

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

CMS CEPCOR LTD., and
CMS CEPCOR AMERICAS LLC,
Petitioner,

v.

SANDVIK INTELLECTUAL PROPERTY AB,
Patent Owner.

Patent No. 11,014,090

Inter Partes Review No. IPR2024-01381

PATENT OWNER RESPONSE

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PATENT OWNER'S EXHIBIT LIST

Exhibit #	Exhibit Description
2001	Declaration of Harri Kytömaa, PH.D.
2002	Curriculum Vitae and Publications of Dr. Kytömaa
2003	Richard G. Budynas & J. Keith Nisbett, <i>Shigley's Mechanical Engineering Design</i> , Ninth Edition (2011) (Chapter 3)
2004	Andrew W. Batchelor & Gwidon W. Stachowiak, <i>Engineering Tribology</i> , Second Edition (2001)
2005	Robert C. Juvinall & Kurt M. Marshek, <i>Fundamentals of Machine Component Design</i> , 3rd Edition (2000) (Chapter 9)
2006	Oscar J. Horger, <i>Metals Engineering Design</i> , First Edition (1953)
2007 [NEW]	Second Declaration of Harri Kytömaa, Ph.D.
2008 [NEW]	EP Application No. 13192402.9
2009 [NEW]	U.S. Application No. 15/035,774
2010 [NEW]	Third Declaration of Harri Kytömaa, Ph.D.
2011 [NEW]	Deposition Transcript of David Smith dated June 11, 2025
2012 [NEW]	Merriam-Webster's Collegiate Dictionary, 11th ed. (2012) (definition of "end")
2013 [NEW]	The Oxford English Dictionary, 2nd ed. (1989) (definition of "indented")

Exhibit #	Exhibit Description
2014 [NEW]	PCT Application No. PCT/EP2014/060594
2015 [NEW]	Richard G. Budynas & J. Keith Nisbett, <i>Shigley's Mechanical Engineering Design</i> , Ninth Edition (2011) (Chapter 8)
2016 [NEW]	John H. Bickford, <i>An Introduction to the Design and Behavior of Bolted Joints</i> , 3rd Edition (1995) (excerpts from Chapter 2)
2017 [NEW]	Robert C. Juvinall & Kurt M. Marshek, <i>Fundamentals of Machine Component Design</i> , 3rd Edition (2000) (excerpts from Chapter 10)

I. INTRODUCTION

Sandvik Intellectual Property AB (“Sandvik” or “Patent Owner”) submits this Patent Owner Response in response to the Petition (Paper 2) and the Decision on Institution (Paper 9). The Petition was filed by CMS Cepcor Ltd. and CMS Cepcor Americas LLC (collectively, “CMS” or “Petitioner”) requesting *inter partes* review of U.S. Patent No. 11,014,090 (the “’090 Patent”) (Ex. 1001).

The Petition seeks to cancel claims 1–14 of the ’090 Patent based on a combination of U.S. Patent No. 4,410,143 to Polinski (“Polinski”) (Ex. 1017) and U.S. Patent No. 6,270,026 to Piepho et al. (“Piepho”) (Ex. 1018) in view of U.S. Patent No. 2,840,399 to Harless et al. (“Harless”) (Ex. 1033). However, these references fail to anticipate or render obvious claims 1–14, and Petitioner’s asserted combination is fundamentally flawed.

First, Petitioner’s asserted combination of Polinski and Piepho fails to disclose or suggest “an axial region of the shaft body extending from the second end and being tapered relative to a longitudinal axis of the shaft body” as recited in all three independent claims. For this limitation, Petitioner relies on the combined teachings of Polinski and Piepho, neither of which disclose a tapered region *extending from the second end* of the shaft.

Second, Petitioner’s asserted combination of Polinski and Piepho fails to disclose or suggest “a sleeve fitted over the tapered axial region, the sleeve having

a tapered wall thickness, such that the wall thickness at a second end of the sleeve is greater than the wall thickness at a first end of the sleeve” as recited in independent claims 9 and 14. For this limitation, Petitioner relies on the combined teachings of Polinski and Piepho, neither of which disclose that the wall thickness *at a second end of the sleeve is greater than the wall thickness at a first end of the sleeve*.

Third, a POSITA would not be motivated to combine Harless with Polinski and Piepho to arrive at any of the claimed inventions. Petitioner asserts that it would have been obvious to incorporate an oil groove, as disclosed by Harless, into a gyratory crusher shaft of Polinski to assist with the mounting and removing of a sleeve that is fit to the shaft. There is, however, no motivation to make such a modification. Polinski is directed to mitigating shaft failure. Specifically, Polinski is directed to a joint between a gyratory crusher shaft and a crusher mantle in which geometrical discontinuities (threads) are removed from high stress regions near the top of the shaft (and instead placed in a sleeve) to prevent fatigue failure. Piepho, cited for its disclosure of a tapered bushing supporting a yoke, is directed to a coal pulverizer shaft designed to mitigate fretting induced bending fatigue. Piepho discloses an intervening material that is applied to the surface of a coal pulverizer shaft to reduce relative motion between the shaft and the yoke of the coal pulverizer. Given these express disclosures, a POSITA would not incorporate

an oil groove into the surface of a gyratory crusher shaft of Polinski as Petitioner urges. Such a groove would increase the likelihood of both fatigue failure and fretting wear, which Polinski and Piepho aim to prevent. Any benefits associated with the addition of a groove in Polinski would appear diminished in view of the existential risk of shaft failure—a risk that Mr. Smith, Petitioner’s expert, admitted is a “major concern.”

Fourth, Petitioner’s asserted combination of Polinski fails to disclose or suggest “[an] end retainer [that] includes a recess extending circumferentially at the perimeter region to allow axial movement of the sleeve into the recess.” For this limitation, Petitioner relies on the combined teachings of Polinski, Piepho, and Harless, none of which disclose an end retainer that includes a recess extending circumferentially at the perimeter region to allow axial movement of the sleeve into the recess. Petitioner’s entire mapping rests on identifying a recess in Harless that Mr. Smith, on cross-examination, was not sure he could identify.

For at least these reasons, as detailed below and supported by the declarations of Dr. Harri Kytömaa (Ex. 2001 (Kytömaa I) & Ex. 2007 (Kytömaa II)), Sandvik requests that the Board find the challenged claims not unpatentable.

