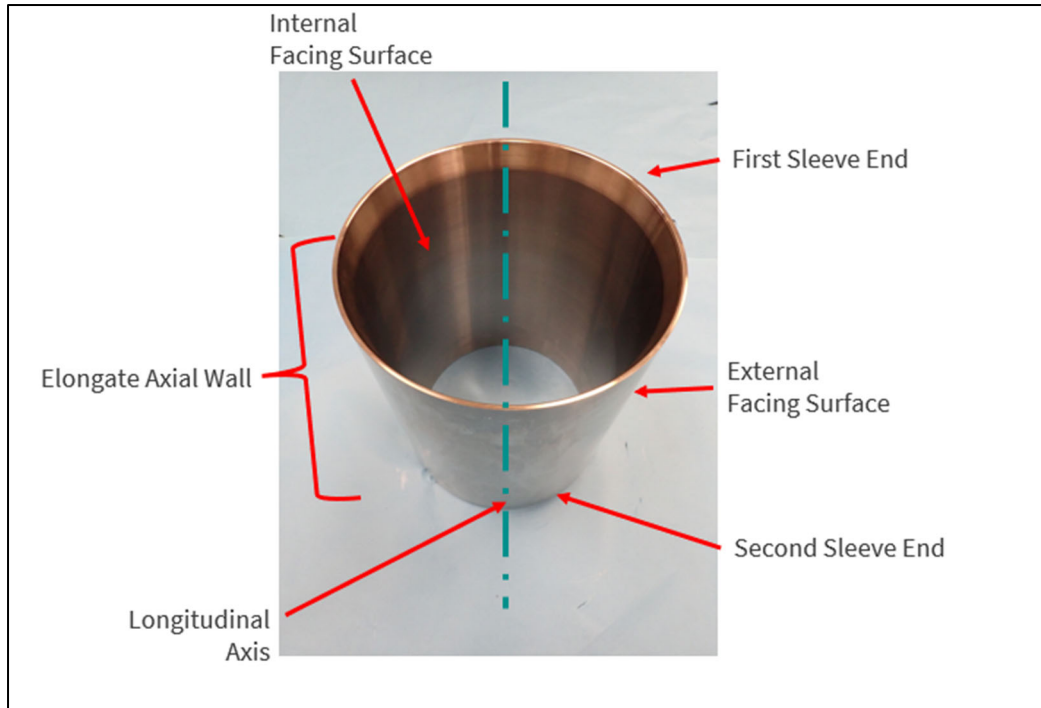


Sandvik CH440 Main Shaft Sleeve

91. The Sandvik CH440 Main Shaft Sleeve includes axial wall having an internal facing surface for positioning in contact with an outward facing surface of the main shaft. The larger inner diameter first sleeve end would be slid over the tapered region of the shaft until the tapered internal facing surface of the sleeve aligns contacts (*e.g.*, via interference fit) the tapered external facing surface of the shaft tapered region.

92. Limitation 11b.3 recites:

[11b.3] an external facing surface relative to the longitudinal axis

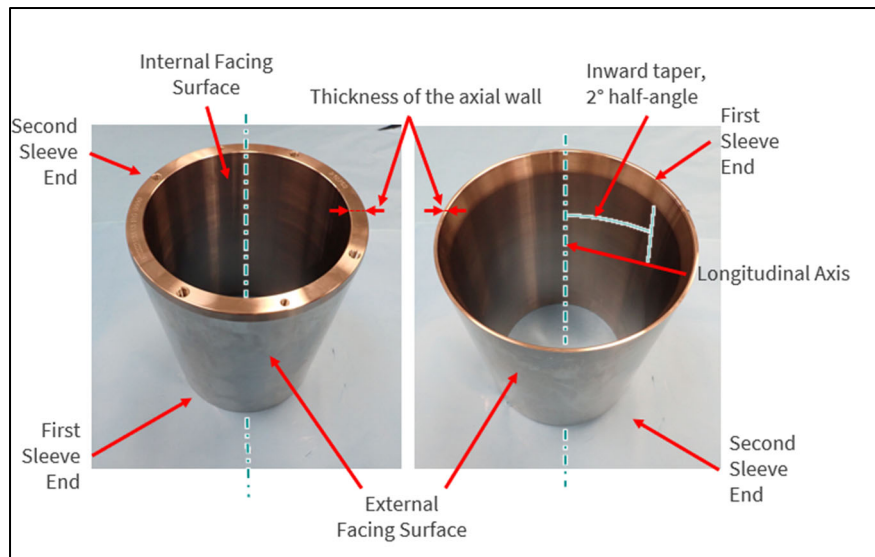


Sandvik CH440 Main Shaft Sleeve

93. The Sandvik CH440 Main Shaft Sleeve includes an external facing surface relative to the longitudinal axis.

94. Limitation [11b.4] recites:

[11b.4] the axial wall extending between the internal and external facing surfaces

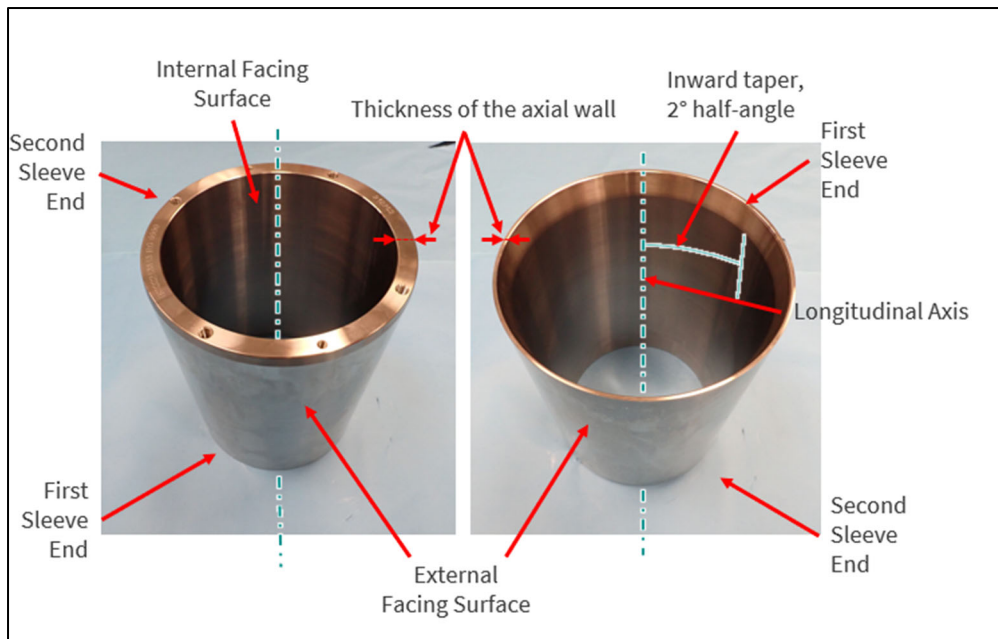


Sandvik CH440 Main Shaft Sleeve

95. The axial wall of the Sandvik CH440 Main Shaft Sleeve extends between the internal and external facing surfaces by a thickness that tapers along the length of the axial wall.

96. Limitation [11b.5] recites:

[11b.5] the axial wall having a first sleeve end for positioning at a lower region of the main shaft, wherein the first sleeve end forms a lower-most end of the sleeve relative to the main shaft

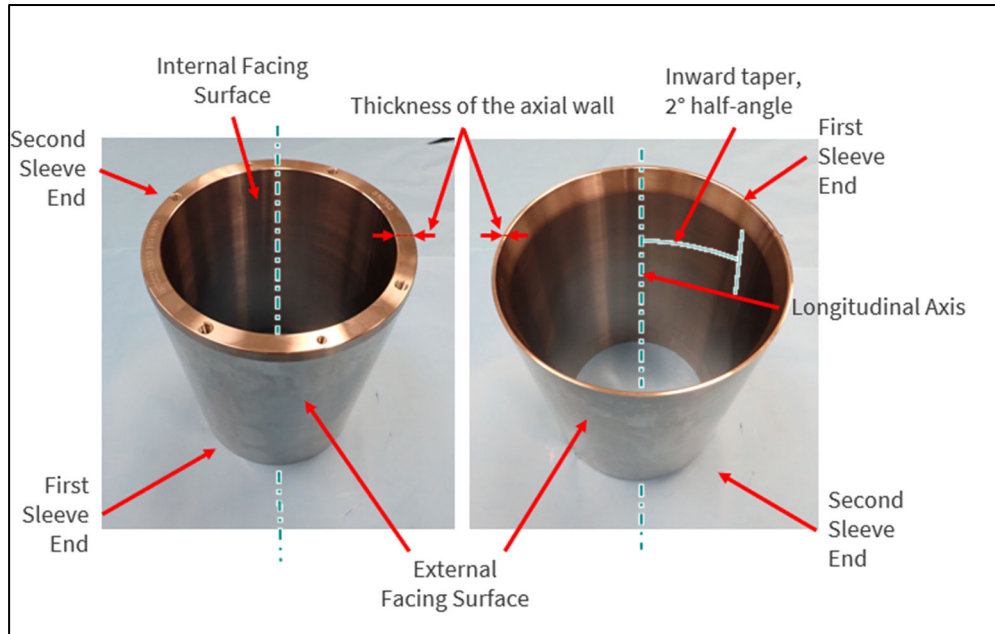


Sandvik CH440 Main Shaft Sleeve

97. As I described above, the larger inner diameter first sleeve end would be slid over the tapered region of the shaft until the tapered internal facing surface of the sleeve contacts the tapered external facing surface of the shaft tapered region. When positioned on the main shaft, the first sleeve end would be the lowermost end of the sleeve relative to the main shaft because it is the outermost extremity of the sleeve at the bottom end of the sleeve.

