

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. 11,014,090

Inter Partes Review No. IPR2024-01381

THIRD 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 Contingent Motion to Amend for *Inter Partes* Review of United States Patent No. 11,014,090 (“the ’090 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 my previous declaration and accompanying appendix (“Kytömaa I”), I summarized my educational background, experience, career history, publications, and other relevant qualifications. (*See* Ex. 2001, ¶¶ 3–14.) Unless otherwise noted below, I will not repeat them here.

III. MATERIALS CONSIDERED

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

- The ’090 patent (Ex. 1001);

- The Petition for *Inter Partes* Review of the '090 patent to which my declaration related ("Petition") and Exhibits thereto, with particular attention to the Exhibits set forth below;
- The prosecution history of the '090 patent (Ex. 1001-1, "'090 prosecution history");
- The Expert Declaration by David G. Smith that accompanies the Petition (Ex. 1002, "Smith");
- Excerpts from Richard G. Budynas & J. Keith Nisbett, *Shigley's Mechanical Engineering Design*, Ninth Edition (2011) (Ex. 2003);
- Excerpts from Andrew W. Batchelor & Gwidon W. Stachowiak, *Engineering Tribology*, Second Edition (2001) (Ex. 2004);
- Excerpts from Robert C. Juvinall & Kurt M. Marshek, *Fundamentals of Machine Component Design*, 3rd Edition (2000) (Ex. 2005);
- Excerpts from Oscar J. Horger, *Metals Engineering Design*, First Edition (1953) (Ex. 2006);
- U.S. Patent No. 4,410,143 issued to Polinski (Ex. 1017, "Polinski");
- U.S. Patent No. 6,270,026 issued to Piepho (Ex. 1018, "Piepho");
- U.S. Patent No. 2,840,399 issued to Harless (Ex. 1033, "Harless");
- U.S. Patent No. 8,302,754 issued to Yagi (Ex. 1040, "Yagi");
- My previous declaration (Kytömaa I; Ex. 2001) in this proceeding;

- The Decision on Institution (“Institution Decision”) dated March 18, 2025;
- EP Application No. 13192402.9 (Ex. 2008);
- U.S. Application No. 15/035,774 (Ex. 2009);
- Deposition Transcript of David Smith dated June 11, 2025 (Ex. 2011);
- Merriam-Webster’s Collegiate Dictionary, 11th ed. (2012) (definition of “end”) (Ex. 2012); and
- The Oxford English Dictionary, 2nd ed. (1989) (definition of “indented”) (Ex. 2013)
- Richard G. Budynas & J. Keith Nisbett, *Shigley’s Mechanical Engineering Design*, Ninth Edition (2011) (Ex. 2015);
- John H. Bickford, *An Introduction to the Design and Behavior of Bolted Joints*, 3rd ed. (1995) (Ex. 2016); and
- Robert C. Juvinall & Kurt M. Marshek, *Fundamentals of Machine Component Design*, 3rd Edition (2000) (Ex. 2017).

IV. DEFINITIONS AND STANDARDS

5. 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 set forth my understanding of those legal standards in Kytömaa I. (*See* Ex. 2001, ¶¶ 16–19.)

V. CLAIM CONSTRUCTION

6. I understand Sandvik is requesting that the Board construe the term “end” as an extremity of a shaft body or sleeve. I also understand that Sandvik is requesting that the Board construe the phrase “indented at the external surface.” My opinion is that the proposed constructions are consistent with the claim language, the specification of the ’090 Patent, and dictionary definitions and would be understood as the plain and ordinary meaning of “end” and “indented at the external surface” to a POSITA.

B. “End”

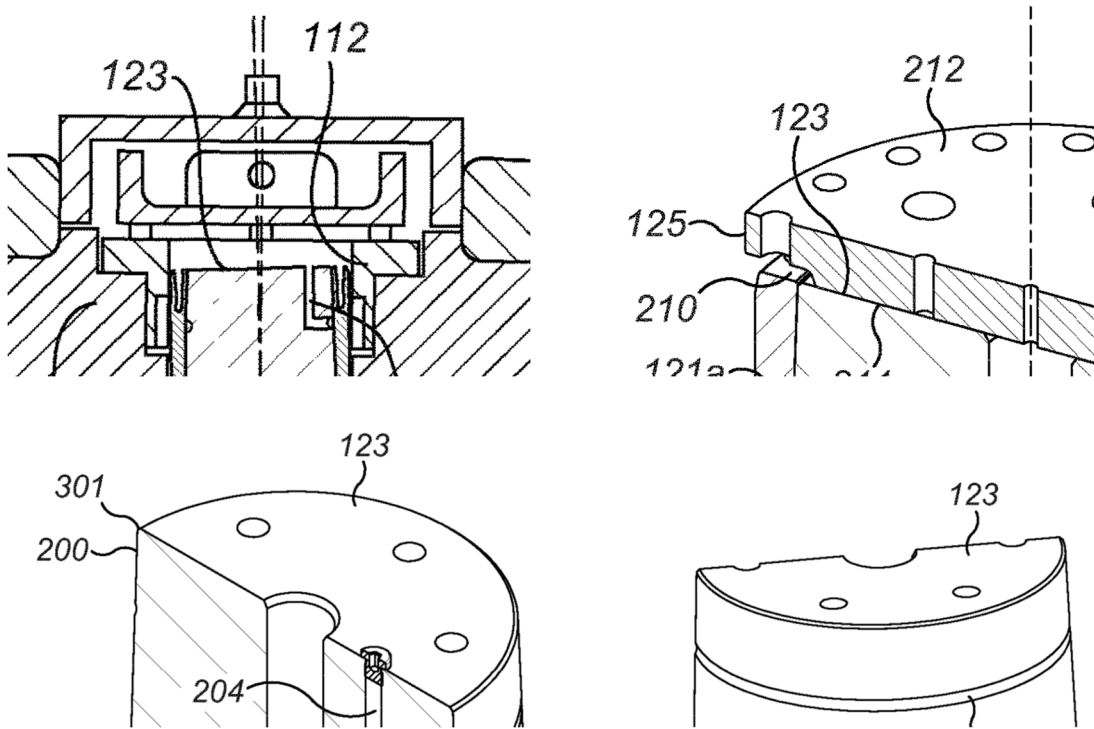
7. The term “end” is an element used in each independent claim of the ’090 Patent. (Ex. 1001.) Claims 15, 21, and 26 refer to “a first end and a second end” of a shaft body. Claims 21 and 26 additionally refer to “a first end of [a] sleeve” and “a second end of [a] sleeve.” As I discuss in detail below, Sandvik’s proposed construction of “end” as an extremity of a shaft body or sleeve is consistent with the claim language, the specification of the ’090 Patent, and a common dictionary definition.

2. Sandvik’s construction of “end” is supported by the claim language

8. Claims 15, 21, and 26 recite a shaft body having a “second end” and “an axial region of the shaft body *extending from the second end*.” In my opinion, a POSITA would find the most natural reading of this claim language to be that the axial region *extends* from a starting point or originating point, *i.e.*, the outermost extremity of the shaft body. Limitation [15f] supports this reading. It requires that the main shaft include “a *fluid inlet conduit extending axially from the second end* and provided in fluid communication with the at least one groove to allow a fluid to be supplied to the at least one groove from the second end.” Claim 15 thus requires that both the tapered axial region and the fluid inlet conduit extend from the same second end. Given that a fluid *inlet* conduit requires an inlet at some location and is described as extending axially, a POSITA would understand that the second end where the inlet is located is the extremity of the shaft and not a location along the length of the shaft.

3. Sandvik’s construction of “end” is also supported by the specification

9. The specification consistently shows a tapered axial region that extends to the outermost extremity of the shaft body in every single figure showing the shaft body in the ’090 Patent (end surface 123):

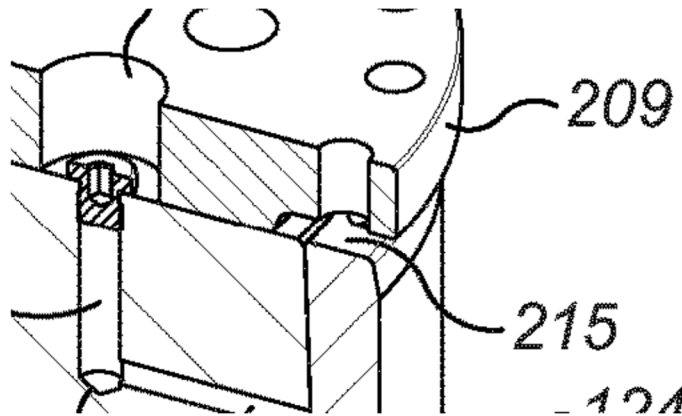


10. (Ex. 1001, FIGS. 1–4.) In all these figures, the end surface 123 of the shaft body is illustrated as the outermost extremity of the shaft body.