II. THE ’090 PATENT

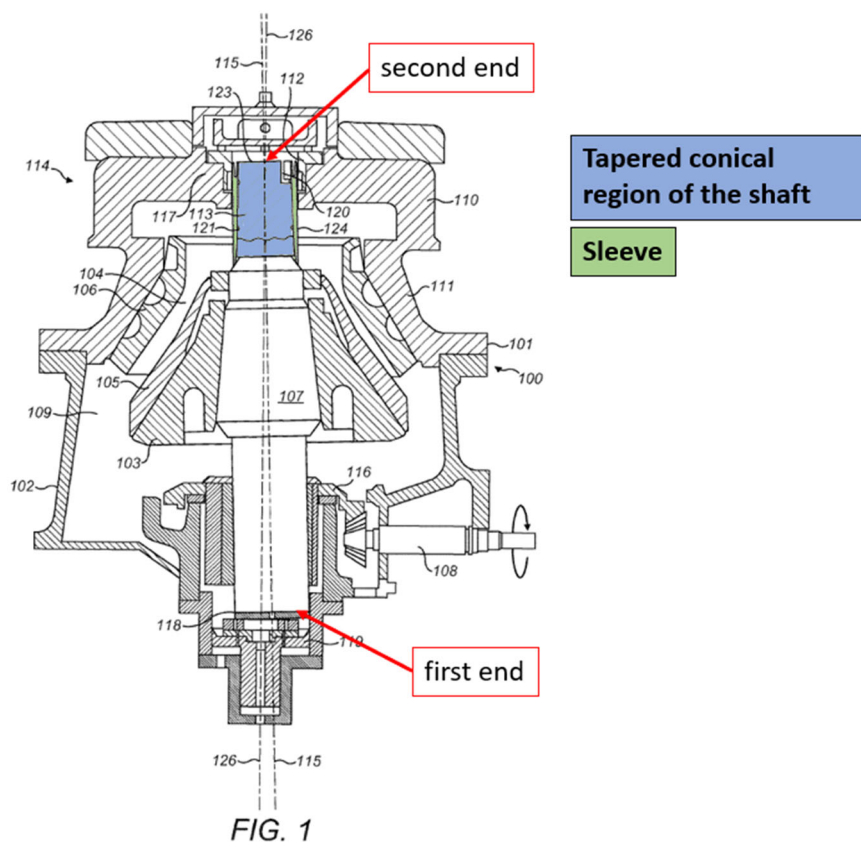
A. Background

Gyratory crushers are used for crushing ore, mineral, and rock material into

smaller sizes. (Ex. 1001, 1:1–2.) The '090 Patent describes, among other things, a gyratory crusher main shaft assembly which includes “a main shaft, an axially upper region of the main shaft including a tapered conical section with a protective sleeve friction fitted over the cone” and “at least one groove indented within a radially external facing surface of the main shaft at the region of the cone”

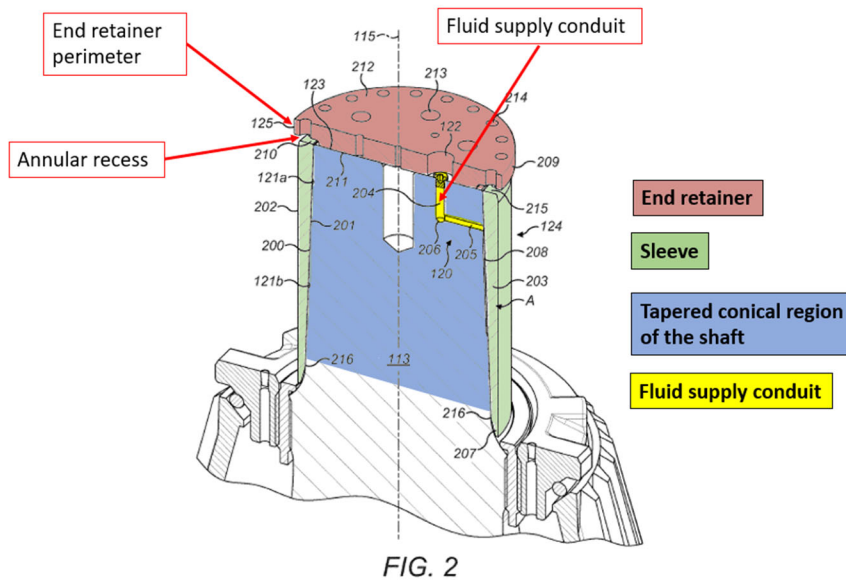
(*Id.*, Abstract; 1:63–66, 2:10–19.) The gyratory crusher main shaft assembly enables efficient mounting and dismounting of the protective sleeve using both (1) a tapered interference fit between the main shaft and the protective sleeve and (2) the at least one groove or channel indented on an outward facing external surface of the shaft configured to receive a pressurized fluid. (*Id.*, 2:46–58.)

Annotated Figure 1 of the '090 Patent below shows a main shaft 107 positioned within a gyratory crusher. The shaft 107 has a first end positioned at a bottom end of the crusher and a second end positioned at the top end of the crusher, as shown in the figure below. A tapered region 113 (blue) of the shaft 107 extends from the second end of the shaft 107 toward the first end of the shaft 107.



In annotated Figure 1 above and Figure 2 below, a protective sleeve 124 (green) is shown mounted to the tapered region 113 of the shaft 107. (*Id.*, 5:25–51.) The protective sleeve 124 comprises an inward facing surface 201 that has a tapered conical profile corresponding to a tapered conical profile of the main shaft tapered region 113. (*Id.*) A fluid supply conduit 120 may connect to a groove 121a, which is indented into the shaft and extends circumferentially around the tapered region 113. (*Id.*, 5:22–25; 6:24–31.) A fluid can be delivered to the groove 121a to lubricate the interface between an outer surface 200 of the shaft 107 and the inward facing surface 201 of sleeve 124. (*Id.*, 6:54–62.) Figure 2 also

shows an additional groove 121b coupled in fluid communication with groove 121a via an axially extending groove or channel 208. The oil grooves, along with the tapered surfaces of the shaft and sleeve, promote efficient mounting and dismounting of the sleeve to the main shaft. (*Id.*, 2:46–59.)



Also shown in annotated Figure 2 (above) is an end retainer 125. The end retainer 125 is releasably mounted at shaft end surface 123 (the second end of the shaft body). (*Id.* 5:56-57.) End retainer 125 includes an annular recess 210 that extends circumferentially around a retainer perimeter 209 and is indented in an underside surface 211 of the end retainer so as to create an axially and radially extending annular gap immediately axially above the annular sleeve end 215. (*Id.* 6:9-14.)

Annotated Figure 3 of the '090 Patent, shown below, depicts the shaft with

the protective sleeve removed. (*Id.*, 4:34-35.) This figure shows grooves 121a and 121b more clearly, depicting how the grooves are coupled in fluid communication with one another via the axial groove or channel 208.

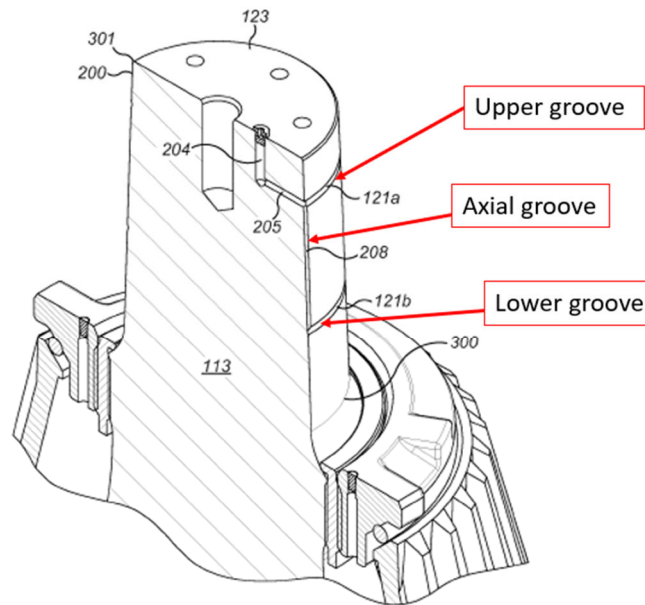


FIG. 3

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

As also illustrated in Figure 3 above, the radial taper of tapered region 113 may be uniform along the axial length between uppermost end 301 and lowermost end 300 of the tapered region 113 of the shaft. (*Id.*)

B. Summary Of The Challenged Claims And File History

Petitioner challenges claims 1–14 of the '090 Patent. (Paper 2, 1–2.)