98. Limitation [11b.6] recites:

[11b.6] a second sleeve end for positioning at an upper region of the main shaft relative to the lower region



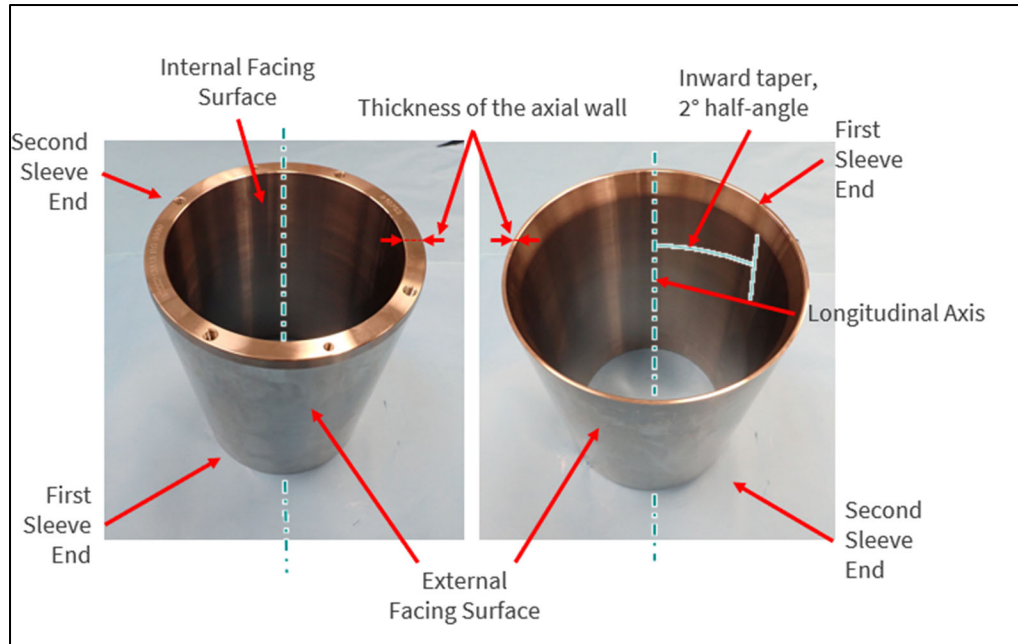
Sandvik CH440 Main Shaft Sleeve (annotated by Exponent staff).

99. When the sleeve is mounted on the main shaft such that the tapered internal facing surface of the sleeve contacts the tapered external facing surface of the shaft tapered region (after sliding the larger inner diameter first sleeve end over the tapered region of the shaft), the second (upper) sleeve end would be positioned at the upper region of the main shaft relative to the lower region.

4. Claim limitation [11c]

100. Limitation [11c] recites:

[11c] wherein a thickness of the axial wall at a region between the first and second sleeve ends tapers and decreases in a direction from the second sleeve end to the first sleeve end



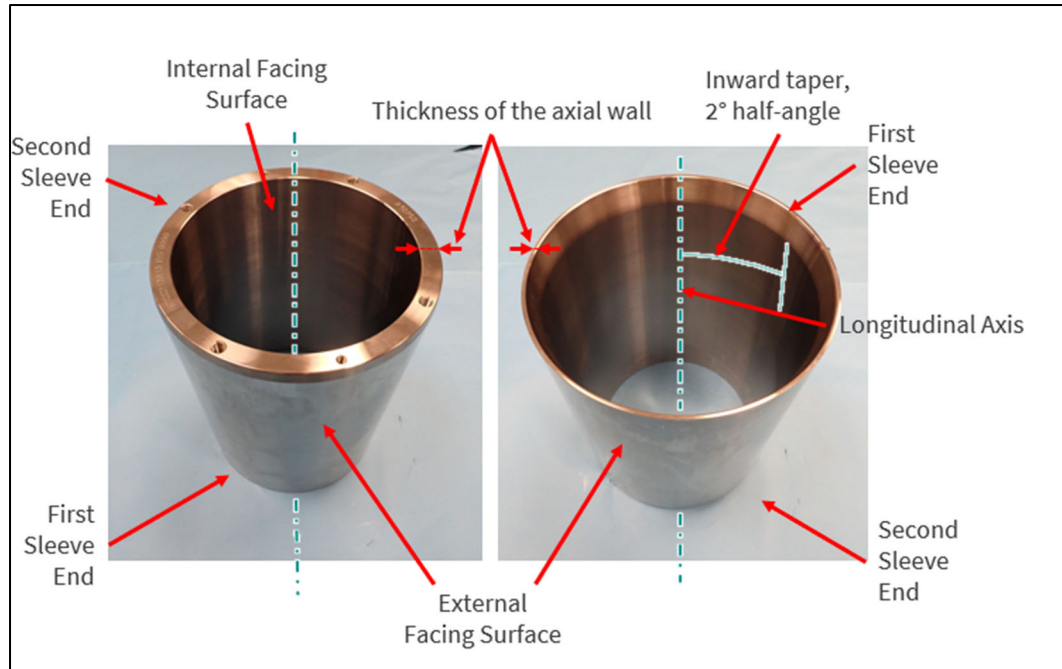
Sandvik CH440 Main Shaft Sleeve

101. The axial wall of the Sandvik sleeve measured by my team at Exponent tapered in thickness from the second sleeve end to the first sleeve end in a direction from the second sleeve end to the first sleeve end. Thus, the second end is thicker than the first end.

5. Claim limitation [11d]

102. Limitation [11d] recites:

[11d] in the axial direction the internal facing surface at said region between the first and second sleeve ends extending transverse to the longitudinal axis so as to taper inwardly towards the longitudinal axis of the sleeve in the direction from the first sleeve end to the second sleeve end



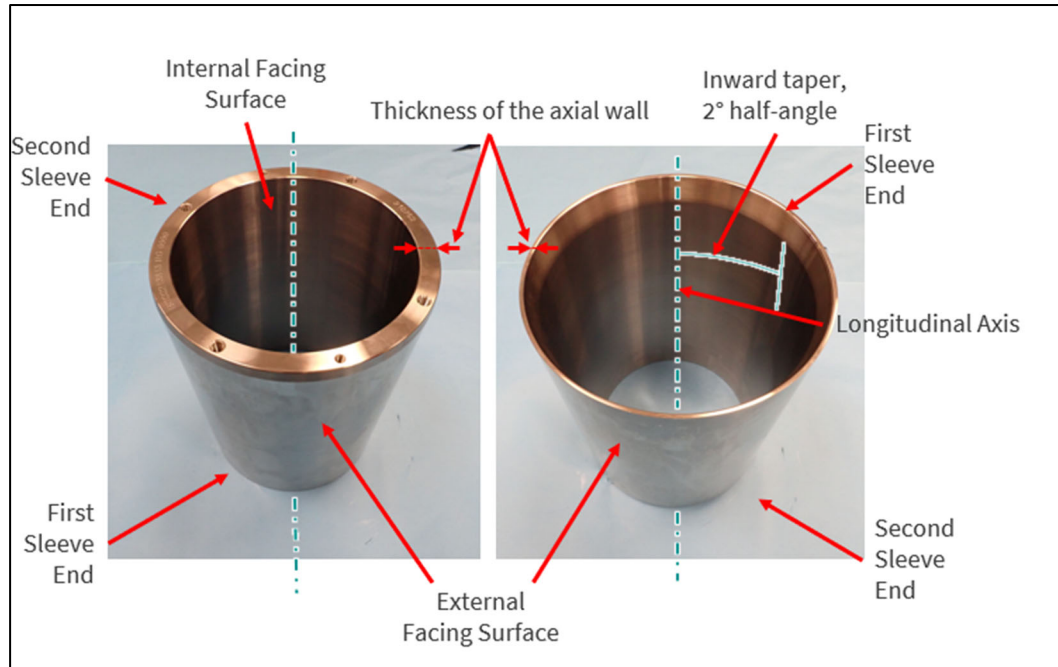
Sandvik CH440 Main Shaft Sleeve (annotated by Exponent staff).