11. With respect to the sleeve, the '090 Patent describes that the “sleeve 124 comprises a radially inward facing surface 201 and a radially outward facing surface 202 with a substantially cylindrical wall 203 defined between surfaces 201, 202. Wall 203 is tapered so as to decrease in radial thickness *from uppermost end 215 to lowermost end 216.*” (Ex. 1001, 4:35–39.) The specification of the '090 Patent thus describes that the radial thickness of the sleeve decreases from the uppermost end to the lowermost end of the sleeve. I understand that this aligns with the limitations of claims 21 and 26, which require that the sleeve include a

first end and a second end, and that “a wall thickness at a second upper end of the sleeve is greater than a wall thickness at a first lower end of the sleeve.”

12. Furthermore, just like the end surface 123 of the shaft body, the '090 Patent illustrates the uppermost end 215 of the sleeve at the sleeve's upper extremity:



13. (Ex. 1001, FIG. 2.) To be sure, the '090 Patent illustrates the lowermost end 216 at a chamfer region 207. (FIG. 2; *see also* Ex. 1001, 5:52–55.) But chamfers and fillets are extremely common features often positioned at the outermost edges of objects, for instance, to reduce stress concentrations and ease assembly of components. The disclosure is thus still consistent with the lowermost end 216 being at an extremity of the sleeve.

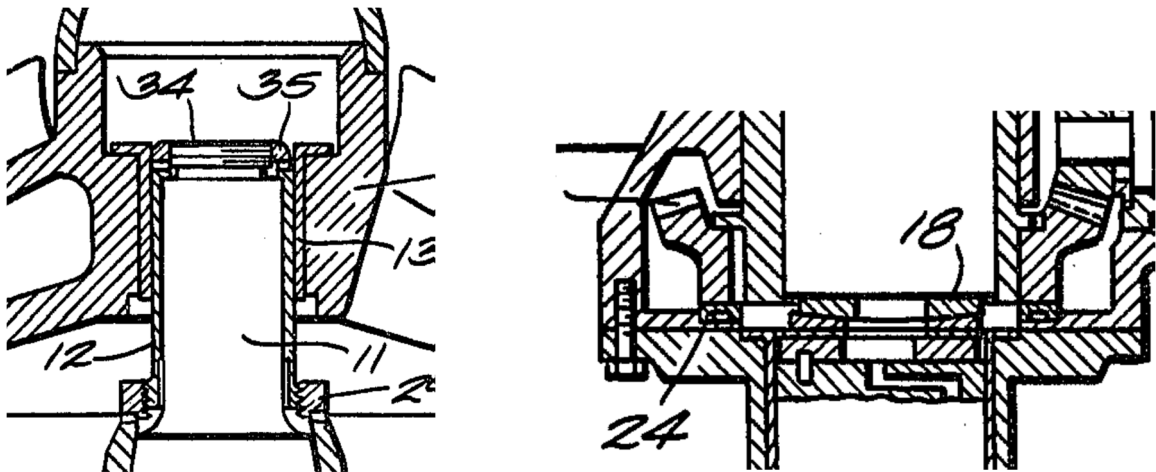
4. A common dictionary definition supports Patent Owner's construction of “end”

14. Sandvik's proposed construction is also consistent with a definition of end provided by Merriam-Webster's Collegiate Dictionary (2012) as “the extreme or last part lengthwise: TIP.” (Ex. 2012, 411 (definition 1c).) A POSITA would

understand this definition is consistent with the use of “end” in the claim language and the specification of the ’090 Patent and supports Sandvik’s construction of “end” as an extremity of the shaft body or sleeve.

5. Testimony from Petitioner’s expert supports Patent Owner’s construction of “end”

15. Petitioner’s expert, Mr. Smith, originally testified that “end” could be near the middle of an object, such as a sleeve. (See, e.g., Ex. 1002, 79.) However, on cross-examination, Mr. Smith testified otherwise. He explained, with reference to FIG. 1 of Polinski, that “there is an upper end of the shaft, generally indicated at around 34, 35. There is a lower end of the shaft, generally indicated around 18.” (Ex. 2011, 62:13–19.) I understand Mr. Smith’s testimony on cross-examination to be more aligned with a POSITA’s natural understanding of the term “end.”



16. (Ex. 1017, FIG. 1.) Given FIG. 1 of Polinski (excerpted above), this testimony is squarely consistent with Patent Owner’s understanding of “end”—the

uppermost extremity of the shaft body labeled 34 above is the “upper end” in Mr. Smith’s view and the lowermost extremity 18 is the “lower end.” (Ex. 1017, FIGS. 1-2.)

6. Piepho’s use of the term “end” does not override my understanding of “end in view of the ’090 Patent

17. In the Decision on Institution, the Board noted that “Piepho states that its shaft 14 includes ‘a tapered joint with *the tapered end (25) of shaft (14).*’” (Paper 9, 15.) However, I do not understand Piepho to assign any consistent terminology to the region labeled 25. Piepho’s shaft region 25 is described as a “shaft end,” “tapered portion,” “tapered end,” “shaft,” and “upper taper.” (Ex. 1018, 3:1–65.) Moreover, even if Piepho describes shaft region 25 as an “end,” I do not understand Piepho’s use of the term to override at least the intrinsic evidence of the ’090 Patent. As I discussed above, the claim language and specification of the ’090 Patent support Patent Owner’s construction that “end” refers to an extremity of a shaft body or sleeve.

C. “Indented at the external surface”

18. The phrase “indented at the external surface” is an element used in each independent claim of the ’090 Patent. (Ex. 1001.) Challenged independent claims 15, 21, and 26 refer to “at least one groove indented at the external surface and positioned at the tapered axial region.” Patent Owner submits that that the phrase “indented at the external surface” should properly construed as a depression

or recess in an external surface—specifically, the external facing surface of the shaft body. This construction is supported by the specification and prosecution history of the '090 Patent as well as a common dictionary definition.

1. The specification supports Patent Owner's construction of "indented at the external surface"

19. From the outset, the '090 Patent unambiguously refers to the at least one groove as a depression or recess in an external surface. For instance, beginning at the abstract, the '090 Patent states that “at least one groove is *indented within a radially external facing surface of the main shaft* at the region of the cone to allow fluid to be introduced under pressure to the region between the sleeve and the cone.” (Ex. 1001, Abstract.) I understand the Detailed Description section and each figure of the '090 Patent to be consistent with the abstract and with Sandvik's proposed construction. For instance, the Detailed Description refers to at least one groove 121 as “*indented within the external facing surface of shaft 107* at region 113. (*Id.*, 5:22–25.) FIG. 1 of the '090 Patent, annotated below, illustrates the groove 121 indented into the surface of the shaft body at the tapered conical region 113.

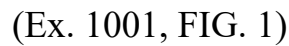


FIG. 2 is a cross-sectional view of a mechanical assembly. It shows a central shaft (113) with a series of holes (123, 122, 121, 120) along its length. A component (121a) is mounted on the shaft, featuring a groove (121a) and a flange (121b). Other components include a housing (115) with a flange (125), a bearing (124), and a seal (126). The assembly is shown in a cross-section with a dashed line indicating the center of the shaft.

FIG. 3 is a cross-sectional view of a mechanical assembly, similar to FIG. 2. It shows a central shaft (113) with a series of holes (123, 122, 121, 120) along its length. A component (121a) is mounted on the shaft, featuring a groove (121a) and a flange (121b). Other components include a housing (115) with a flange (125), a bearing (124), and a seal (126). The assembly is shown in a cross-section with a dashed line indicating the center of the shaft.

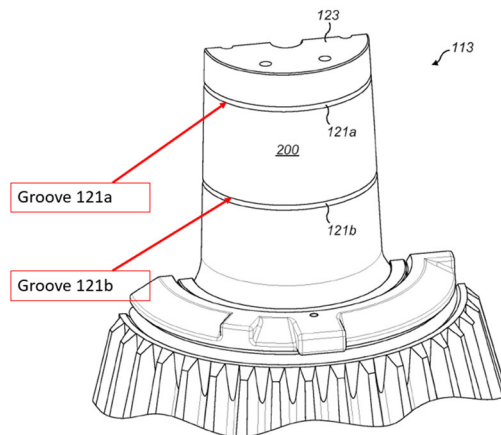


FIG. 4

21. It is my opinion that the specification of the '090 Patent unambiguously supports Patent Owner's construction of "indented at the external surface" to mean a depression or recess in the external surface—specifically, the external facing surface of the shaft body.

1. The prosecution history supports Patent Owner's construction of "indented at the external surface"

22. In response to the anticipation and obviousness rejections during examination, Sandvik noted that the "shaft includes a combination of an upper end region of the shaft being tapered so as to mount a correspondingly tapered protective sleeve with a groove being *in[d]en[t]ed/recessed into the external surface* of this tapered region of the main shaft." (Ex. 1001-1, Amendment dated January 25, 2019, 6.)