Claims 1, 9, and 14 are independent claims as shown below with limitations indicated with alpha-numeric designations:

[1pre] A gyratory crusher main shaft of a crusher comprising:

[1a] a shaft body having a radially outward facing external surface, and a first end and a second end;

[1b] 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;

[1c] a shaft sleeve mounted on the tapered axial region; and

[1d] 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.

[9pre] A gyratory crusher main shaft assembly for a crusher comprising:

[9a] a shaft body having a radially outward facing external surface, and a first end and a second end,

[9b] 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,

[9c] a shaft sleeve mounted on the tapered axial region, and

[9d] 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 pressurised fluid to facilitate mounting and dismounting of the sleeve at the shaft body; and

[9e] a sleeve fitted over the tapered axial region, the sleeve having a tapered wall thickness, such that the wall thickness at a

second end of the sleeve is greater than the wall thickness at a first end of the sleeve.

[14pre] A gyratory crusher comprising;

[14a] 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;

[14b] 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

[14c] 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 pressurised fluid to facilitate mounting and dismounting of the sleeve at the shaft body.

Importantly, limitations [1d], [9d], and [14c] require that the “at least one groove” be “indented at the external surface [of the shaft body] and positioned at the tapered axial region.” As discussed *infra*, Petitioner introduces Harless into its combination to meet limitation [1d] (and the corresponding limitations in independent claims 9 and 14). (Paper 2, 18–21.) This limitation was a basis for the allowance of the issued claims during the original examination.

The Examiner rejected claims 1–14 under 35 U.S.C. § 102(a)(1) as

anticipated by Johnson (Ex. 1041). (Ex. 1001-1, Non-Final Office Action, dated September 25, 2018, 4–5.) In addition, the Examiner rejected the claims under 35 U.S.C. § 103 as obvious over Applicant Admitted Prior Art in view of Johnson. (*Id.*, 5–6.) According to the Examiner, Patent Owner had admitted the original limitations corresponding to limitations [1a]-[1c] above were known and that Johnson disclosed the “at least one groove indented at the external surface arranged to receive a pressurized fluid.”¹ (*Id.*)

In response to the anticipation and obviousness rejections, Patent Owner quoted the limitations of claim 1 and 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.)

Patent Owner explained that “the groove 121 indented specifically at the

¹ The Examiner relied on lines 2-9 of claim 1 as filed for her assertion of Applicant Admitted Prior Art. (Ex. 1001-1, Non-Final Office Action, dated September 25, 2018, 4–6.) Patent Owner did not—and does not—accept that the cited limitations are admitted prior art. The use of “characterized in that” is typical of European prosecution and does not mean an admission of prior art.

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.”² (*Id.*)

Patent Owner then argued that Johnson failed to disclose or suggest (1) a main shaft having a tapered upper end with a groove indented into the tapered region of the main shaft, and (2) a sleeve fitted over the tapered axial region of the main shaft. (*Id.*, 7–8.) With respect to the obviousness rejection, Patent Owner emphasized that Johnson failed to disclose, *inter alia*, limitation [d] for which the Examiner relied upon Johnson only.

The Examiner allowed the application. In her reasons for allowance, she indicated that “a review of the claims and the applicant’s argument indicates the claims distinguish over the prior art of record.” (Ex. 1001-1, March 25, 2019 Notice of Allowance, 2.)

In the Petition, Petitioner repeatedly argues that the original examination failed to consider another Sandvik patent publication—WO 2014/019765 to Aberg et al. (Ex. 1016)—and thus was an incomplete examination. (Paper 2, 1–2, 9.) This assertion is meritless. Aberg is not prior art at least because of 35 U.S.C. §

² All emphases are added in this Paper unless otherwise noted.

102(b)(2)(C). Indeed, Petitioner conspicuously does not present any ground based on Aberg in its Petition, thereby demonstrating that Aberg was irrelevant to the original examination and to the Petition. Thus, contrary to Petitioner’s assertion, the examination of the ’090 Patent was robust rather than incomplete, with over 25 references considered before allowance by an experienced Examiner. As discussed below, the challenged claims are also patentable over the new references in the Petition.

III. LEVEL OF ORDINARY SKILL IN THE ART

Petitioner contends that “a person having ordinary skill in the art [POSITA] would be a person who has a bachelor’s degree in mechanical engineering or a related field, and at least 2 years of experience with industrial equipment design and development.” (Paper 2, 3; *see also* Ex. 2011, 38:25–39:24 (Mr. Smith testifying that the two years of experience is not limited to rock crushers and that “industrial equipment” is a “broad category”).) This 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.” (*Id.*; *see also* Ex. 2011, 49:3–7.) For the purposes of this Motion, Sandvik does not object to the defined level of skill in the art. (Paper 2, 3.)

Sandvik’s technical expert, Harri Kytömaa, Ph.D., readily meets this definition. He has a Ph.D in Mechanical Engineering. (Ex. 2001, ¶ 5; Ex. 2007, ¶

16.) And, unlike Mr. Smith who has no experience designing and developing rock crushers (Ex. 2011, 39:8–10), Dr. Kytömaa’s research at MIT focused on, among other things, comminution and methods of efficient particle size reduction through crushing, and he has designed coal handling equipment including crushers. (Ex. 2001, ¶¶ 7, 11; Ex. 2007, ¶¶ 16–17.)

The level of skill here supports the patentability of the challenged claims. (Ex. 2007, ¶ 17.) As discussed *infra*, a POSITA would not have been motivated to modify Polinski, Piepho, and Harless to meet the claimed inventions. 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 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.)

IV. CLAIM CONSTRUCTION

The Board construes claims under *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005) (en banc), with claim terms given their plain and ordinary meaning unless otherwise noted. For the purposes of this Response, Patent Owner does not believe any terms require formal construction other than “end” and “indented at the external surface.”

A. “end”

The term “end” is an element used in each independent claim of the ’090 Patent. (Ex. 1001.) Challenged independent claims 1, 9, and 14 refer to “a first end and a second end” of a shaft body. Challenged dependent claim 2 also refers to “a fluid inlet conduit extending axially from the second end [of the shaft body].” Challenged claims 9 and 14 additionally refer to “a first end of [a] sleeve” and “a second end of [a] sleeve.” Patent Owner submits that the proper construction of “end” is an extremity of a shaft body or sleeve under its plain and ordinary meaning. Patent Owner’s proposed construction is consistent with the claim language, the specification of the ’090 Patent, and a common dictionary definition.³ (Ex. 2007, ¶¶ 21–32.)

³ This construction is also consistent with the Board’s understanding of Patent Owner’s position in the Decision on Institution. (Paper 9, 14–15 (“Patent Owner appears to assume that ‘extending from the second end’ in limitation 1b requires the tapered axial region to include a taper that extends *all the way to the outermost extremity at the end of the shaft*. While we may ultimately agree with Patent Owner’s implicit position, we are reluctant to reach that conclusion without a proposed express construction to that effect from Patent Owner and after considering responsive argument and evidence from Petitioner.”).)