103. The axial wall of the Sandvik sleeve measured by my team extends transverse to the longitudinal axis so as to taper inwardly towards the longitudinal axis of the sleeve in the direction from the first sleeve end to the second sleeve end.

6. Claim limitation [11e]

104. Limitation [11e] recites:

[11e] wherein the external facing surface from the first sleeve end to the second sleeve end is parallel to the longitudinal axis of the sleeve such that the external facing surface of the sleeve when viewed externally has a cylindrical geometry



Sandvik CH440 Main Shaft Sleeve



Sandvik CH440 Main Shaft Sleeve

105. The external facing surface from the first sleeve end to the second sleeve end is parallel to the longitudinal axis of the sleeve. This is demonstrated by the 90 degree measurement of the external facing surface relative to a substantially flat support surface on which the sleeve is positioned in the figure above. The

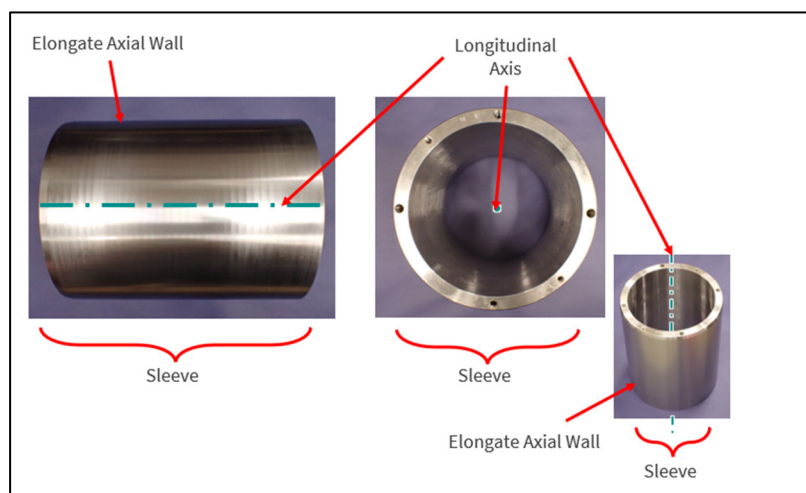
external facing surface of the sleeve measured by my team, when viewed externally, has a cylindrical geometry.

B. Sandvik's product is essentially the invention recited in original claim 1

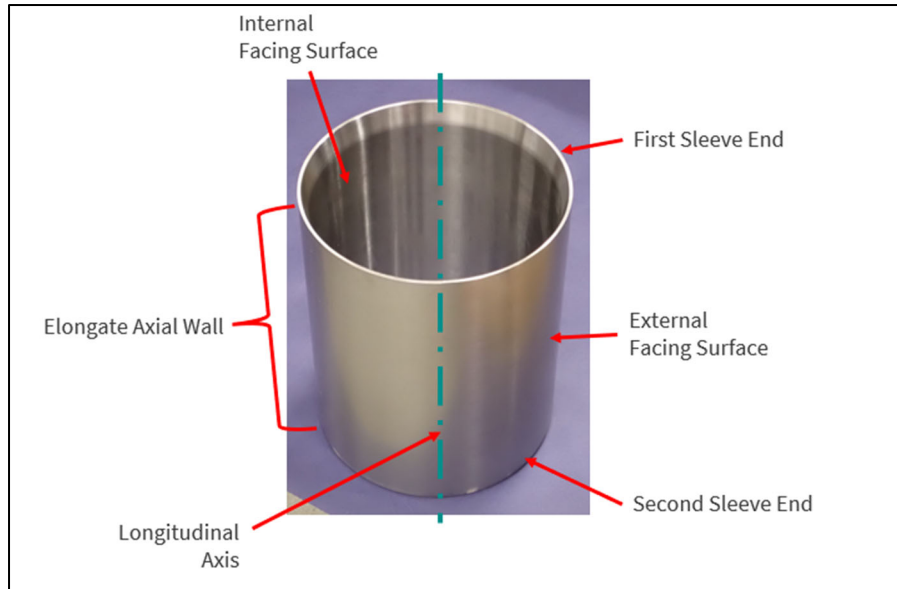
106. As I demonstrate above, Sandvik's product is essentially the invention recited in substitute claim 11, thereby making it coextensive with the claimed invention. Substitute claim 11 only adds limitations to original claim 1. Thus, Sandvik's product is also essentially the invention recited in original claim 1.

C. Petitioner's product is essentially the invention recited in substitute claim 11

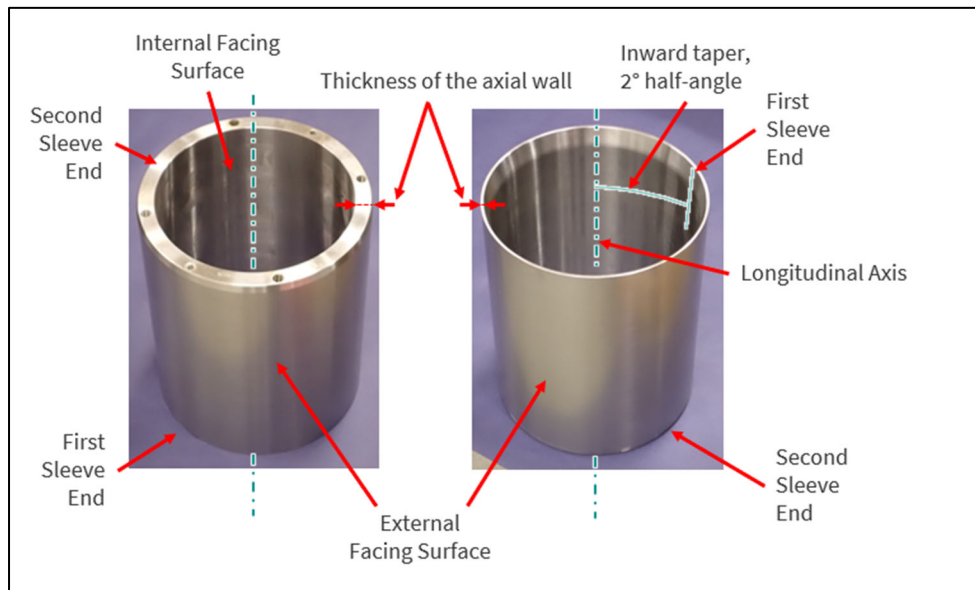
107. As illustrated in the annotated figures prepared by my team below, Petitioner's product identified in Copying Ex. 2, above, embodies the limitations of substitute claim 11 and is coextensive with those limitations such that Petitioner's product is essentially the invention recited in substitute claim 11.



Petitioner's Main Shaft Sleeve



Petitioner's Main Shaft Sleeve



Petitioner's Main Shaft Sleeve

1. Claim limitation [11pre]

108. As I noted above, the parties agree the preamble of challenged claim 1 is not limiting. (Paper 2, (asserting “This preamble is not limiting” with reference

to “a gyratory crusher comprising”).) The preamble recited in substitute claim 11 is the same as the preamble of challenged claim 1, and nothing has been added to the body of substitute claim 1 that would render the preamble limiting.

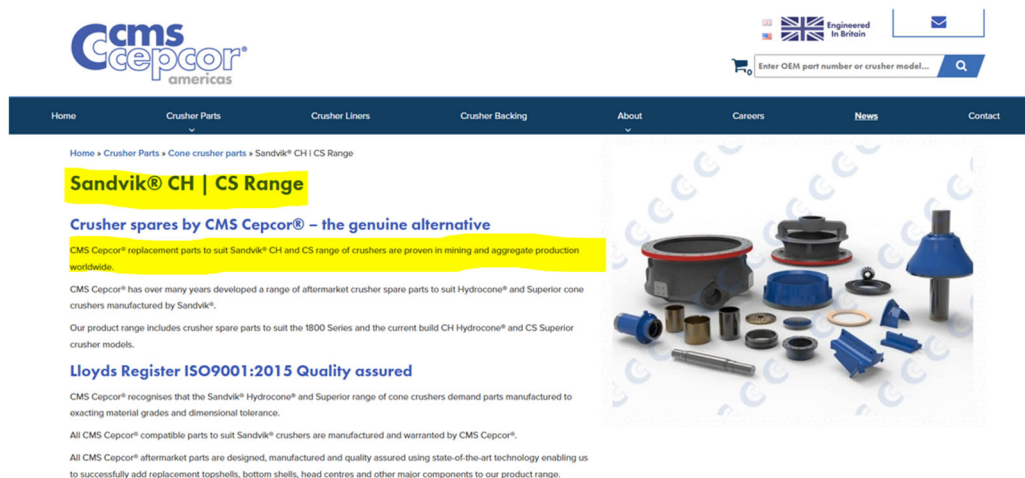
2. Claim limitation [11a]

109. Limitation [11a] recites the following features.

[11a.1] a main shaft including a shaft body having a first end for positioning at a lower region of the crusher and a second end for positioning at an upper region of the crusher relative to the first end,

[11a.2] a thickness of the shaft body being tapered in an axial direction of the main shaft at a tapered region of the second end so as to taper and decrease in cross-sectional area

110. As I discussed above, Petitioner’s website (Ex. 2010) indicates that Petitioner is selling “all of the replacement parts you need” for Sandvik products.