23. Sandvik then explained that "the groove 121 indented specifically at the external surface 200 of the main shaft *as opposed to being recessed into the*

sleeve 124 . . . maintains the strength and integrity of the sleeve and avoid[s] it splitting in response to the introduction of the pressurized fluid between the main shaft and the sleeve.” (Id.) Sandvik thus argued that the groove 121 is indented specifically at the external surface 200 of the main shaft body *as opposed to being recessed into the sleeve 124*. Thus, a POSITA would find that the prosecution history of the ’090 Patent supports Patent Owner’s construction of indented at the external surface to mean a depression or recess in the external surface—specifically, the external facing surface of the shaft body.

2. A common dictionary definition supports Patent Owner’s construction of “indented at the external surface”

24. Finally, Patent Owner’s construction is consistent with the Oxford English Dictionary, which provides that a definition of indented is “impressed, struck, or dented in, so as to make a depression or hollow in a surface.” (Ex. 2013, 846 (definition of “indented”).) This definition supports Patent Owner’s construction of “indented at the external surface” as a depression or recess in the external surface of the shaft body.

VI. LEVEL OF ORDINARY SKILL IN THE ART

25. 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. 2011, 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.

26. 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.

27. 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.

28. Thus, as described in Kytömaa I and in this declaration, I qualify as a POSITA in a number of ways.

29. 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, Piepho, and Harless 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 here, 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.).

30. Designing the shaft for a gyratory rock crusher involves significant challenges due to demanding conditions. The shaft must withstand variable and unpredictable fatigue loads resulting from a wide range of material hardnesses. Its eccentric design introduces complexity not typically encountered by an engineer with only two years of experience.

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

31. The '090 patent issued from U.S. App. No. 15/035,774 (the “'774 application”; Ex. 2009). The '774 application is a national stage entry of PCT/EP2014/060594 (Ex. 2014), filed on May 23, 2014, and claims priority to EP

Application No. 13192402.9 (Ex. 2008), filed on November 12, 2013. The originally filed disclosures (Exs. 2008 and 2009) support each substitute claim and make clear that no new matter has been introduced. The left column of the chart below shows the substitute independent claims in comparison to the challenged independent claims, with added limitations underlined and deleted limitations with strikethroughs. The right column shows exemplary support in the original disclosure—first with respect to the limitations of the challenged independent claims and then for the newly added limitations.

Substitute Independent Claims	Support in EP Application No. 13192402.9 (Ex. 2008) and the '774 Application (Ex. 2009)
15. A gyratory crusher main shaft of a crusher comprising: [15a] a shaft body having a radially outward facing external surface, and a first end and a second end; [15b] an axial region of the shaft body extending from the second end and being tapered relative to a longitudinal axis of the shaft body such that a cross sectional area of the shaft body at the tapered axial region decreases in a direction from the first end to the second end; [15c] a shaft sleeve mounted on the tapered axial region; [[and]] [15d] <u>at least one groove a plurality of grooves</u> indented at the external surface and positioned at the tapered axial region, the ~~at least one groove~~ <u>plurality of grooves</u> being arranged to receive a pressurized fluid to facilitate	<u>'090 patent claim 1</u> Exs. 2008 & 2009: 3:20–29; FIGS. 1–3. [15d]: ~~“at least one groove~~ <u>a plurality of grooves</u> indented at the external surface and positioned at the tapered axial region, the ~~at least one groove~~ <u>plurality of grooves</u> being arranged to receive a pressurized fluid to facilitate mounting and dismounting of the shaft sleeve at the shaft body” Exs. 2008 & 2009: 5:1; FIGS. 3–4. [15e]: <u>“wherein the plurality of grooves comprise a first groove and a second groove, wherein the first groove is positioned closer to the second end relative to the second groove”</u> Exs. 2008 & 2009: 5:7–16; 10:3–9; FIGS. 1–3

mounting and dismounting of the shaft sleeve at the shaft body, [15e] wherein the plurality of grooves comprise a first groove and a second groove, wherein the first groove is positioned closer to the second end relative to the second groove; and [15f] a fluid inlet conduit extending axially from the second end and provided in fluid communication with the first groove, wherein the fluid inlet conduit extends internally within the shaft body only to the first groove, [15g] wherein the first groove and the second groove are coupled in fluid communication.	[15f]: <u>“a fluid inlet conduit extending axially from the second end and provided in fluid communication with the first groove, wherein the fluid inlet conduit extends internally within the shaft body only to the first groove”</u> Exs. 2008 & 2009: 4:9–23: 10:1–5 FIGS. 1–3. [15g]: <u>“wherein the first groove and the second groove are coupled in fluid communication”</u> Exs. 2008 & 2009: 5:4–8; FIGS. 2–3; claim 7.
21. A gyratory crusher main shaft assembly for a crusher comprising: [21a] a shaft body having a radially outward facing external surface, and a first end and a second end, an axial region of the shaft body extending from the second end and being tapered relative to a longitudinal axis of the shaft body such that a cross sectional area of the shaft body at the tapered axial region decreases in a direction from the first end to the second end, [21b] a shaft sleeve mounted on the tapered axial region, and [21c] at least one groove indented at the external surface and positioned at the tapered axial region, the at least one groove being arranged to receive a pressurized fluid to facilitate mounting and dismounting of the shaft sleeve at the shaft body, ~~and~~ [21d] wherein the shaft ~~[[a]]~~ sleeve	<u>’090 patent claim 9</u> Exs. 2008 & 2009: 3:20–29; 5:18–22; FIGS. 1–3. [21e]: <u>“an end retainer releasably mounted at the second end of the shaft body and having a perimeter region extending radially outward beyond the external surface at the tapered region, the perimeter region positioned to radially overlap the shaft sleeve at the second end of the shaft sleeve to inhibit axial separation of the shaft sleeve from the sleeve body”</u> Exs. 2008 & 2009: 5:24–28; 6:4–5, FIG. 2; claim 10. [21f]: <u>“wherein the end retainer includes a recess extending circumferentially at the perimeter region to allow axial movement of the sleeve into the recess”</u>

is fitted over the tapered axial region, the <u>shaft sleeve</u> having a tapered wall thickness, such that the wall thickness at a second end of the <u>shaft sleeve</u> is greater than the wall thickness at a first end of the <u>shaft sleeve</u>; and [21e] <u>an end retainer releasably mounted at the second end of the shaft body and having a perimeter region extending radially outward beyond the external surface at the tapered axial region, the perimeter region positioned to radially overlap the shaft sleeve at the second end of the shaft sleeve to inhibit axial separation of the shaft sleeve from the sleeve body,</u> [21f] <u>wherein the end retainer includes a recess extending circumferentially at the perimeter region to allow axial movement of the shaft sleeve into the recess,</u> [21g] <u>wherein the recess defines an annular gap between the end retainer and the second end of the shaft sleeve when an underside surface of the end retainer is positioned in contact with the second end of the shaft.</u>	Exs. 2008 & 2009: 6:1–3; FIG. 2; claim 11. [21g]: <u>“wherein the recess defines an annular gap between the end retainer and the second end of the shaft sleeve when an underside surface of the end retainer is positioned in contact with the second end of the shaft”</u> Exs. 2008 & 2009: 9:18–24; FIG. 2.
26. A gyratory crusher comprising: [26a] a main shaft including a shaft body having a radially outward facing external surface, 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; [26b] an axial region of the shaft body extending from the second end and being tapered relative to a longitudinal axis of the shaft body such that a cross sectional area of the shaft	<u>’090 patent claim 14</u> Exs. 2008 & 2009: 3:20–29; 5:19–20; 6:18–19; FIGS. 1–3. [26f]: <u>“wherein the shaft sleeve is configured such that when positioned on the shaft body, the shaft sleeve is independent of a crushing head and a crushing shell”</u> Exs. 2008 & 2009: 7:11–12; FIGS. 1–2.

body at the tapered axial region decreases in a direction from the first end to the second end, the tapered axial region being configured to mount a shaft sleeve; [26c] a sleeve fitted over tapered axial region, the sleeve having a tapered wall thickness such that a wall thickness at a second upper end of the sleeve is greater than a wall thickness at a first lower end of the sleeve; and [26d] at least one groove indented at the external surface and positioned at the tapered axial region, the at least one groove being arranged to receive a pressurized fluid to facilitate mounting and dismounting of the sleeve at the shaft body, [26f] <u>wherein the shaft sleeve is configured such that when positioned on the shaft body, the shaft sleeve is independent of a crushing head and a crushing shell.</u>	
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The chart below shows the exemplary support for the substitute dependent claims.