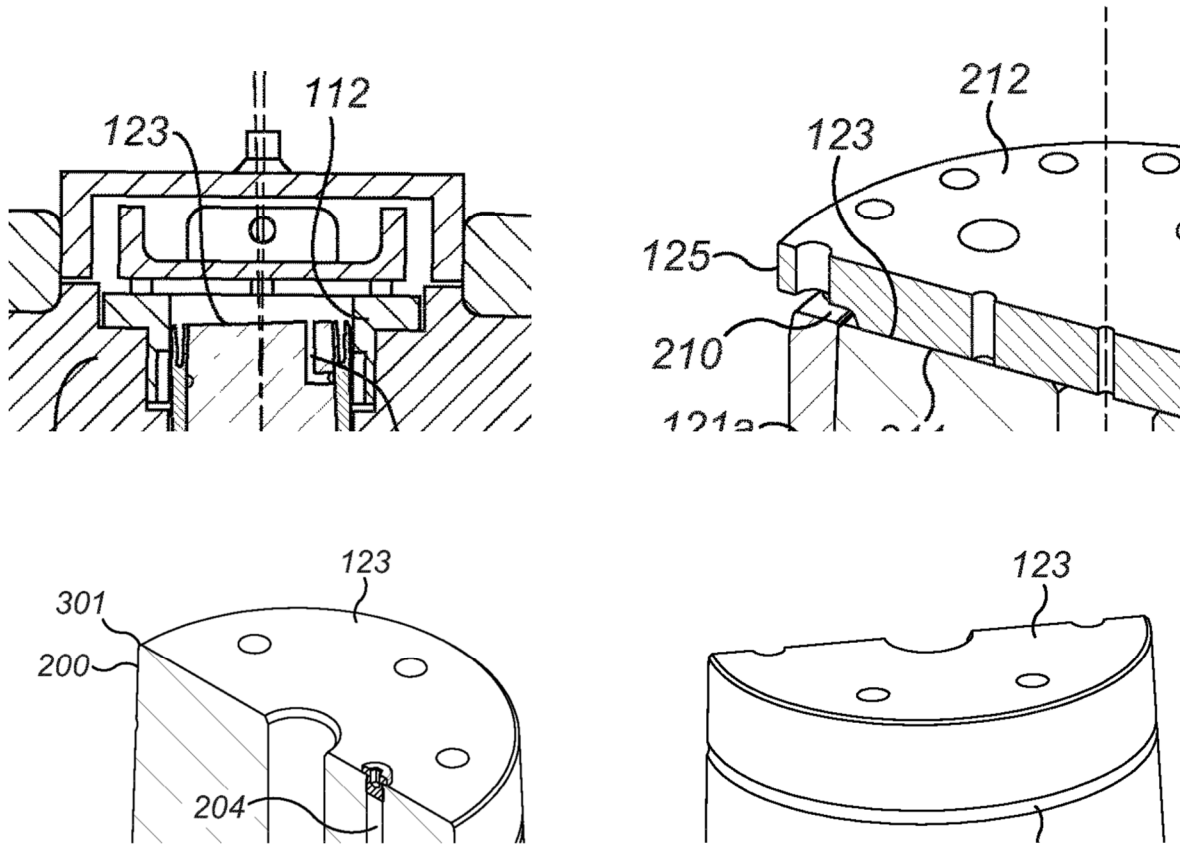
1. The claim language supports Patent Owner's construction of "end"

Claims 1, 9, and 14 recite a shaft body having a "second end" and "an axial region of the shaft body *extending from the second end*." The most natural reading of this claim language is that the axial region *extends* from a starting point or originating point, *i.e.*, the outermost extremity of the shaft body. Dependent claim 2 support 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." Claims 1 and 2 thus require 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. (Ex. 2007, ¶ 23.)

2. The specification supports Patent Owner's construction of "end"

In the Decision on Institution, the Board stated that "the specification arguably supports Patent Owner's implicit reading of the limitation by showing a taper that does extend to the outermost extremity of the shaft." (Paper 9, 15.) Not only does the specification show a taper that extends to the outermost extremity of

the shaft body, but every single figure of the shaft body in the '090 Patent illustrates the tapered axial region extending from the outermost extremity (end surface 123):

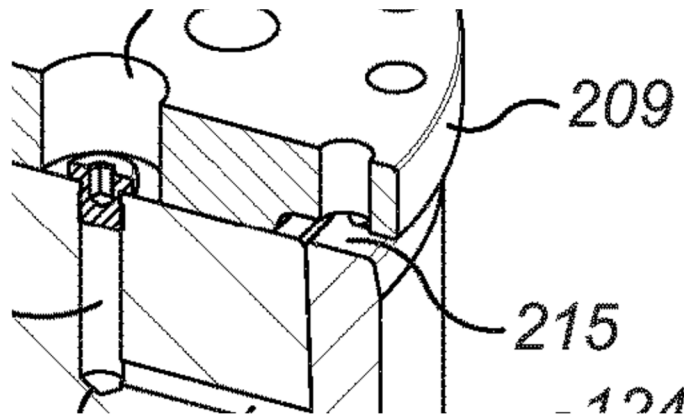


(Ex. 1001, FIGS. 1–4.) In all these figures, the end surface 123 of the shaft body is illustrated as the outermost extremity of the shaft body. (Ex. 2007, ¶¶ 24–25.)

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.) Thus, the specification of the

'090 Patent describes that the radial thickness of the sleeve decreases from the uppermost end to the lowermost end of the sleeve. This aligns with the limitations of claims 9 and 14, 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.” (Ex. 2007, ¶ 26.)

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:



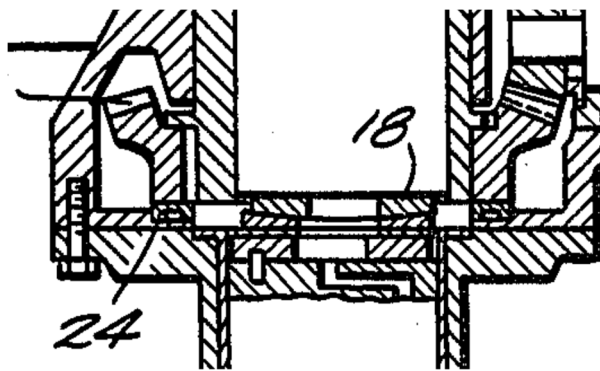
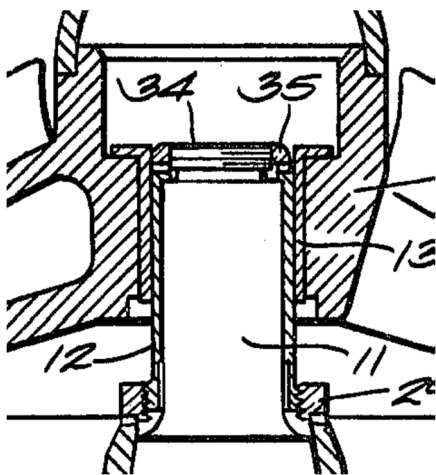
(Ex. 1001, FIG. 2.) To be sure, the '090 Patent illustrates the lowermost end 216 at a chamfer region 207. (FIG. 2; *see also* Ex. 1001, 5:52–55.) But chamfers and fillets are extremely common features often positioned at the outermost edges of objects, for instance, to reduce stress concentrations and ease assembly of components. The disclosure is thus still consistent with the lowermost end 216 being at an extremity of the sleeve. (Ex. 2007, ¶¶ 27–28.)