(See, e.g., Ex. 2010.)

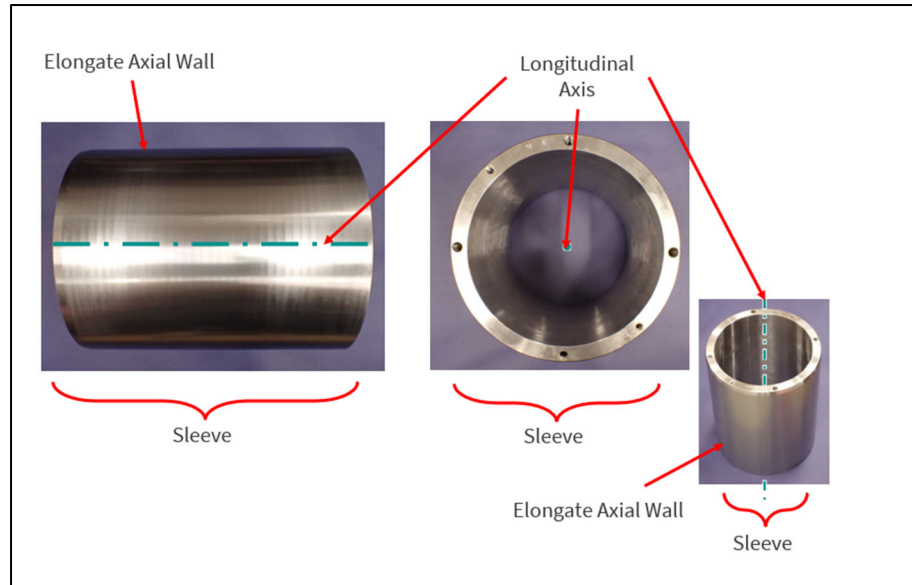
111. By advertising that it sells “all of the replacement parts you need” for Sandvik products, I understand Petitioner to advertise the sale of an identical shaft to the shaft advertised by Patent Owner’s website discussed above. (Ex. 2010; *see also* Ex. 2011.) Thus, Petitioner’s shaft is “a main shaft including a shaft body having a first end for positioning at a lower region of the crusher and a second end for positioning at an upper region of the crusher relative to the first end,” as required by [11a.1]. Additionally, Petitioner’s shaft would necessarily include [11a.2] for the reasons discussed above with reference to Patent Owner’s shaft. (*See* Ex. 2007, 80 (Mr. Smith testifying in the related IPR proceeding that “a bushing that . . . mates with a tapered portion of shaft will naturally have a wall thickness that tapers from one end to the other in order to fill the space between the two surfaces.”).)

3. Claim limitation [11b]

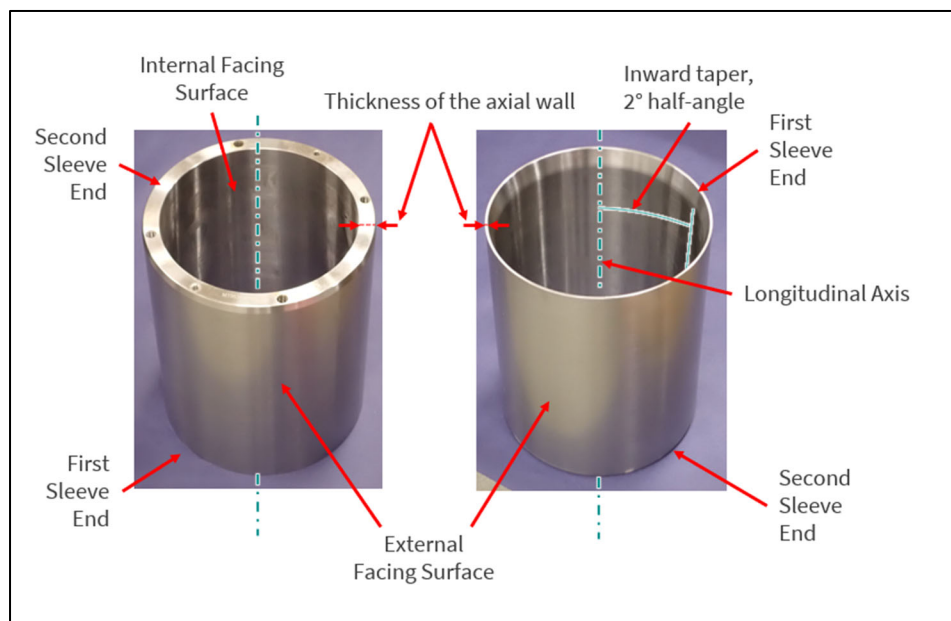
112. Limitation [11b] is broken into its constituent portions [11b.1]-[11b.6] below, and annotated images of Petitioner’s sleeve demonstrating that Petitioner’s product includes the recited feature are provided for each respective portion.

113. Limitation [11b.1] recites:

[11b.1] a sleeve fitted over the tapered region at the second end of the main shaft, the sleeve including an elongate axial wall extending around a longitudinal axis of the sleeve



Petitioner Main Shaft Sleeve



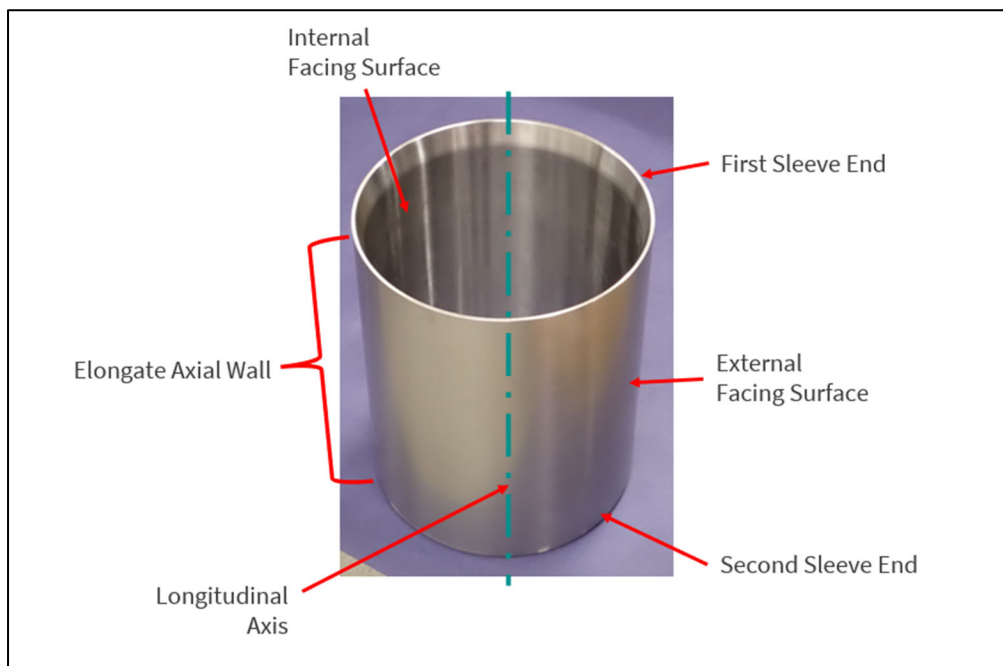
Petitioner Main Shaft Sleeve

114. Petitioner's main shaft sleeve includes an elongate axial wall extending around a longitudinal axis of the sleeve. The sleeve includes a tapered internal facing surface and thus, as I discussed above, the sleeve is configured to be fit over a tapered region of the main shaft for the CH440 stationary cone crusher.

The shaft sleeve is configured to be positioned on the shaft body such that its second sleeve end relatively closer to the second end of the shaft, which has a relatively smaller diameter due to the taper of the shaft body.