Substitute Dependent Claims	Support in EP Application No. 13192402.9 (Ex. 2008) and the '774 Application (Ex. 2009)
Claim 16	“wherein the first groove is positioned on a first side of a cross-sectional area center of the shaft sleeve relatively closer to the second end and the second groove is positioned on a second side of a cross-sectional area center of the shaft sleeve relatively further from the second end” Exs. 2008 & 2009: 5:4–16; 10:5–9; FIGS. 3–4.
Claim 17	“wherein the first groove and the

	second groove are positioned at an equal distance from the cross-sectional area center of the shaft sleeve such that when the pressurized fluid is supplied to the first groove and the second groove, an expansion force is distributed substantially uniformly along the axial length of the sleeve” Exs. 2008 & 2009: 5:4–16; 10:3–13; FIGS. 3–4.
Claim 18 (corresponding to claim 4)	Exs. 2008 & 2009: 4:25.
Claim 19 (corresponding to claim 5)	Exs. 2008 & 2009: 4:25–27.
Claim 20 (corresponding to claim 8)	Exs. 2008 & 2009: 4:15–18.
Claim 22	“wherein the end retainer comprises a first plurality of bores distributed circumferentially around the end retainer and configured to align with a plurality of sleeve bores in the second end of the shaft sleeve such that the retainer can be attached to the shaft sleeve” Exs. 2008 & 2009: 9:11–15, FIG. 2.
Claim 23	“wherein the end retainer comprises a surface opposite the underside surface of the end retainer configured to mate against the second end of the shaft sleeve when the retainer is inverted” Exs. 2008 & 2009: 9:29–30; FIG. 2. “wherein the end retainer is configured to force the shaft sleeve axially over the tapered axial region when a plurality of attachment members

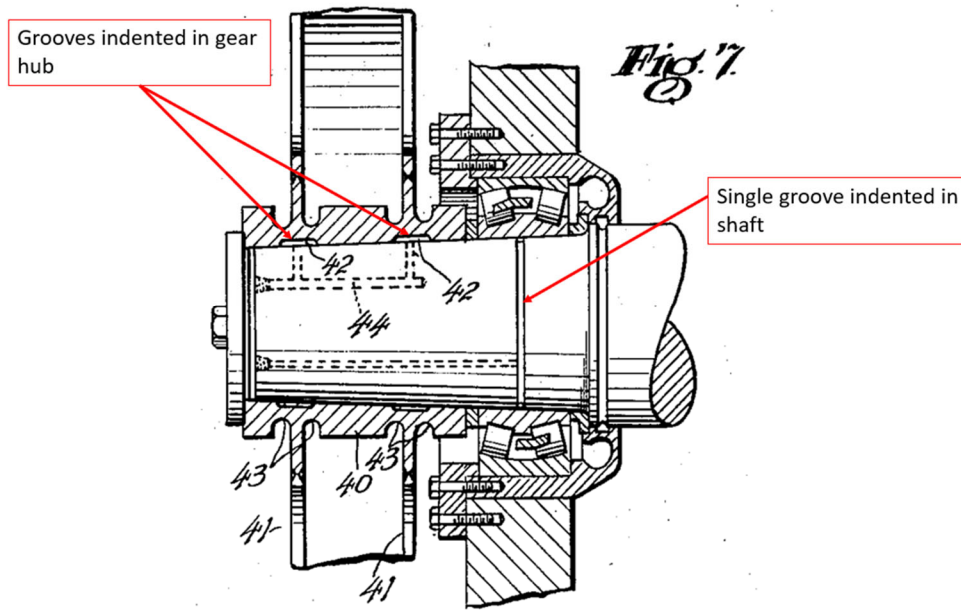
	extending through a second plurality of bores in the end retainer and into a plurality of corresponding shaft bores in the second end of the shaft body are tightened” Exs. 2008 & 2009: 9:13–18, 26–31.
Claim 24 (corresponding to claim 12)	Exs. 2008 & 2009: 4:9–11.
Claim 25 (corresponding to claim 13)	Exs. 2008 & 2009: 6:14–16

VIII. THE SUBSTITUTE CLAIMS ARE PATENTABLE OVER THE PRIOR ART OF THE INSTITUTED GROUND

A. Polinski, Piepho, and Harless fail to disclose or suggest substitute claim 15’s limitation [15d].

32. Polinski, Piepho, and Harless, fail to disclose or suggest a plurality of grooves indented at the external surface and positioned at the tapered axial region, as set forth in [15d]. As discussed in my original declaration Harless is the only reference of the three relied on by Mr. Smith and Petitioner as disclosing any grooves indented at the external surface and positioned at the tapered axial region as set forth in substitute claim 15. (*See, e.g.*, Ex. 2001, ¶47.) Harless discloses, at most, a *single* groove 12 indented at the external surface of the shaft body and arranged to receive a pressurized fluid, as shown in FIG. 1 of Harless. Harless discloses additional grooves (*e.g.*, groove 15 in FIG. 1 and grooves 42 in FIG. 7); however, the additional grooves are indented into a gear hub—not into the shaft body. (Ex. 1033, FIGS. 1, 3-4, 5, 7). FIG. 7 of Harless is shown below for

reference. I have annotated the single groove 12 indented into the shaft and the two grooves indented into the gear hub.



(*Id.*, FIG. 7 (annotated.))

33. Nothing else in Harless cures the deficiencies of FIG. 7. (*See Id.*, FIGS. 1–8.) Thus, even when considered in combination, Polinski, Piepho, and Harless do not disclose or suggest “a plurality of grooves indented at the external surface and positioned at the tapered axial region, the plurality of grooves being arranged to receive a pressurized fluid to facilitate mounting and dismounting of the shaft sleeve at the shaft body,” as recited in [15d].

34. Moreover, as discussed in Kytömaa I, a POSITA would not have been motivated to incorporate any oil grooves into the shaft disclosed by the purported

combination of Polinski and Piepho. (*See, e.g.*, Ex. 2001, ¶¶48–59.) Polinski’s stated purpose is mitigating shaft fatigue failure. (Ex. 1017, 1:61–67; Ex. 2001, ¶30.) Polinski teaches that structural discontinuities increase the likelihood of fatigue failure and counsels that discontinuities should be removed from the bearing journal 11 fit with sleeve 12. (*See* Ex. 1017, 1:15–20.)

35. Adding *multiple* grooves in the shaft body, in order to satisfy the requirement for “a plurality of grooves indented at the external surface and positioned at the tapered axial region” would create structural discontinuities that would increase the likelihood of fatigue failure in Polinski. As set forth in Kytömaa I, *Shigley*—a textbook that Mr. Smith describes as “very popular book” on machine design (Ex. 2011, 48:3–12)—explains that stress concentrations can arise from a single groove. (Ex. 2003, 10; Ex. 2001, ¶¶ 50–51 (“Adding an oil groove to bearing journal would have a similar effect [of high local stress concentrations] to the threads described by Polinski.”) Adding grooves to the shaft adds stress concentration locations which increases the risk of fatigue failure. Adding grooves also adds more regions near the edge of contact area where fretting wear can occur and provide still more potential initiation sites for fatigue cracks.

36. A POSITA, with limited experience and facing a “fairly complex machine” (Ex. 1002, ¶ 27), would not be motivated to undermine the intended—

and express—purpose of Polinski by adding multiple grooves that would introduce multiple discontinuities into the bearing journal. A POSITA would know that fatigue is a complicated failure mechanism that is difficult to predict analytically. Fatigue testing is difficult to setup and run and requires many samples to generate meaningful data. Moreover, a strong understanding of the fatigue loading conditions is required to evaluate fatigue, but a POSITA would have difficulty predicting the fatigue loads to use in this scenario to run the analysis. For these reasons, A POSITA would not be motivated to modify Polinski in a way that would compromise the fatigue life of the shaft given Polinski's core focus is preventing such fatigue failure and the complexity of the analysis required.