3. A common dictionary definition supports Patent Owner’s construction of “end”

Merriam-Webster’s Collegiate Dictionary (2012) provides that a definition of end is “the extreme or last part lengthwise: TIP.” (Ex. 2012, 411 (definition 1c).) 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. (Ex. 2007, ¶ 29.)

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

Mr. Smith, Petitioner’s expert, provided direct (and surprising) testimony that “end” could be near the middle of an object, such as a sleeve. (*See, e.g.*, Ex. 1002, 79.) But, 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.)



(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; Ex. 2007, ¶¶ 30–31.)

5. Piepho’s use of the term “end” cannot override the intrinsic evidence of the ’090 Patent

Finally, 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.) As an initial matter, Piepho assigns no 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,” Piepho’s use of the term should not be used to override at least the intrinsic evidence of the ’090 Patent. As set forth *supra*, 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. (Ex. 2007, ¶ 32.)

B. “indented at the external surface”

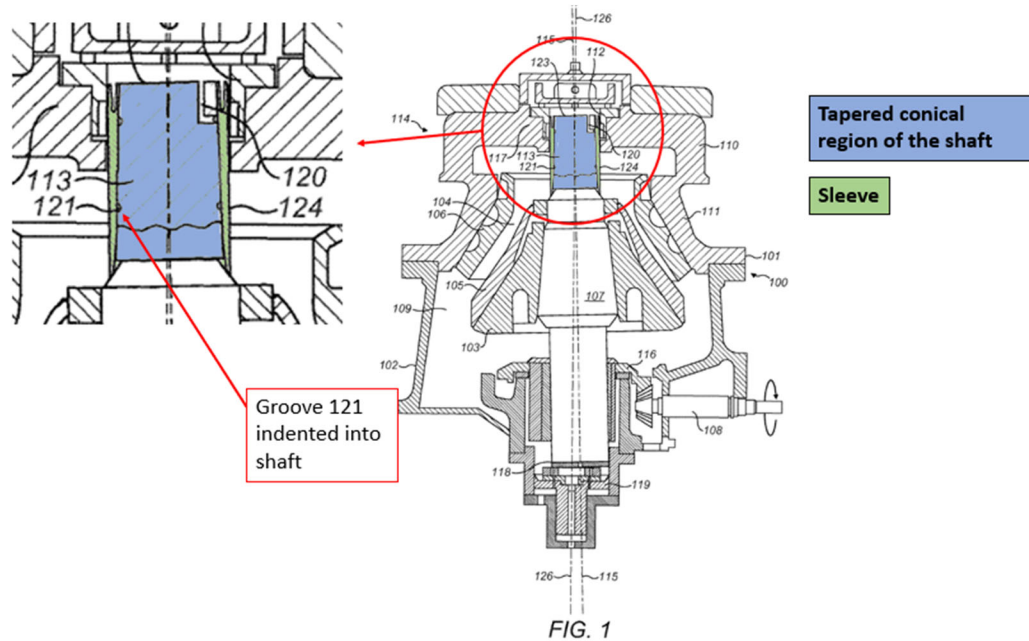
The phrase “indented at the external surface” is an element used in each independent claim of the ’090 Patent. (Ex. 1001.) Challenged independent claims 1, 9, and 14 refer to “at least one groove indented at the external surface and

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. (Ex. 2007, ¶¶ 33–39.)

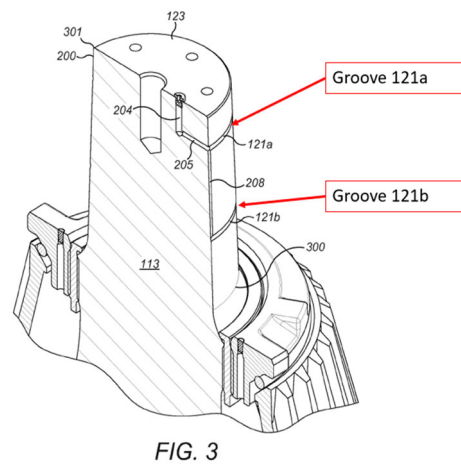
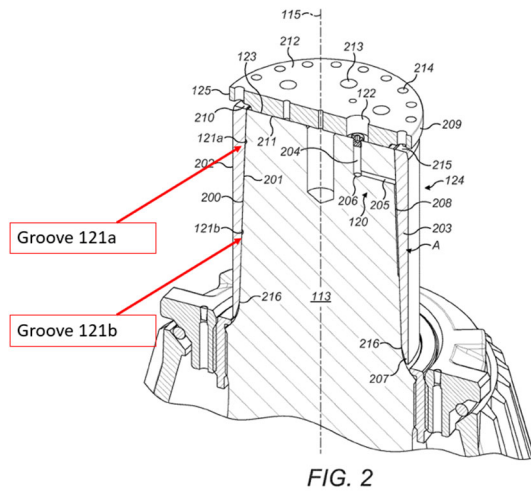
1. The specification supports Patent Owner’s construction of “indented at the external surface”

Beginning with the abstract, the ’090 Patent is unambiguous—the “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.)

The Detailed Description section and each figure of the ’090 Patent are likewise consistent. 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.



FIGS. 2–4 (annotated below) of the '090 Patent also illustrate two grooves (121a and 121b) indented (as a depression or recess in a surface) into the external facing surface of the shaft body at the tapered axial region 113.



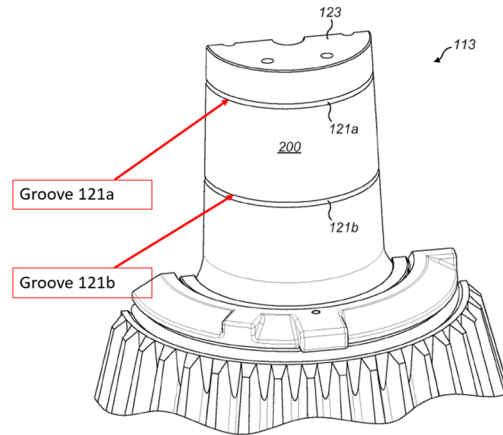


FIG. 4

Thus, 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. (Ex. 2007, ¶¶ 34–36.)

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

As discussed *supra*, in response to the anticipation and obviousness rejections during examination, Patent Owner 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.)

Patent Owner 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.) Patent Owner 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, 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. (Ex. 2007, ¶ 37–38.)

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

Finally, the Oxford English Dictionary 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 thus supports Patent Owner’s construction of “indented at the external surface” as a depression or recess in the external surface of the shaft body. (Ex. 2007, ¶ 39.)