115. Limitation [11b.2] recites:

[11b.2] the axial wall having an internal facing surface for positioning in contact with an outward facing surface of the main shaft

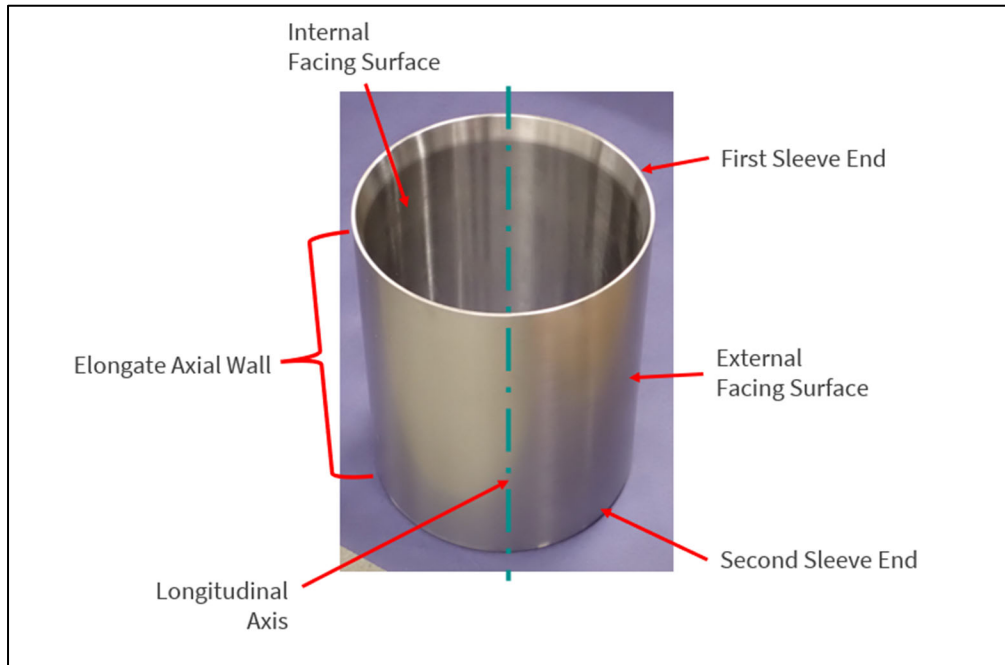


Petitioner Main Shaft Sleeve

116. Petitioner's sleeve includes axial wall having an internal facing surface for positioning in contact with an outward facing surface of the main shaft. The larger inner diameter first sleeve end would be slid over the tapered region of the shaft until the tapered internal facing surface of the sleeve aligns contacts (*e.g.*, via interference fit) the tapered external facing surface of the shaft tapered region.

117. Limitation 11b.3 recites:

[11b.3] an external facing surface relative to the longitudinal axis

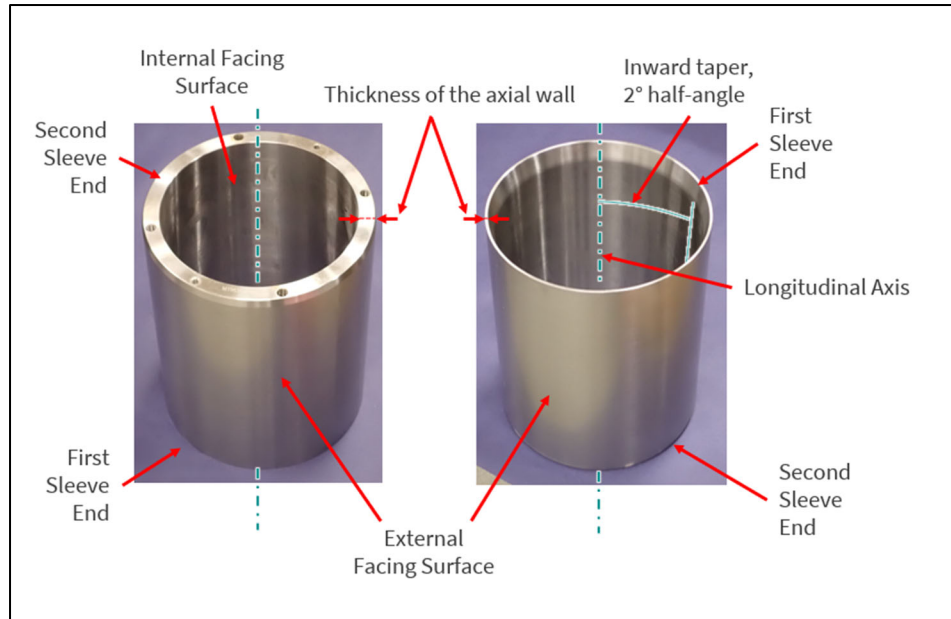


Petitioner Main Shaft Sleeve

118. Petitioner's main shaft sleeve includes an external facing surface relative to the longitudinal axis.

119. Limitation [11b.4] recites:

[11b.4] the axial wall extending between the internal and external facing surfaces

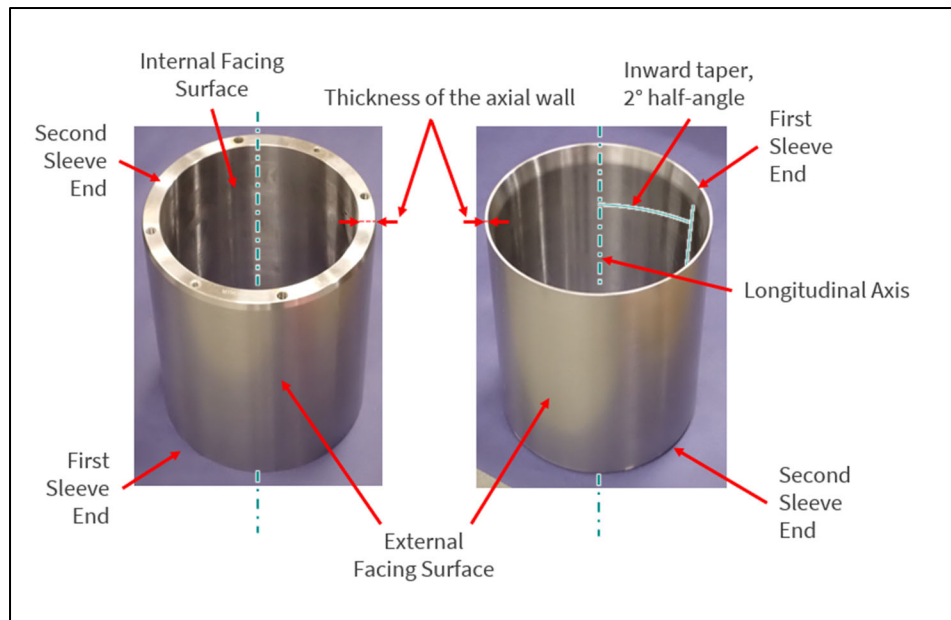


Petitioner Main Shaft Sleeve

120. The axial wall of Petitioner's main shaft sleeve extends between the internal and external facing surfaces by a thickness that tapers along the length of the axial wall.

121. Limitation [11b.5] recites:

[11b.5] the axial wall having a first sleeve end for positioning at a lower region of the main shaft, wherein the first sleeve end forms a lower-most end of the sleeve relative to the main shaft

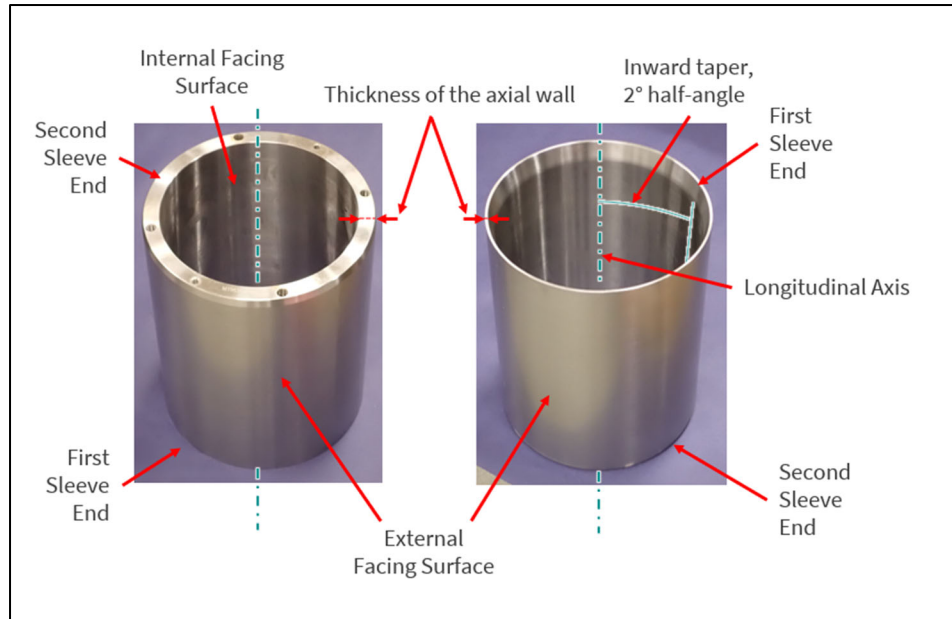


Petitioner Main Shaft Sleeve

122. As I described above, the larger inner diameter first sleeve end would be slid over the tapered region of the shaft until the tapered internal facing surface of the sleeve contacts the tapered external facing surface of the shaft tapered region. When positioned on the main shaft, the first sleeve end would be the lowermost end of the sleeve relative to the main shaft because it is the outermost extremity of the sleeve at the bottom end of the sleeve.