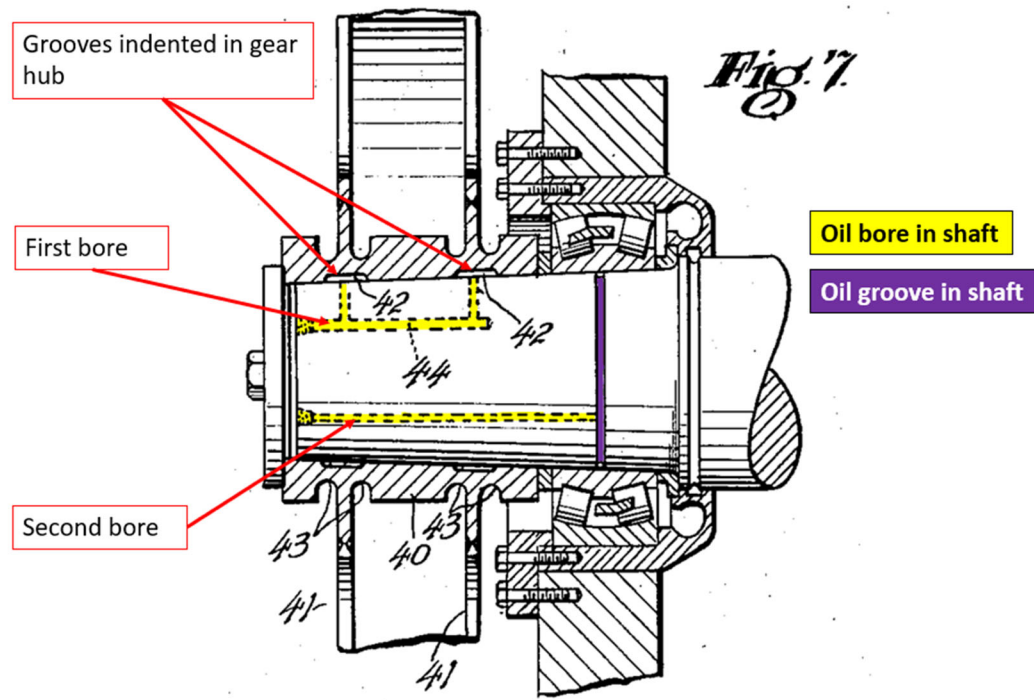
37. Petitioner contends that the groove in Harless would simplify making and breaking interference fits. (See Paper 2, 21.) In the Decision on Institution, the Board found that Sandvik had not contested the advantages associated with the introduction of a single groove in a shaft and that the weighing of advantages and disadvantages were better suited for trial. (Paper 9, 19.) The increased risk of shaft failure posed by the addition of oil grooves—particularly given the specific concerns with shaft failure addressed by the purported inventions in Polinski and Piepho—would dissuade a designer from incorporating them in order to realize unproven benefits with respect to making and breaking interference fits, especially given the lack of guidance or support in the prior art. Whatever advantages that a

groove in a shaft may provide, the designer would need to ensure that those benefits outweighed the heightened risk of *shaft failure*. Because such failure would be an existential threat, it would be a front and center consideration for the POSITA. Mr. Smith agrees. On cross-examination, he admitted that “if you are experiencing a lot of shaft failures, then it becomes a *major concern*” and that “you would want to design it in a way that the shaft fails less often.” (Ex. 2011, 44:5–16.)

38. The loading on the shaft of a gyratory rock crusher is complex and demanding. The eccentric motion and the highly variable crushing forces result in loads that put the shaft at risk for fatigue failure. The failure of a shaft is a significant issue and requires significant downtime and expensive components to replace. A POSITA would thus not be motivated to introduce *multiple* grooves that run directly contrary to the primary concern of Polinski, to wit, shaft failure.

B. Polinski, Piepho, and Harless also fail to disclose or suggest substitute claim 15’s limitations: [15e]–[15g].

39. Neither Polinski nor Piepho discloses or suggests any “fluid inlet conduit,” as recited in [15e]–[15g]. Although Harless discloses an internal oil bore 44 extending to two grooves 42 in a gear hub (Ex. 1033, 4:20–22; FIG. 7), it does not teach or suggest a bore that extends “internally within the shaft body only to the first groove,” as required by substitute claim 15. Instead, oil bore 44 extends to both grooves 42 as shown in FIG. 7 (below).



(Id., FIG. 7 (annotated).)

40. Harless includes a separate oil bore 13 in FIG. 7; however, this bore does not supply the “first groove” because groove 12 is not positioned closer to the second end than any other groove as required by [15e], nor is groove 12 “coupled in fluid communication” with another groove as required by [15g]. Accordingly, Polinski, Piepho, and Harless do not disclose or suggest [15e]–[15g].

Nor would there be any reason to modify Polinski’s shaft to have these claimed features. First, modifying Polinski in view of Harless to include *a plurality* of grooves indented into the surface of the shaft (e.g., a first groove and a second groove) would not be obvious at least for the reasons discussed *infra* with respect to Polinski’s concerns regarding shaft failure resulting from stress concentrations

due to discontinuities in the surface of the shaft. Moreover, *even if* Polinski could be modified to include multiple circumferential grooves indented into the shaft surface, it would not be obvious to modify Polinski to couple those grooves in fluid communication. To couple the two grooves in fluid communication without an internal conduit extending axially to the second groove (further from the second end) would require an external groove extending axially to the second groove along the external surface of the shaft. An axially extending groove indented into the surface of the shaft presents even more heightened concerns for shaft fatigue failure. The axial groove would further increase the bending stress concentration caused by the circumferential grooves at the point where the axial grooves intersect with the circumferential grooves.

C. Polinski, Piepho, and Harless also fail to disclose or suggest the limitations of substitute claim 16.

41. Polinski, Piepho, and Harless, taken both alone and in combination, fail to disclose or suggest the limitations of substitute dependent claim 16 relating to the placement of the first and second grooves. Polinski and Piepho do not disclose any grooves indented at the external surface and positioned at the tapered axial region arranged to receive a pressurized fluid to facilitate mounting and dismounting of the shaft sleeve at the shaft body. Harless does not disclose multiple grooves indented at the external surface of the shaft in the tapered axial region, nor does it specify the positioning of its grooves relative to a cross-

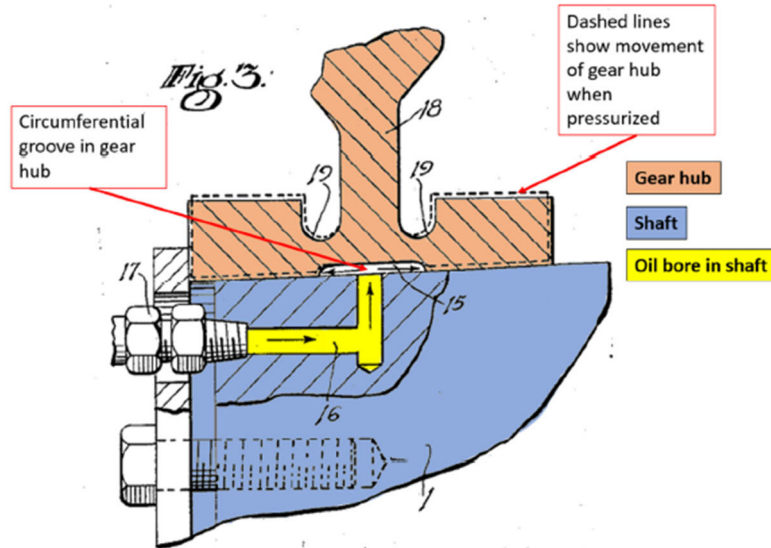
sectional area center of any shaft sleeve. As a result, Harless does not disclose or suggest a first groove situated on one side of that cross-sectional area center, and a second groove placed on the opposite side, as claim 16 requires.

D. Polinski, Piepho, and Harless also fail to disclose or suggest the limitations of substitute claim 17.

42. Polinski, Piepho, and Harless, taken both alone and in combination, fail to disclose or suggest the limitations of substitute dependent claim 17. As discussed *supra*, Polinski and Piepho fail to disclose any grooves indented at the external surface and positioned at the tapered axial region arranged to receive a pressurized fluid to facilitate mounting and dismounting of the shaft sleeve at the shaft body. As also discussed *supra*, Harless fails to disclose or suggest a plurality of grooves indented at the external surface positioned at the tapered axial region. Harless necessarily also fails to disclose that a first groove and a second groove are positioned at an equal distance from the cross-sectional area center of the shaft sleeve as set forth in substitute claim 17.

43. Moreover, Harless does not contemplate a configuration of grooves that achieves substantially uniform expansion force distributed along the axial length of the sleeve as also set forth in substitute claim 17. As I discussed in my original declaration, Harless is directed to a gear hub having grooves for receiving pressurized oil to cause the gear hub to expand in particular locations while *not* expanding in other locations. (Ex. 1033, 1:30–34; 2:33–43; 4:22–23; Ex. 2001,

¶¶45–46.) Specifically, as shown in FIG. 3 of Harless below, Harless discloses a gear hub in which grooves 19 are formed into a peripheral surface of a gear hub.



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

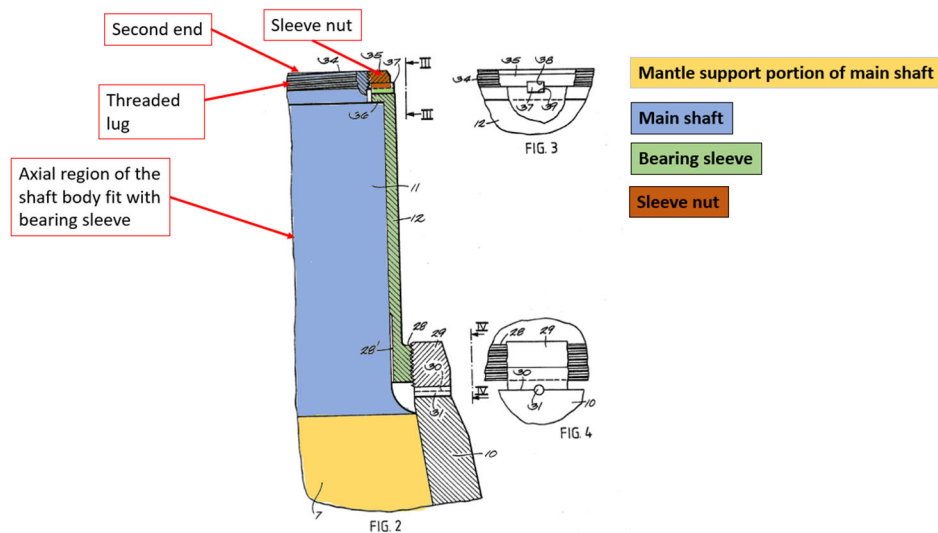
44. When oil is introduced under pressure into an oil groove 15 indented into the gear hub, portions of the hub expand outwardly as the hub bends above grooves 19, but the web 18 does not move. (Ex. 1033, 2:32–43.) Mr. Smith likewise testified that the gear hub of Harless is configured to expand in particular locations but not in others. (Ex. 2011, 91:21–92:4.)