V. THE ASSERTED PRIOR ART REFERENCES

A. Polinski (Ex. 1017)

Polinski is directed to a gyratory crusher main shaft and bearing sleeve

arrangement. (Ex. 1017, 1:44–47.)⁴ Polinski teaches that conventional gyratory crusher shafts typically include a threaded section on the shaft for securing the mantle (the portion used to crush rock) to the shaft. (*Id.*, 1:10–20.) Gyratory crusher shafts are subjected to high stresses resulting from cyclic bending loads, according to Polinski. (*Id.*, 1:20–37.) It teaches that the threaded portions cut into the shaft result in stress concentrations that increase the chance of shaft failure:

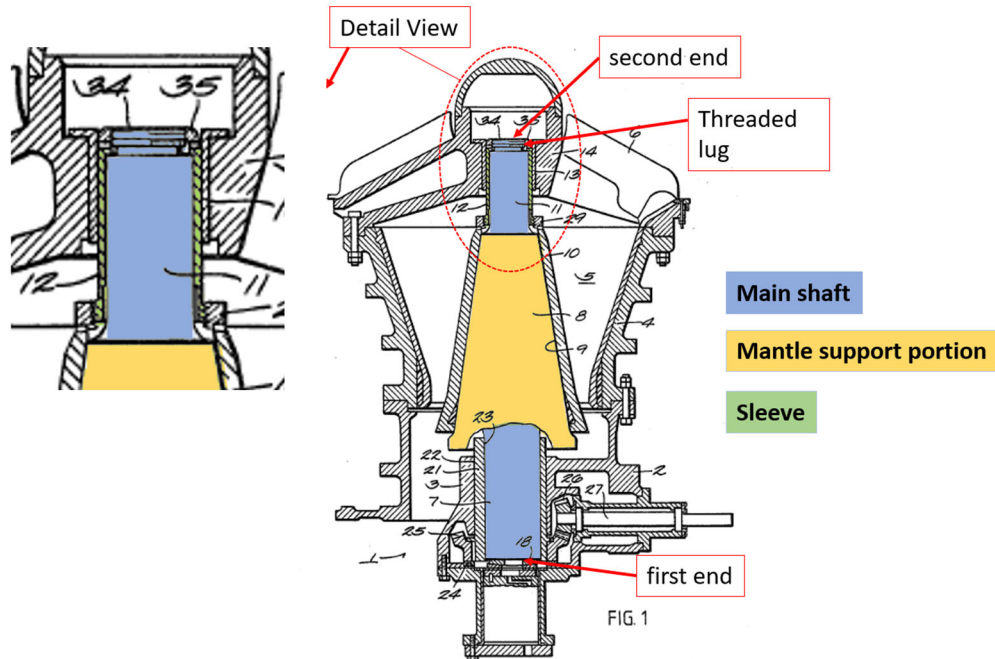
While this type of arrangement [threads cut into the shaft] has proven to be satisfactory for most crusher installations, experience has indicated that the relatively abrupt changes in the cross-sectional area of the shaft above and below the threaded section have resulted in high local stress concentrations 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**

⁴ Unless otherwise indicated, all citations in this Patent Owner Response and Kytömaa I and II refer to the original pagination of the exhibits being cited.

service and the shaft replaced before crushing operations can be resumed. (*Id.*, 1:20–37.)

Polinski teaches that “the 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.*, 1:60–68.)

As illustrated in the annotated version Figure 1 of Polinski below, a gyratory crusher shaft 7 (blue) includes a first end, a second end, and a mantle support portion 8 (yellow). (*Id.*, 2:30–47.) A cylindrical journal 11 is positioned near the second end of the shaft 7. (*Id.*) Above the cylindrical journal 11, shaft 7 includes a threaded lug that extends to the top end and is adapted to receive a sleeve nut 35 of a bearing sleeve 12. (*Id.*, 3:15–47.)



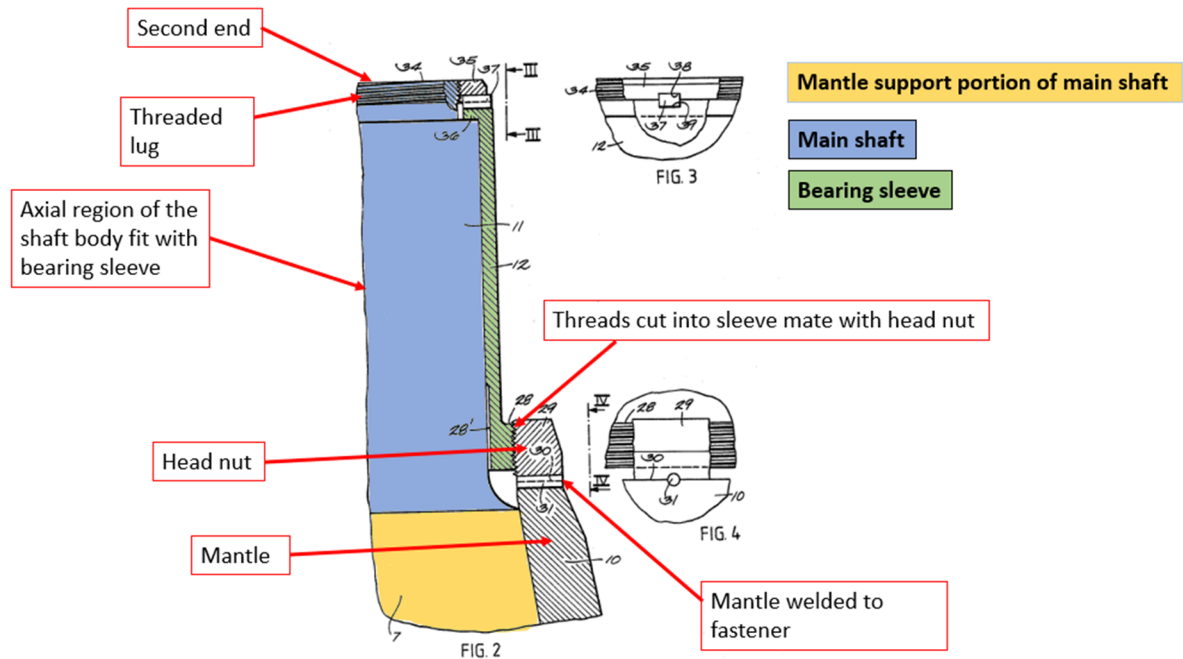
(*Id.*, FIG. 1 (cropped and annotated).)

The bearing sleeve 12 (green) is fitted onto the cylindrical journal 11 of the gyratory crusher shaft 7. (*Id.*, 2:30–47.) Polinski discloses that “the direction of the threading on the lug 34 and the sleeve nut 35 is such that the sleeve nut is essentially self-tightening,” preventing excessive rotation of the sleeve on the shaft. (*Id.*)

Polinski does not disclose that external facing surface of the journal 11 of shaft 7 includes a taper extending from the second end of the shaft. Neither does Polinski disclose that sleeve 12 includes a taper or that it is mounted to a tapered region of the shaft 7. Finally, Polinski does not disclose a groove indented at the external surface of the shaft 7 and positioned at a tapered region of the shaft 7.

Petitioner agrees with these deficiencies of Polinski, given its reliance on Piepho and Harless in the Petition. (Paper 2, 16, 18–21.)

FIG. 2 below depicts additional detail of the journal 11 and sleeve 12.