123. Limitation [11b.6] recites:

[11b.6] a second sleeve end for positioning at an upper region of the main shaft relative to the lower region



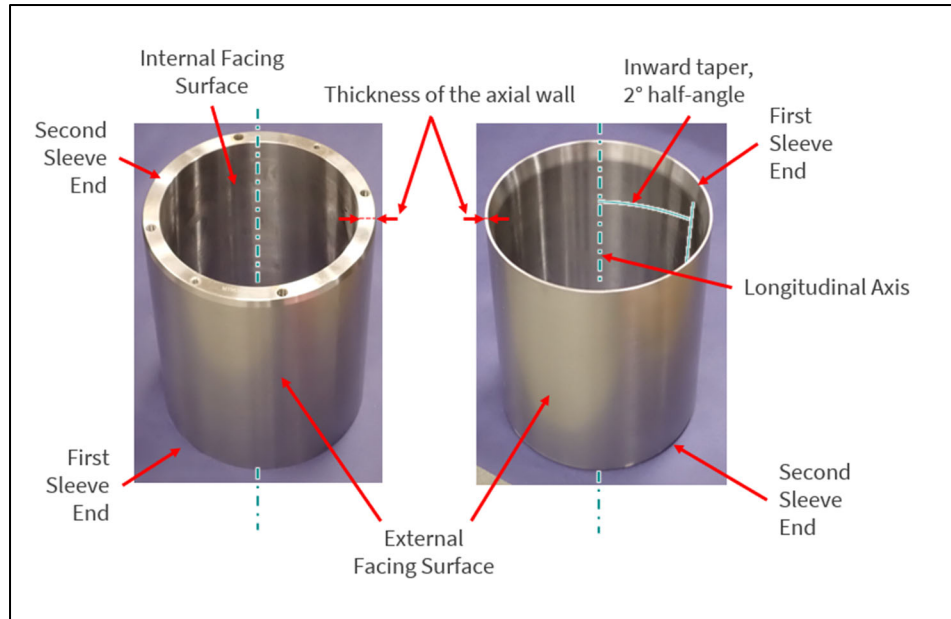
Petitioner Main Shaft Sleeve

124. When the sleeve is mounted on the main shaft such that the tapered internal facing surface of the sleeve contacts the tapered external facing surface of the shaft tapered region (after sliding the larger inner diameter first sleeve end over the tapered region of the shaft), the second (upper) sleeve end would be positioned at the upper region of the main shaft relative to the lower region.

4. Claim limitation [11c].

125. Limitation [11c] recites:

[11c] wherein a thickness of the axial wall at a region between the first and second sleeve ends tapers and decreases in a direction from the second sleeve end to the first sleeve end



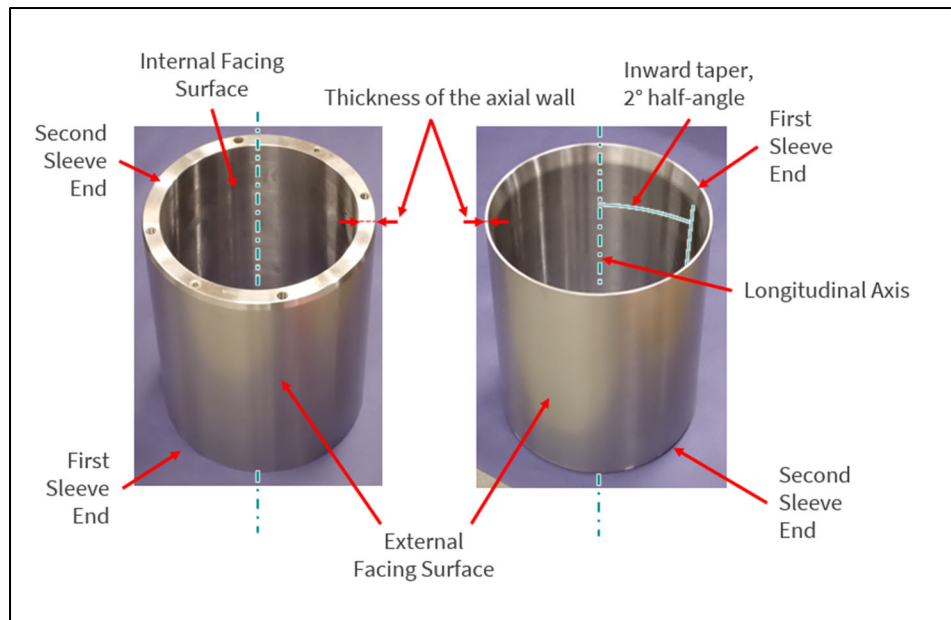
Petitioner Main Shaft Sleeve

126. The axial wall of Petitioner's main shaft sleeve measured by my team at Exponent tapered in thickness from the second sleeve end to the first sleeve end in a direction from the second sleeve end to the first sleeve end. Thus, the second end is thicker than the first end.

5. Claim limitation [11d]

127. Limitation [11d] recites:

[11d] in the axial direction the internal facing surface at said region between the first and second sleeve ends extending transverse to the longitudinal axis so as to taper inwardly towards the longitudinal axis of the sleeve in the direction from the first sleeve end to the second sleeve end



Petitioner Main Shaft Sleeve

128. The axial wall of Petitioner's main shaft sleeve measured by my team extends transverse to the longitudinal axis so as to taper inwardly towards the longitudinal axis of the sleeve in the direction from the first sleeve end to the second sleeve end.

6. Claim limitation [11e]

129. Limitation [11e] recites:

[11e] wherein the external facing surface from the first sleeve end to the second sleeve end is parallel to the longitudinal axis of the sleeve such that the external facing surface of the sleeve when viewed externally has a cylindrical geometry



Petitioner Main Shaft Sleeve

130. The external facing surface from the first sleeve end to the second sleeve end is parallel to the longitudinal axis of the sleeve. This is demonstrated by the 90 degree measurement of the external facing surface relative to a substantially flat support surface on which the sleeve is positioned in the figure above. The external facing surface of the sleeve measured by my team, when viewed externally, has a cylindrical geometry.

131. Thus, as shown in the annotated images of Petitioner's main shaft sleeve product above, Petitioner's product includes essentially identical features to Patent Owner's sleeve. Further, as I discussed above, Petitioner's website explicitly indicates that Petitioner is selling "all of the replacement parts you need" for Sandvik products. Petitioner thus also sells the corresponding main shaft for the

shaft sleeve in the figures above, which would necessarily include the limitations of [11a] for the same reasons established above with reference to Patent's Owner's main shaft. Thus, for all of the same reasons discussed with reference to Patent Owner's sleeve and main shaft, Petitioner's sleeve and main shaft embody claim 11 and are essentially the claimed invention, thereby making them coextensive with the claimed invention. Thus, in my opinion, nexus should be presumed here or, in the alternative, there is nexus in fact given that evidence of copying is a direct result of the unique characteristics of the claimed invention, such as its merits, as discussed below.

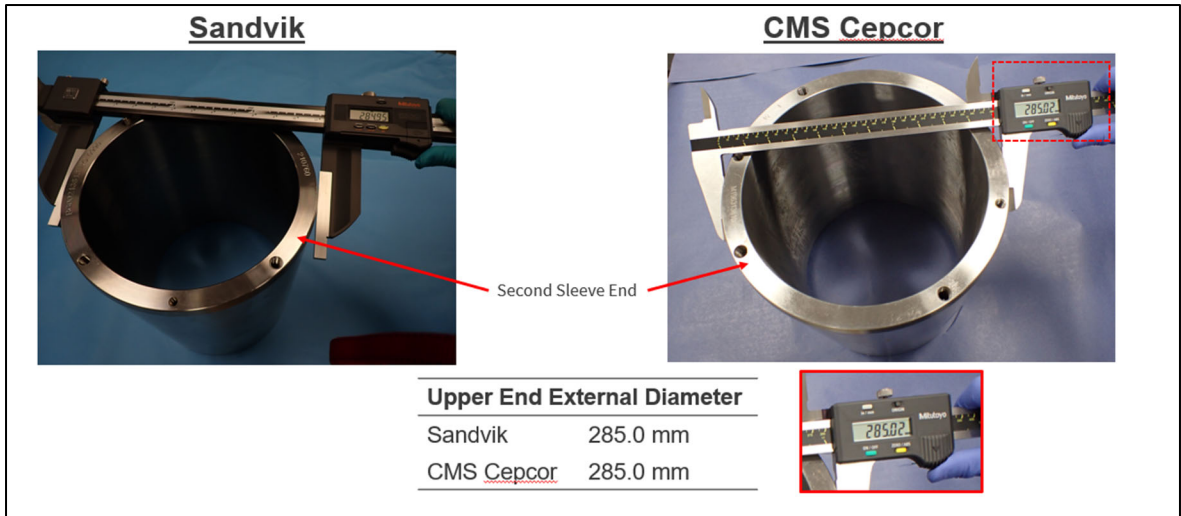
D. Petitioner's product is substantially identical to Sandvik's product