E. Polinski, Piepho, and Harless also fail to disclose or suggest the limitations of substitute claims 18–20.

45. Substitute dependent claims 18–20 correspond to original claims 4, 5, and 8. These claims are patentable for at least the reasons set forth above for substitute claim 15.

F. Polinski, Piepho, and Harless also fail to disclose or suggest the limitations of substitute claim 21.

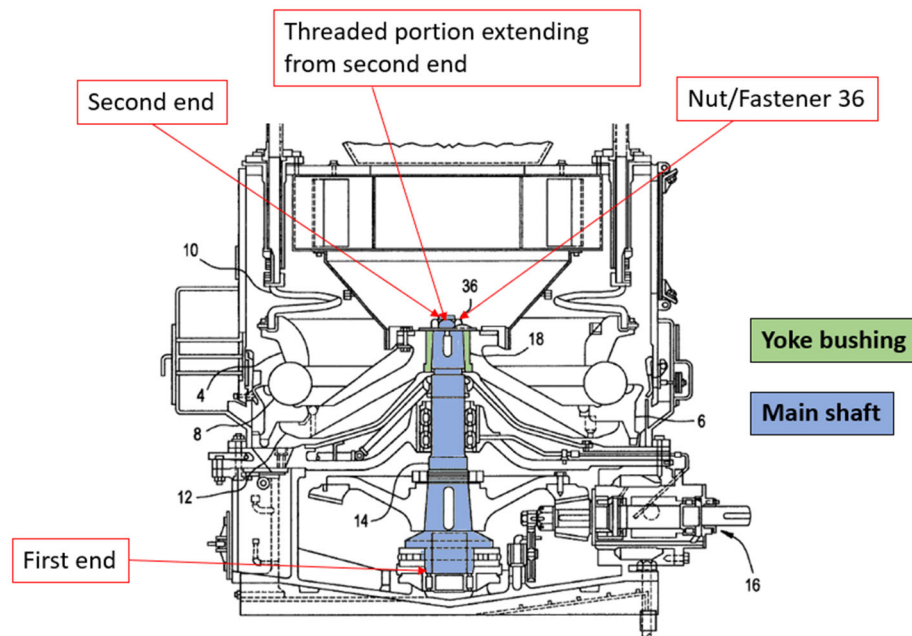
46. Polinski, Piepho, and Harless, taken either alone or in combination, fail to the limitations recited in substitute claim 21 directed to an end retainer. As I previously discussed in my original declaration, Polinski teaches that a journal 11 lies near the second end of the shaft 7 and that shaft 7 includes a threaded lug 34 extending from the journal 11 to the shaft's uppermost end for receiving sleeve nut 35, which in turn secures annular lip 36 of sleeve 12. (Ex. 2001, ¶28; Ex. 1017, 2:30–47, 3:15–47.) As illustrated in FIG. 2 of Polinski (below), this arrangement places sleeve nut 35 in contact with annular lip 36 of sleeve 12, securing the sleeve 12 to the journal 11.



47. Specifically, Polinski discloses that the annular lip 36 is secured against the upper marginal edge surface of the shaft 7 by the sleeve nut 35 which is in turn rigidly coupled to the sleeve 12 by at least one key 37 welded in a

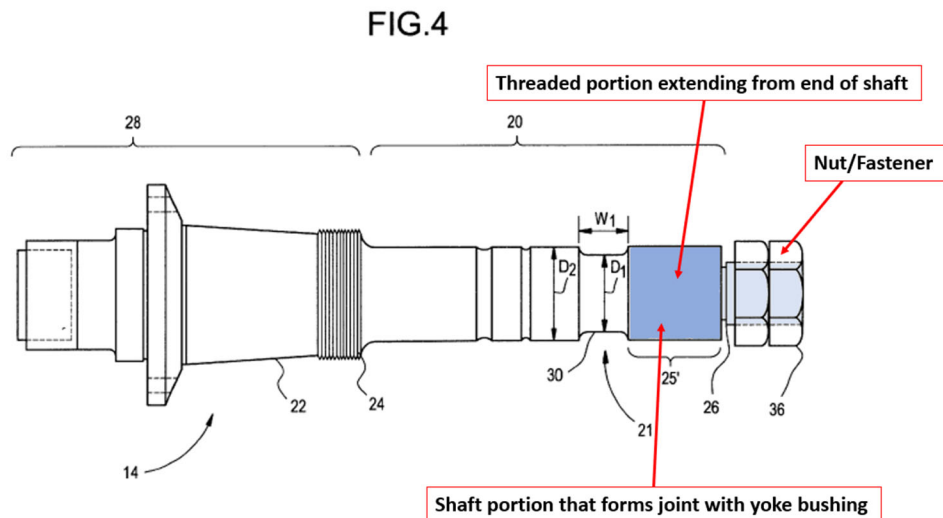
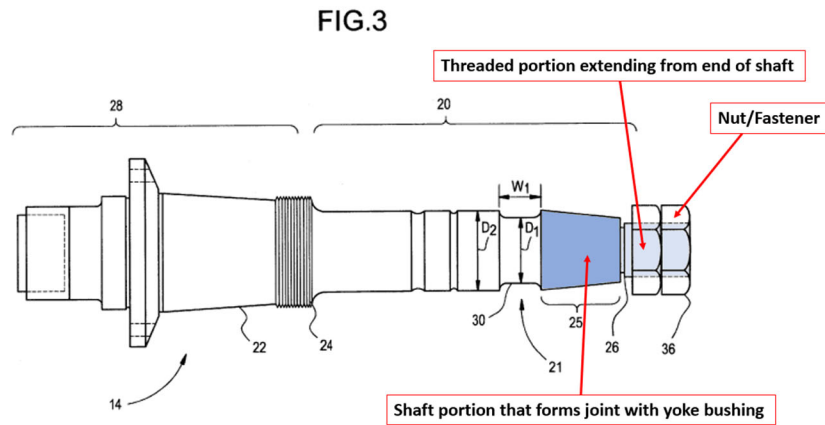
corresponding pair of keyways 38 and 39 spaced about the peripheries of the sleeve nut and the sleeve. (*Id.*, 3:28–33.) This arrangement is depicted above in annotated FIGS. 2 and 3 of Polinski. Thus, to the extent Polinski is viewed as teaching any end retainer (which Patent Owner does not concede), Polinski fails to disclose any circumferential recess in the retainer that accommodates axial movement of a shaft sleeve as set forth in [21f].

48. Similarly, Piepho's coal pulverizer and coal pulverizer main shaft illustrations (FIGS. 1, 3–4, shown below) show a nut 36 attached to a threaded region 26 at the top of the shaft—as shown in FIG. 1 below, the nut/fastener 36 holds a plate or washer against the yoke bore 18. (Ex. 1018, FIGS. 1, 3–4.)



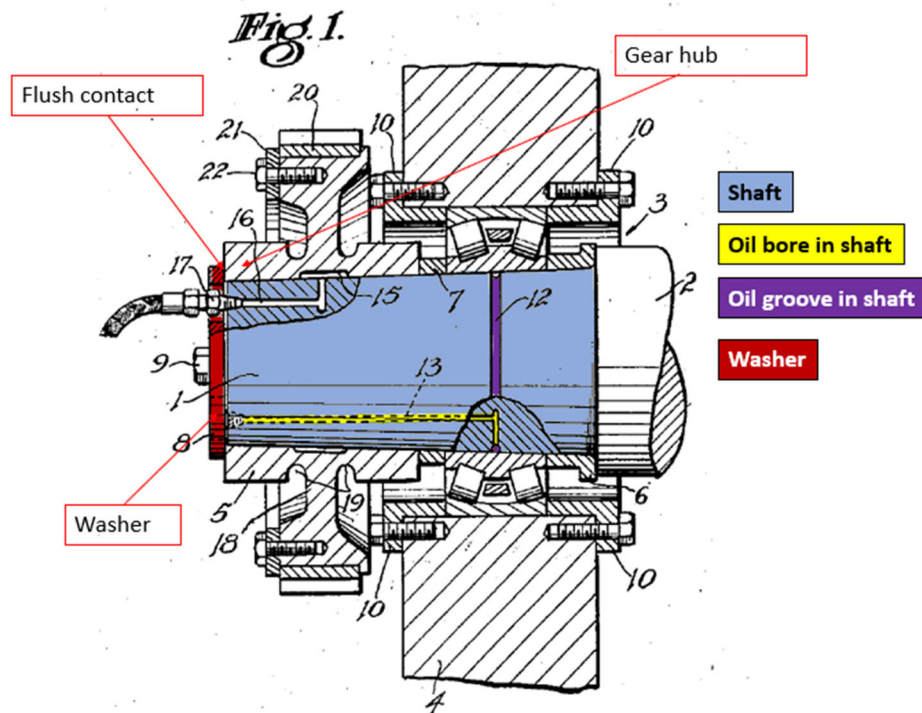
(*Id.*, FIG. 1.)