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

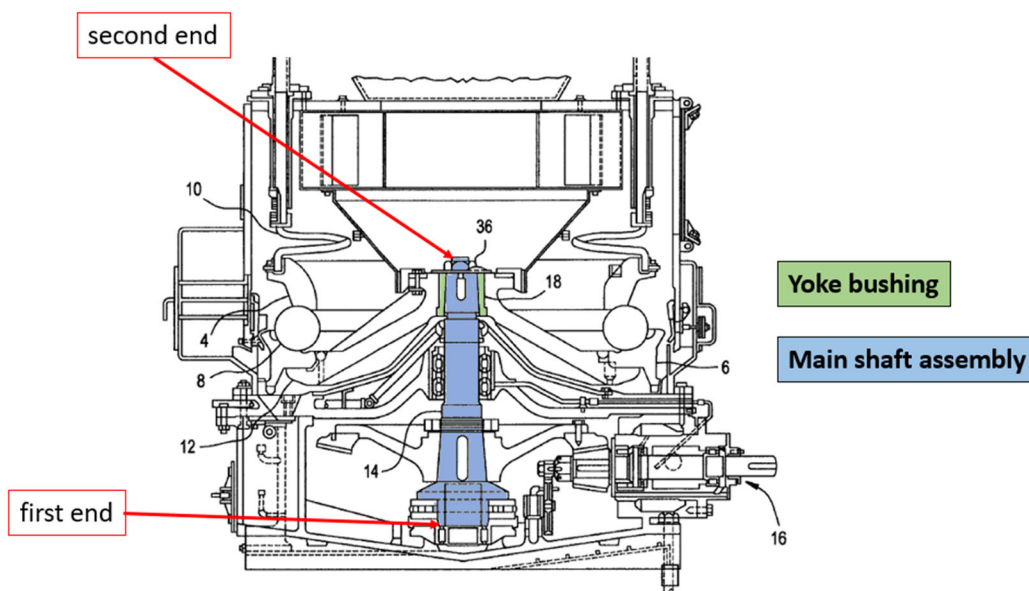
As illustrated above, Polinski teaches that a threaded shoulder 28 is provided on a bearing sleeve 12. (*Id.*, 2:67–68; 3:1–10.) The threaded shoulder 28 is configured to receive a head nut 29 that abuts the upper end of the mantle 10 to secure the mantle to the bearing sleeve 12. (*Id.*) Thus, the threading is not cut into the shaft to secure the mantle to the shaft. Instead, it is provided on the threaded shoulder 28 of the bearing sleeve. Journal 11 thus omits any abrupt changes in the

cross-sectional area of the shaft in high stress regions to avoid fatigue crack initiation. (*See id.*, 1:60–68.)

B. Piepho (Ex. 1018)

Piepho discloses a main shaft for a coal pulverizer. (Ex. 1018, 2:55–57.)

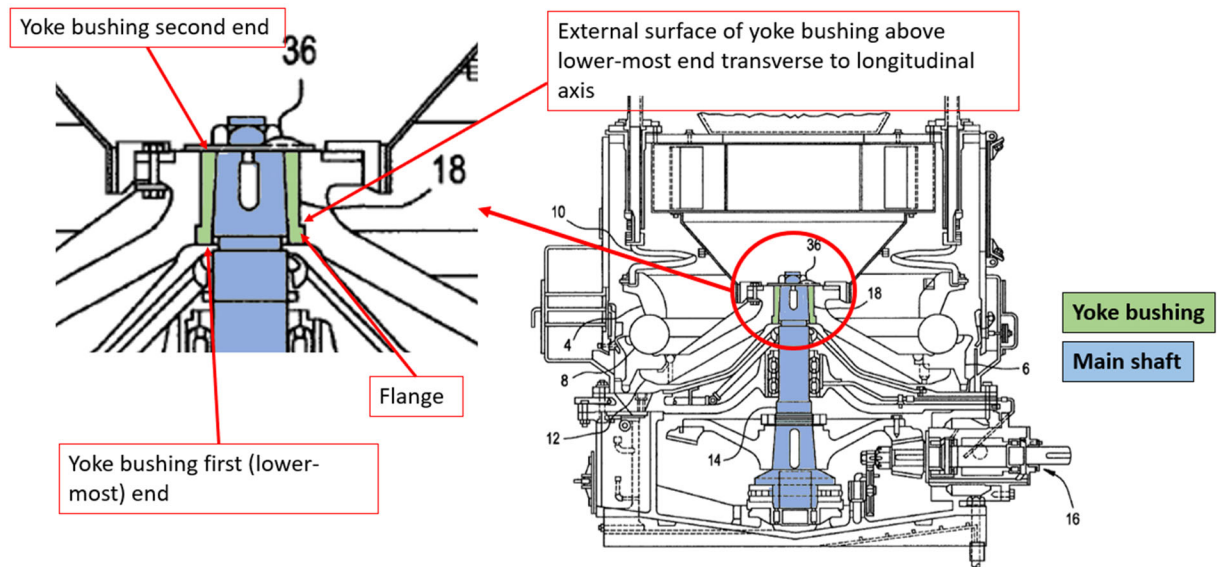
Annotated Figure 1 of Piepho, shown below, illustrates an example of a coal pulverizer assembly including a main shaft 14 (blue) fitted with a yoke bushing 18 (green). (*Id.*, 1:45–50.)



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

Piepho discloses a flange extending from the lowermost end of a yoke bushing 18 that results in a region of increased thickness near the bottom end of the yoke bushing, as shown below in FIG. 1. The flange supports the yoke 12 of the coal pulverizer. (Ex. 2007, ¶ 47.) Petitioner agrees that the flange acts as a

structural support in the related IPR proceeding. (See IPR2024-01380, Paper 2, 31–32 (Petition referring to Mr. Smith’s declaration that the flange “provide[s] a shoulder bearing surface which can transmit axial loads.”).)



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

Piepho is directed to techniques for mitigating shaft failure induced by fretting wear. Specifically, Piepho discloses that its purported invention resides in a main shaft for a coal pulverizer designed to reduce shaft failure due to fretting induced bending fatigue. (*Id.*, 2:55–58.) Piepho, similar to Polinski, teaches that fretting wear, stress concentrations, and cyclic loading can lead to fatigue failure, as follows:

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.*, 1:50–60.)

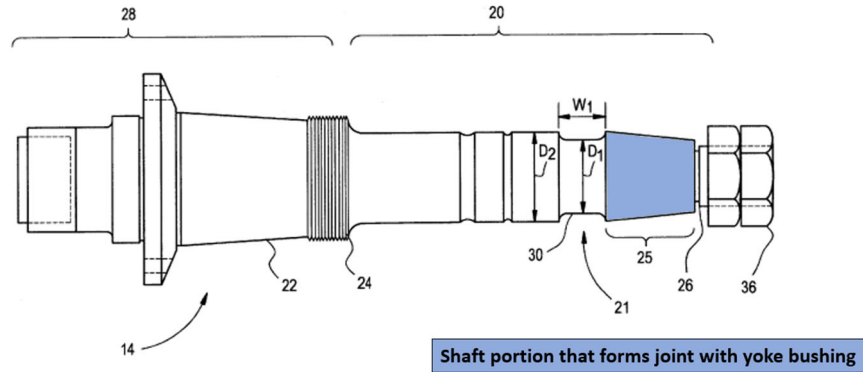
Piepho teaches that shaft failures occur most likely as the result of deterioration of the finely machined shaft surfaces within a joint between the shaft and the bore of the yoke. (*Id.*, 3:12–23.) Piepho further teaches that remedial efforts, including employing an anti-seize compound at a tapered joint, using a bushing with an undercut center portion, using full contact bushings with no undercut center portion, shot peening, and nitriding to harden surfaces have failed to prevent such failure. (*Id.*, 1:66–67; 2:1–13.) Finally, Piepho teaches that 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.*)

To mitigate such shaft failures, Piepho discloses coating a portion of the main shaft with an intervening material. (*Id.*, 3:23–35.) The intervening material reduces local stresses in the shaft by reducing the relative movement between the shaft and the yoke. (*Id.*, 2:19–25.)