132. My team also obtained the following corresponding measurements of the Sandvik sleeve identified in Copying Ex. 1 and Petitioner's sleeve identified in Copying Ex. 2. As shown below, the Sandvik sleeve identified in Copying Ex. 1 and the CMS sleeve identified in Copying Ex. 2 are essentially identical to one another, underscoring that the copying is a direct result of the unique characteristics of the claimed invention, particularly with respect to the merits of the sleeve in achieving convenient assembly of the sleeve to the shaft. Additionally, as indicated above, Petitioner's website indicates that "CMS Cepcor offer all the replacement parts you need for CH440." The main shaft replacement

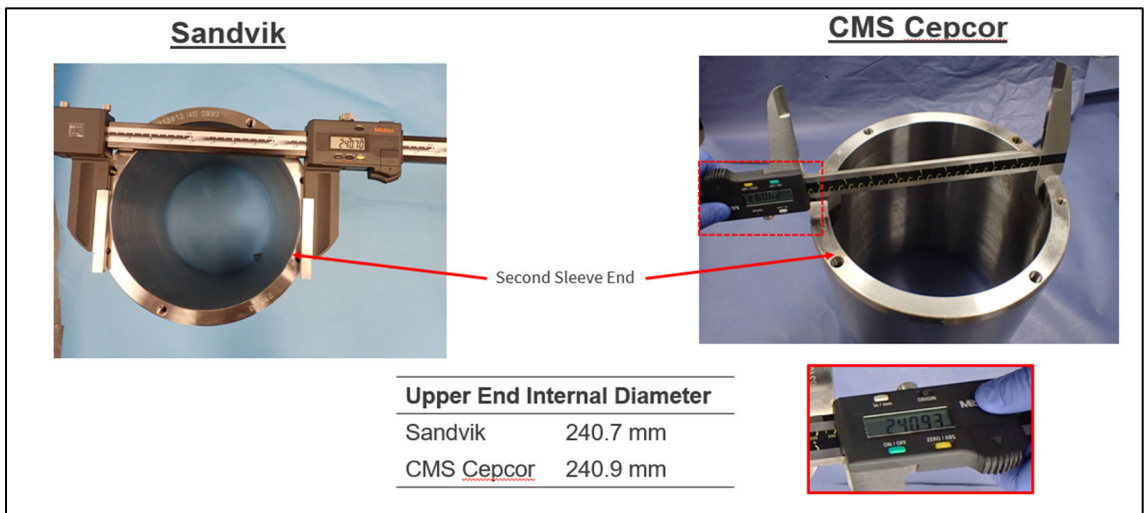
part sold by petitioner would be substantially identical to the main shaft sold by Sandvik such that it can be fit with the tapered main shaft sleeve discussed below.

133. Each of the corresponding measurements taken between the Sandvik sleeve and Petitioner's sleeve, including the upper (second end) external diameter, upper (second end) internal diameter, lower (first end) external diameter, lower (first end) internal diameter, overall length, and upper chamfer length, are within one millimeter of one another. The taper angles of the internal facing surface relative to the longitudinal axis of each sleeve is also substantially identical. As I noted above, the Sandvik sleeve and Petitioner's sleeve have the same OEM number, indicating the two sleeves can serve as replacement parts for one another. The individual measurements are provided below.

134. The upper end (second end) external diameter of the Sandvik sleeve was measured by my team to be 284.95 millimeters (285.0 millimeters at four significant digits) and the upper end (second end) external diameter of Petitioner's sleeve was measured to be 285.02 millimeters (285.0 millimeters at four significant digits).

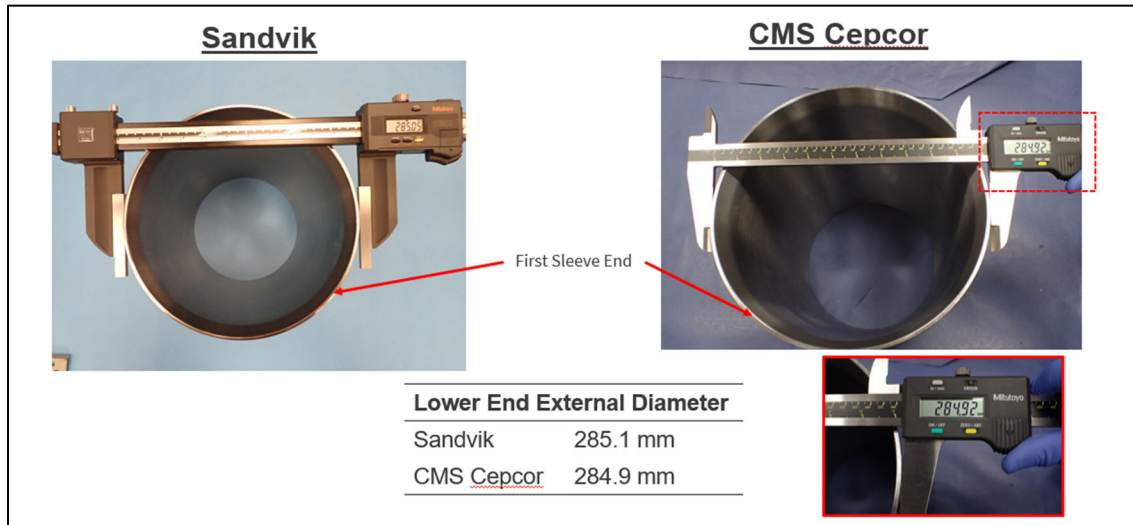


135. The upper end (second end) internal diameter of the Sandvik sleeve was measured by my team to be 240.70 millimeters (240.7 millimeters at four significant digits) and the upper end (second end) internal diameter of Petitioner's sleeve was measured to be 240.93 millimeters (240.9 millimeters at four significant digits).

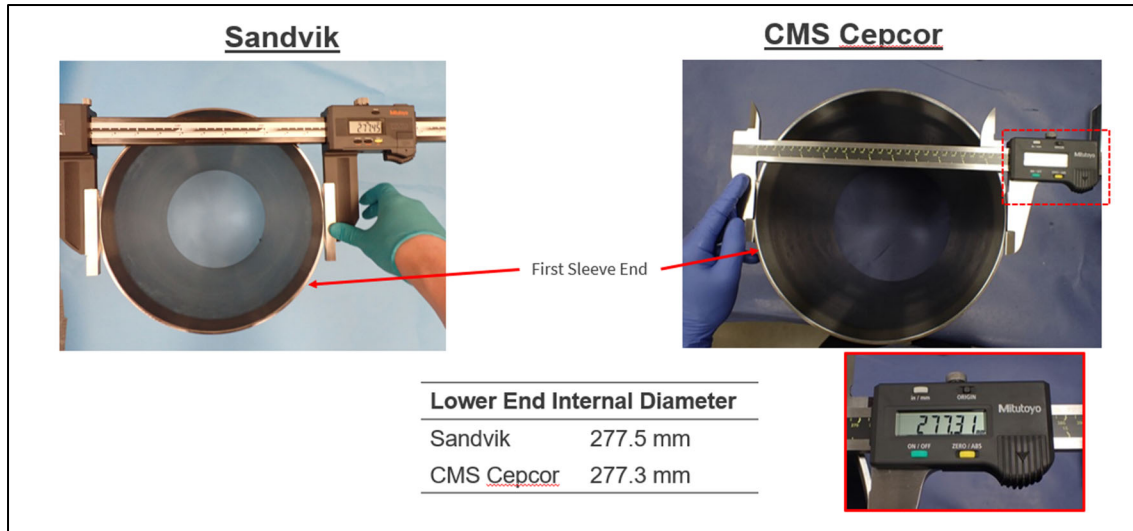


136. The lower end (first end) external diameter of the Sandvik sleeve was measured by my team to be 285.05 millimeters (285.1 millimeters at four

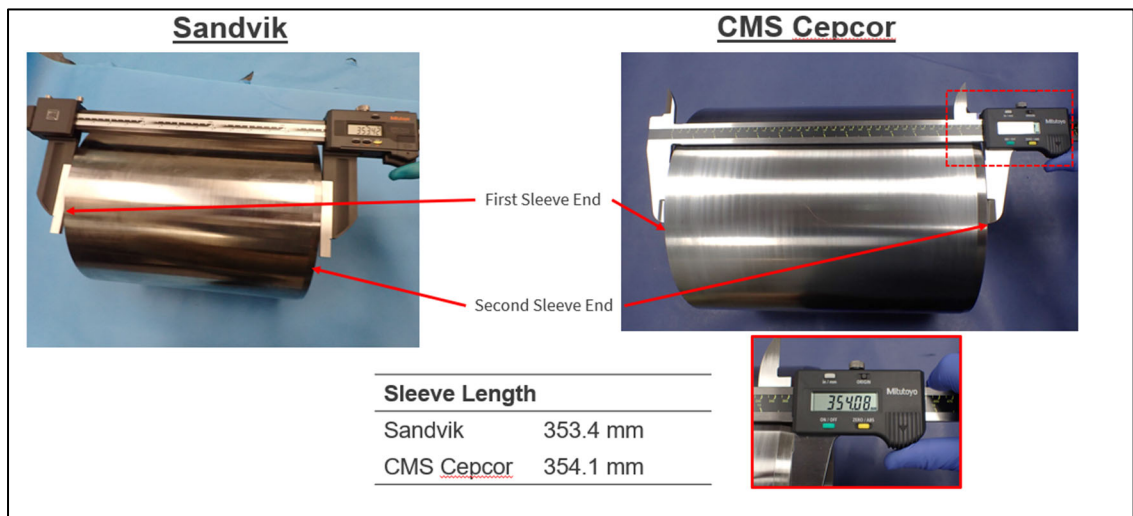
significant digits) and the lower end (first end) external diameter of Petitioner's sleeve was measured to be 284.92 millimeters (284.9 millimeters at four significant digits).