49. As depicted in FIG. 1, like Polinski, Piepho does not disclose any end retainer with a recess extending circumferentially such that a shaft sleeve can move into that recess as set forth in [21f]. FIGS. 3 and 4 of Piepho (below), show additional detail of the threaded portion extending from the end of the shaft and the nut/fastener 36 attached to the shaft.



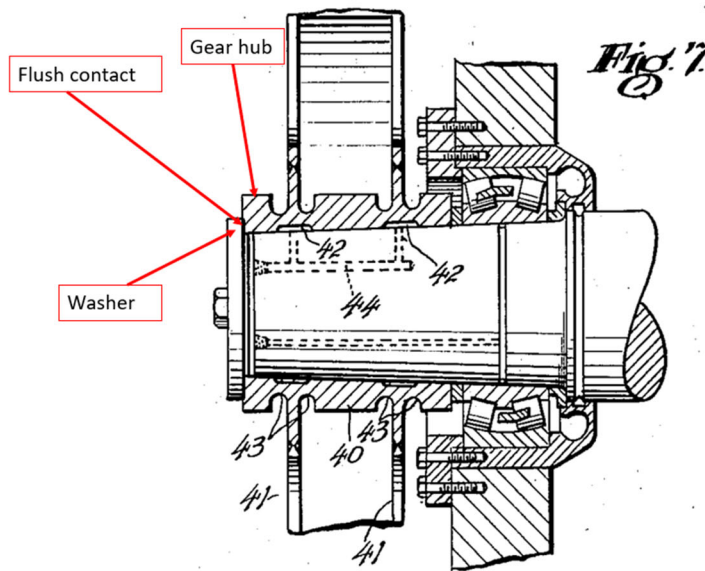
(*Id.*, FIG. 4 (annotated).)

50. Harless, cited by Petitioner for a washer 8 purportedly acting as an end retainer, likewise fails to disclose the end retainer recess as recited in [21f]. In FIG. 1 and FIG. 7 of Harless, the washer 8 is depicted as flush against and in contact with the end of the gear hub 40. (Ex. 1033, FIGS. 1, 7.) FIG. 1 (below) is representative of the positioning of the end retainer relative to the end of the gear hub 40 in Harless.



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

51. Harless FIG. 7 similarly depicts the washer 8 flush with the end of the gear hub.



(*Id.*, FIG. 7 (annotated).)

52. There is no teaching or suggestion in Harless that the washer 8 includes an undercut shoulder or recess permitting axial movement of the hub (alleged to be the “sleeve” recited in claim 9). Petitioner’s argument that the unlabeled portion in FIG. 7 is an undercut shoulder is based on a modified version of Harless FIG. 7 showing the washer 8 artificially shifted away from the gear hub and shaft. (Paper 2, 39.) However, Harless never identifies this unlabeled region as an undercut shoulder in washer 8, nor does it disclose any movement of the washer away from the gear hub when bolts 9 are backed off. (*See* Ex. 1033, 3:16–22.) Mr. Smith likewise testified only to a possible gap, chamfer, or fillet at the shaft end, not an undercut shoulder on washer 8. (Ex. 2011, 88:3–8; 89:22–90:8.)

53. Mr. Smith likewise testified only to a possible gap, chamfer, or fillet at the shaft end, not an undercut shoulder on washer 8:

A. So looking at that [FIG. 1], I believe that the side of the washer 8 is going to be flush up against the end of the tapered shaft. The two lines that you see here, I would expect represent either a chamfer or a fillet, a small curve at the end of the tapered shaft, not some space between the two components.

Q. And would there be a chamfer or a fillet associated with the end of the shaft in Figure 7 of Harless?

A. That's possible, yes. I don't know for sure, but it's possible.

Q. So how do you understand the vertically parallel lines that are shown in Figure 7, between the washer 18 -- sorry. Strike that -- the washer 8 and the tapered shaft?

A. Yeah. So here, there are three vertical lines, and the patent doesn't really describe what each of them are. So I'm not sure what to tell you.

(Ex. 2011, 88:3–8; 89:22–90:8.) Accordingly, as admitted by Petitioner's own expert, Harless does not disclose an end retainer having a recess extending circumferentially at the perimeter region to allow axial movement of the shaft sleeve into the recess as set forth in [21f].

54. Moreover, even if Harless did disclose an end retainer with a recess as recited in [21f] (which Patent Owner denies), Harless does not disclose or suggest that the recess defines an annular gap between the end retainer and the second end of the shaft sleeve when an underside surface of the end retainer is positioned in contact with the second end of the shaft, as recited in [21g]. The perimeter of Harless's washer 8 sits flush against the gear hub 40 without leaving any circumferential recess or gap for movement in each and every embodiment depicted in Harless—whether the washer 8 is flush with the end of shaft 1 or not. (Ex. 1033, FIG. 1–8.) Piepho and Polinski do not remedy this deficiency.

G. Polinski, Piepho, and Harless also fail to disclose or suggest the limitations of substitute claim 22.

55. Nothing in Polinski, Piepho, or Harless discloses or suggests an end retainer that comprises a first plurality of bores distributed circumferentially around the end retainer and configured to align with a plurality of sleeve bores in the second end of the shaft sleeve such that the retainer can be attached to the shaft sleeve. Patent Owner thus respectfully submits that substitute claim 22 is patentable over Polinski, Piepho, and Harless at least based on this additional reason.

H. Polinski, Piepho, and Harless also fail to disclose or suggest the limitations of substitute claim 23.

56. Nothing in Polinski, Piepho, or Harless discloses or suggests an end retainer that comprises a surface opposite the underside surface of the end retainer configured to mate against the second end of the shaft sleeve when the retainer is inverted, wherein the end retainer is configured to force the shaft sleeve axially over the tapered axial region when a plurality of attachment members extending through a second plurality of bores in the end retainer and into a plurality of corresponding shaft bores in the second end of the shaft body are tightened, as recited in substitute claim 23. Patent Owner thus respectfully submits that substitute claim 22 is patentable over Polinski, Piepho, and Harless based on at least this additional reason.

I. Polinski, Piepho, and Harless also fail to disclose or suggest the limitations of substitute claim 24-25.

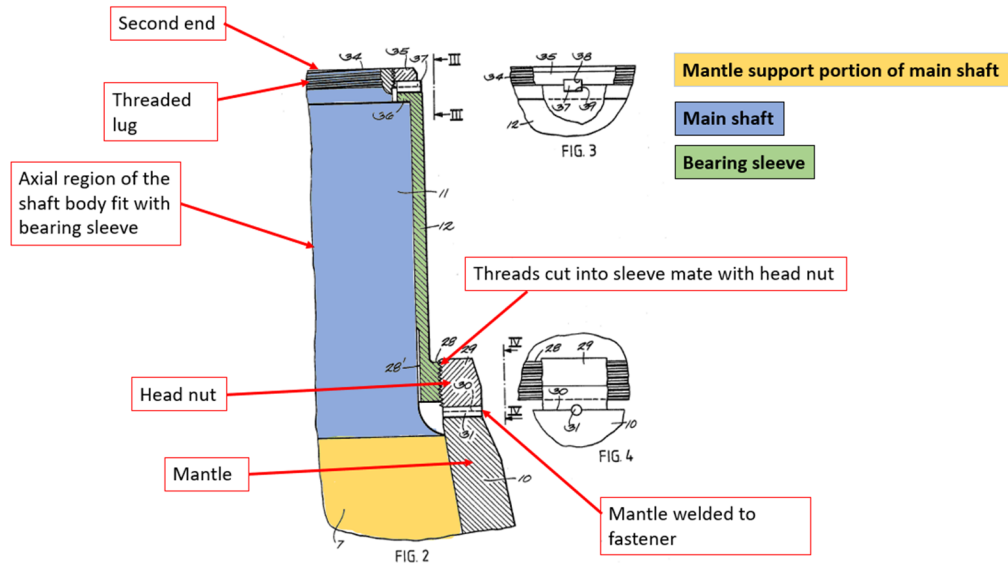
57. Substitute dependent claims 24–25 correspond to original claims 12 and 13. These claims are patentable for at least the reasons set forth above for substitute claim 21.

J. Polinski, Piepho, and Harless also fail to disclose or suggest the limitations of substitute claim 26.

58. Polinski, Piepho, and Harless, taken both alone and in combination, fail to disclose or suggest the limitations of substitute independent claim 26. Specifically, the references fail to disclose or suggest a shaft sleeve that is configured such that when positioned on the shaft body, the shaft sleeve is

independent of a crushing head and a crushing shell as recited in [26f]. (*See also* Ex. 2011, 34:2–35:8.) Polinski discloses that a sleeve 12, relied on by Petitioner for the sleeve recited in challenged claim 14, includes a threaded shoulder 28 near the bottom end of the sleeve 12 for securing a mantle 10 (corresponding to a crushing shell or crushing head mounted to the shaft 7 of Polinski) to a tapered mantle support portion 8 of the shaft 7.

59. Specifically, as I discussed in my original declaration (Ex. 2001, ¶31), 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.” (Ex. 1017, 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.) This arrangement is depicted below in FIG. 2 of Polinski.



(Ex. 1017, FIG. 2.)

60. Accordingly, as shown in FIG. 2 above, the sleeve is configured to secure the mantle 10 (corresponding to a crushing shell or crushing head) to the main shaft 7—Polinski’s sleeve 12 is configured such that when positioned on the shaft body, the shaft sleeve is not independent of a crushing head and a crushing shell.

61. Moreover, it would not have been obvious to modify Polinski in view of Piepho and Harless to include a sleeve that is configured such that, when positioned on the shaft body, it is independent of a crushing head and a crushing shell. 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. 1017, 1:44–47.) As discussed *supra*, Polinski’s sleeve 12 is configured to secure the crushing mantle 10 to the tapered

portion of the main shaft 7. (Ex. 1017, 3:1–9.) Modifying Polinski such that the sleeve 12 is independent of a crushing head and a crushing shell when positioned on the shaft body would change the principle of operation of Polinski's stated invention, and thus such a modification would not be obvious to a POSITA.

* * *

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.

15. (Substitute for claim 1, if found unpatentable) A gyratory crusher main shaft of a crusher comprising:

a shaft body having a radially outward facing external surface, and a first end and a second end;

an axial region of the shaft body extending from the second end and being tapered relative to a longitudinal axis of the shaft body such that a cross sectional area of the shaft body at the tapered axial region decreases in a direction from the first end to the second end;

a shaft sleeve mounted on the tapered axial region; [[and]]

~~at least one groove~~ a plurality of grooves indented at the external surface and positioned at the tapered axial region, the ~~at least one groove~~ plurality of grooves being arranged to receive a pressurized fluid to facilitate mounting and dismounting of the shaft sleeve at the shaft body, wherein the plurality of grooves comprise a first groove and a second groove, wherein the first groove is positioned closer to the second end relative to the second groove; and

a fluid inlet conduit extending axially from the second end and provided in fluid communication with the first groove, wherein the fluid inlet conduit extends internally within the shaft body only to the first groove, wherein the first groove and the second groove are coupled in fluid communication.

16. (Substitute for claim 2, if found unpatentable) The main shaft as claimed in claim 15, wherein the first groove is positioned on a first side of a cross-sectional area center of the shaft sleeve relatively closer to the second end and the second groove is positioned on a second side of a cross-sectional area center of the shaft sleeve relatively further from the second end ~~further comprising a fluid inlet conduit extending axially from the second end and provided in fluid communication with the at least one groove to allow a fluid to be supplied to the at least one groove from the second end.~~

17. (Substitute for claim 3, if found unpatentable) The main shaft as claimed in claim [[2]]16, wherein the first groove and the second groove are positioned at an equal distance from the cross-sectional area center of the shaft sleeve such that when the pressurized fluid is supplied to the first groove and the second groove, an expansion force is distributed substantially uniformly along the axial length of the sleeve ~~wherein the fluid inlet conduit extends internally within the shaft body such that a part of the fluid inlet conduit extends radially outward to the at least one groove.~~

18. (Substitute for claim 4, if found unpatentable) The main shaft as claimed in claim ~~[[3]]~~15, wherein the ~~at least one groove~~ plurality of grooves extend~~[[s]]~~ in a circumferential direction around the tapered axial region shaft body.

19. (Substitute for claim 5, if found unpatentable) The main shaft as claimed in claim ~~[[4]]~~18, wherein the ~~at least one groove~~ plurality of grooves extend~~[[s]]~~ substantially or completely circumferentially around the shaft body.

20. (Substitute for claim 8, if found unpatentable) The main shaft as claimed in claim ~~[[7]]~~15, wherein at least a part of the fluid inlet conduit is indented and extends axially at the external surface as a channel to couple the first and second grooves in fluid communication.

21. (Substitute for claim 9, if found unpatentable) A gyratory crusher main shaft assembly for a crusher comprising:

a shaft body having a radially outward facing external surface, and a first end and a second end, an axial region of the shaft body extending from the second end and being tapered relative to a longitudinal axis of the shaft body such that a cross sectional area of the shaft body at the tapered axial region decreases in a direction from the first end to the second end,

a shaft sleeve mounted on the tapered axial region, and at least one groove indented at the external surface and positioned at the tapered axial region, the at

least one groove being arranged to receive a pressurized fluid to facilitate mounting and dismounting of the sleeve at the shaft body, ~~and~~

wherein the [[a]] shaft sleeve is fitted over the tapered axial region, the shaft sleeve having a tapered wall thickness, such that the wall thickness at a second end of the shaft sleeve is greater than the wall thickness at a first end of the sleeve; and
an end retainer releasably mounted at the second end of the shaft body and having a perimeter region extending radially outward beyond the external surface at the tapered axial region, the perimeter region positioned to radially overlap the shaft sleeve at the second end of the sleeve to inhibit axial separation of the shaft sleeve from the shaft body, wherein the end retainer includes a recess extending circumferentially at the perimeter region to allow axial movement of the shaft sleeve into the recess, wherein the recess defines an annular gap between the end retainer and the second end of the shaft sleeve when an underside surface of the end retainer is positioned in contact with the second end of the shaft body.

22. (Substitute for claim 10, if found unpatentable) The assembly as claimed in claim [[9]]21, wherein the end retainer comprises a first plurality of bores distributed circumferentially around the end retainer and configured to align with a plurality of sleeve bores in the second end of the shaft sleeve such that the end retainer can be attached to the shaft sleeve ~~further comprising an end retainer releasably mounted at the second end of the shaft body and having a perimeter~~

~~region extending radially outward beyond the external surface at the tapered region, the perimeter region positioned to radially overlap the sleeve at the second end of the sleeve to inhibit axial separation of the sleeve from the shaft body.~~

23. (Substitute for claim 11, if found unpatentable) The assembly as claimed in claim ~~[[10]]~~22, wherein the end retainer comprises a surface opposite the underside surface of the end retainer configured to mate against the second end of the shaft sleeve when the end retainer is inverted, and wherein the end retainer is configured to force the shaft sleeve axially over the tapered axial region when a plurality of attachment members extending through a second plurality of bores in the end retainer and into a plurality of corresponding shaft bores in the second end of the shaft body are tightened ~~wherein the end retainer includes a recess extending circumferentially at the perimeter region to allow axial movement of the sleeve into the recess.~~

24. (Substitute for claim 12, if found unpatentable) The assembly as claimed in claim ~~[[9]]~~21, further comprising a fluid inlet conduit extending axially from the second end of the shaft body in fluid communication with the at least one groove to allow a fluid to be supplied to the at least one groove from the second end of the shaft body.

25. (Substitute for claim 13, if found unpatentable) The assembly as claimed in claim ~~[[9]]~~21, further comprising a fluid inlet conduit extending radially

through the wall thickness of the sleeve in fluid communication with the at least one groove to allow a fluid to be supplied to the at least one groove through the sleeve.

26. (Substitute for claim 14, if found unpatentable) A gyratory crusher comprising:

a main shaft including a shaft body having a radially outward facing external surface, 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,

an axial region of the shaft body extending from the second end and being tapered relative to a longitudinal axis of the shaft body such that a cross sectional area of the shaft body at the tapered axial region decreases in a direction from the first end to the second end, the tapered axial region being configured to mount a shaft sleeve;

a sleeve fitted over the tapered axial region, the sleeve having a tapered wall thickness such that a wall thickness at a second upper end of the sleeve is greater than a wall thickness at a first lower end of the sleeve; and

at least one groove indented at the external surface and positioned at the tapered axial region, the at least one groove being arranged to receive a pressurized fluid to facilitate mounting and dismounting of the sleeve at the shaft body,

wherein the shaft sleeve is configured such that when positioned on the shaft body,
the shaft sleeve is independent of a crushing head and a crushing shell.