137. The lower end (first end) internal diameter of the Sandvik sleeve was measured by my team to be 277.45 millimeters (277.5 millimeters at four significant digits) and the lower end (first end) internal diameter of Petitioner's sleeve was measured to be 277.31 millimeters (277.3 millimeters at four significant digits).

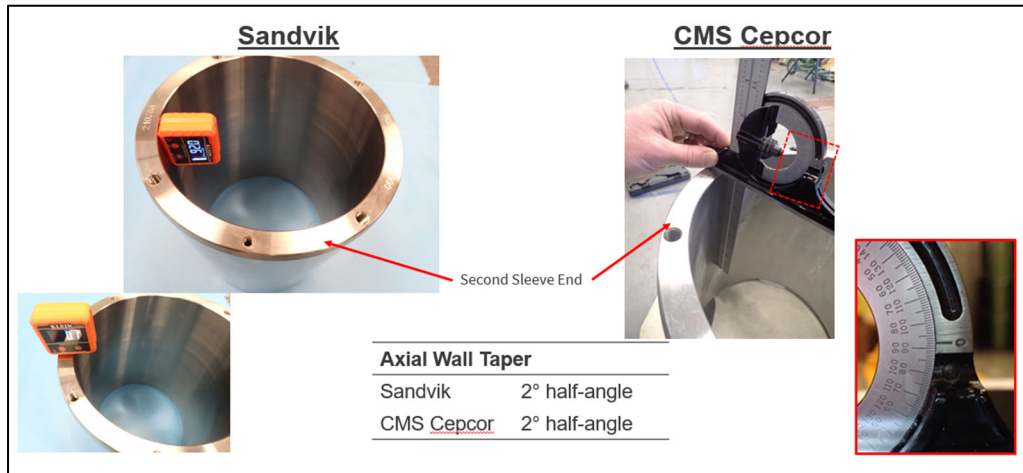


138. The overall sleeve length of the Sandvik sleeve was measured by my team to be 353.42 millimeters (353.4 millimeters at four significant digits) and the overall sleeve length of Petitioner's sleeve was measured to be 354.08 millimeters (354.1 millimeters at four significant digits).

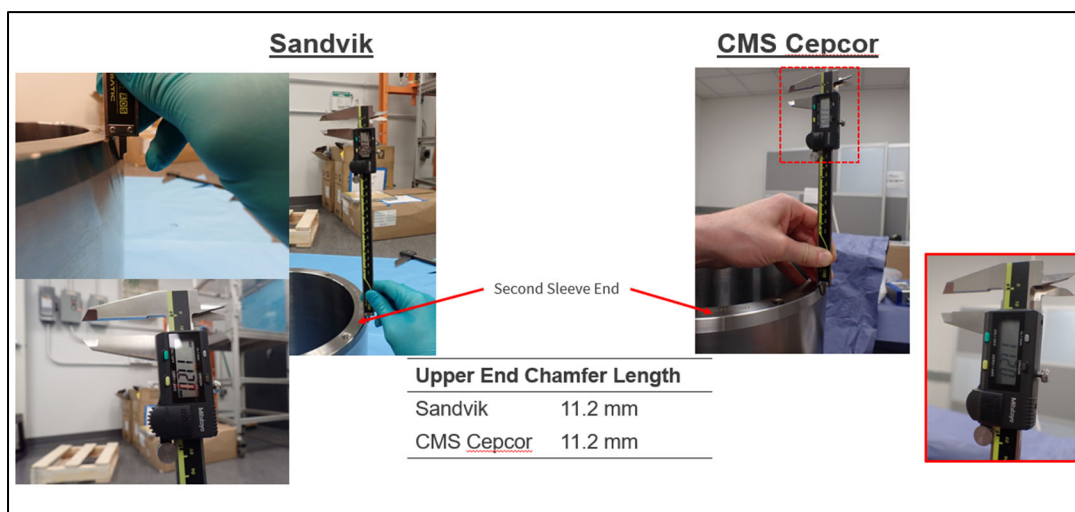


139. The taper angle of the axial wall of the Sandvik sleeve was measured by my team to be two degrees to one significant digit. The taper angle of the axial

wall of Petitioner's sleeve was also measured by my team to be two degrees to one significant digit.



140. An upper chamfer length of the Sandvik sleeve was measured by my team to be 11.2 millimeters at three significant digits and an upper chamfer length of Petitioner's sleeve was also measured to be 11.2 millimeters at three significant digits.



141. Accordingly, the sleeve sold by Sandvik and the sleeve sold by Petitioner are essentially identical. The corresponding main shaft embodying the

claim limitations of original claim 1 and claim 11 would necessarily be essentially identical as well. Thus, given the near identity, there is strong evidence that Petitioner copied Sandvik's claimed invention.

* * *

I declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and that these statements were made with knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code.

Dated: June 24, 2025



Harri Kytömaa, Ph.D.

APPENDIX A – LISTING OF SUBSTITUTE CLAIMS

Patent Owner presents the following substitute claims in marked-up form with underling indicating inserted text and brackets or strikethrough indicating deleted text from the original patent claims.

11. (Substitute for claim 1) A gyratory crusher comprising:

a main shaft including a shaft body having a first end for positioning at a lower region of the crusher and a second end for positioning at an upper region of the crusher relative to the first end, a thickness of the shaft body being tapered in an axial direction of the main shaft at a tapered region of the second end so as to taper and decrease in cross-sectional area; and

a sleeve fitted over the tapered region at the second end of the main shaft, the sleeve including an elongate axial wall extending around a longitudinal axis of the sleeve, the axial wall having an internal facing surface for positioning in contact with an outward facing surface of the main shaft, and an external facing surface relative to the longitudinal axis, the axial wall extending between the internal and external facing surfaces, the axial wall having a first sleeve end for positioning at a lower region of the main shaft and a second sleeve end for positioning at an upper region of the main shaft relative to the lower region,

wherein a thickness of the axial wall at a region between the first and second sleeve ends tapers and decreases in a direction from the second sleeve end to the first sleeve end,

in the axial direction the internal facing surface at said region between the first and second sleeve ends extending transverse to the longitudinal axis so as to taper inwardly towards the longitudinal axis of the sleeve in the direction from the first sleeve end to the second sleeve end, and

wherein the external facing surface from the first sleeve end to the second sleeve end is parallel to the longitudinal axis of the sleeve such that the external facing surface of the sleeve when viewed externally has a cylindrical geometry.

12. (Substitute for claim 2) The gyratory crusher as claimed in claim 11, wherein the region over which the thickness of the axial wall tapers and decreases extends ~~substantially~~ the full axial length of the sleeve.

13. (Substitute for claim 3) The gyratory crusher as claimed in claim 11, further comprising a radial wall extending perpendicular or transverse to the axial wall, the radial wall being positioned at or towards the second end and extending inwardly towards the longitudinal axis.

14. (Substitute for claim 5) The gyratory crusher as claimed in claim 11, wherein a cross-sectional shape profile of the external facing surface is substantially circular.

15. (Substitute for claim 6) The gyratory crusher as claimed in claim 11, wherein a cross-sectional shape profile of the internal facing surface is substantially circular.

16. (Substitute for claim 8) The gyratory crusher as claimed in claim 11, wherein a shape profile of the internal facing surface defines a section of a cone in the axial direction.

17. (Substitute for claim 9) The gyratory crusher as claimed in claim 11, further comprising at least one bore provided through the axial wall to allow the passage of a fluid to the internal facing surface.

18. (Substitute for claim 10) The gyratory crusher as claimed in claim 11, wherein at a ~~curved~~ region ~~[[of]]~~ proximal to the first sleeve end, the thickness of the axial wall reduces at an increased rate relative to a region of the axial wall proximal to the second sleeve end ~~the internal facing surface is curved radially~~

~~outward relative to the longitudinal axis in a direction towards the external facing surface such that the axial wall thickness decreases to zero at the curved region.~~

19. (Substitute for claim 4) The gyratory crusher as claimed in claim ~~[[3]]~~18, wherein the thickness of the axial wall reduces at a uniform rate along an entire axial length of the sleeve other than the region proximal to the first sleeve end~~the radial wall includes a through bore positioned at the longitudinal axis of the sleeve.~~