The portion (25) of the shaft forming the joint with the yoke bushing 18 may be tapered, as shown in Figure 3 of Piepho below, or cylindrical, as shown in

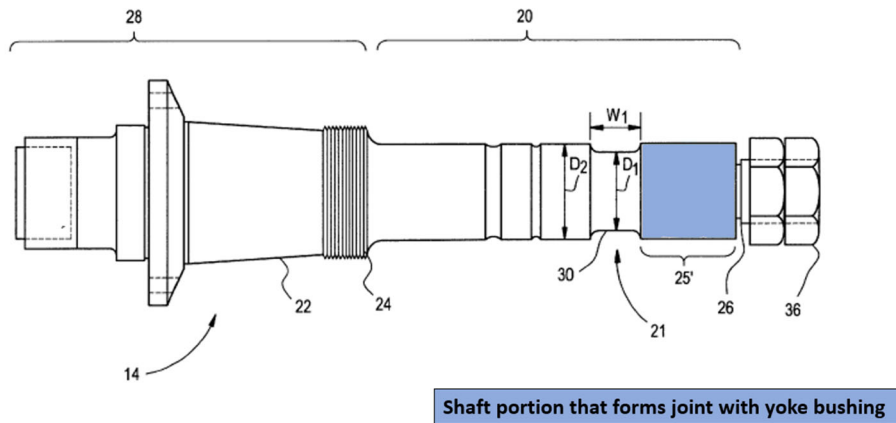
Figure 4 of Piepho below.

FIG.3



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

FIG.4



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

As illustrated in the above figures, the tapered portion 25 of the shaft does not extend from the second (top) end of the shaft. Instead, a cylindrical portion

labeled 26 extends from the second (top) end of the shaft between the second end and the portion labeled 25 configured to be fit with a yoke bushing. A POSITA would understand that the cylindrical portion 26 is configured such that a corresponding fastener component 36 can be attached to secure the yoke to the shaft, as depicted in FIG. 1, shown above. (Ex. 2001, ¶ 62.)

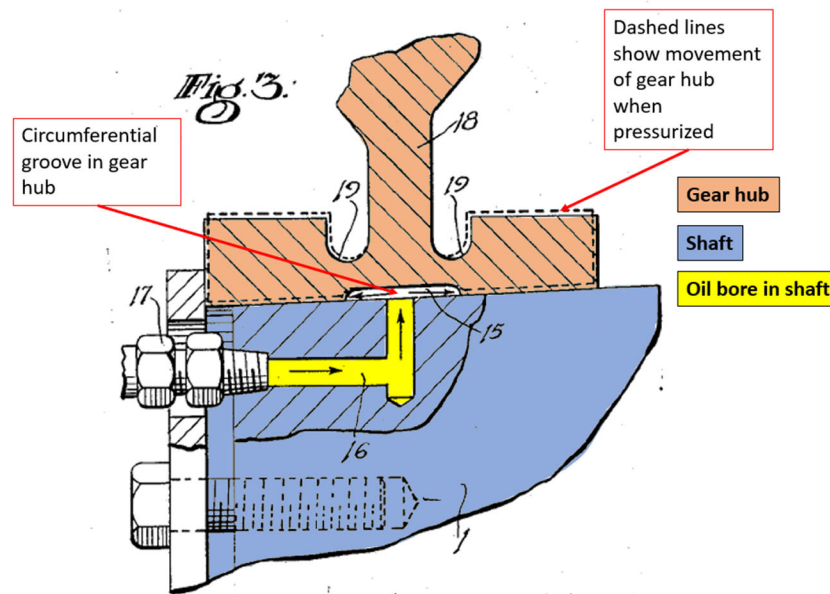
C. Harless (Ex. 1033)

Harless is directed to improvements in the attachment of gears and similar members to shafts. (Ex. 1033, 1:14-24.) In particular, Harless discloses methods and devices for shrink fitting gears and similar members on tapered shafts. (*Id.*)

Harless discloses:

It is an object of the invention to provide for the attachment of a gear or other drive member to a tapered shaft, by expanding certain portions of the hub of the gear, while avoiding the excess pressure necessary to expand the web or any other radially extending part of the gear. (*Id.*, 1:30–34.)

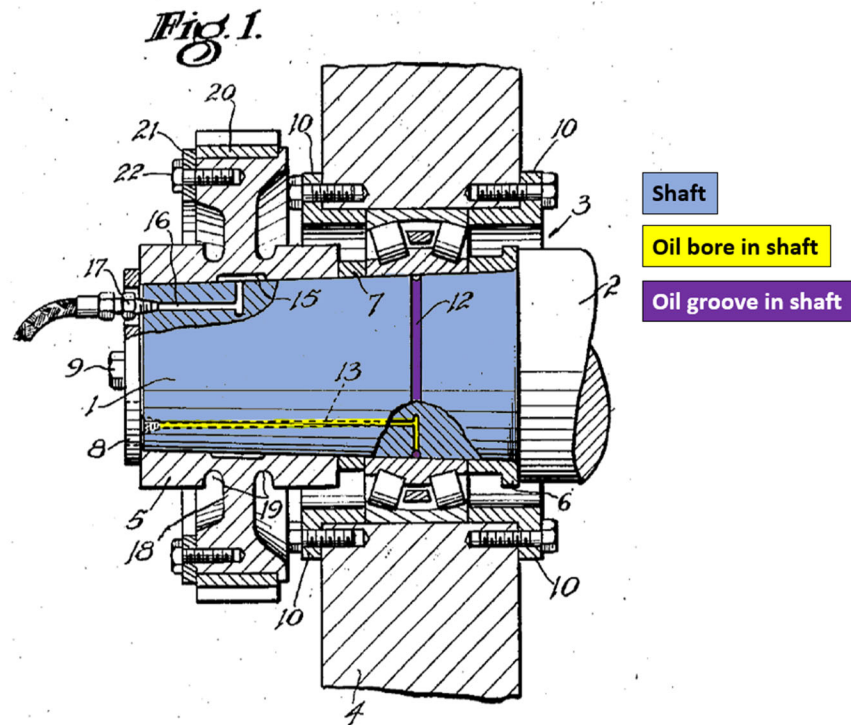
The purported invention disclosed by Harless reduces the amount of pressure needed to push a gear hub radially away from the shaft to dismount the gear, as illustrated in the annotated version of FIG. 3 of Harless below. (*Id.*, 1:30–34.)



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

An oil groove 15 radially aligned with the web 18 (orange) is indented into the gear hub and extends circumferentially. (*Id.*, 2:32–43.) Oil is provided to the groove 15 via a bore 16 (yellow) in the shaft (blue). (*Id.*, 2:32–51.) When a sufficiently high pressure is achieved, the gear hub bends at grooves 19 on either side of web 18 to lift the gear hub from the shaft, allowing it to be installed or removed. (*Id.*) The grooves 19 thus reduce the amount of pressure required to remove the gear hub from the shaft (relative to pushing the web 18 radially outward).

Harless also discloses a single oil groove indented into a tapered end of a shaft 1, as shown in FIG. 1 provided below.

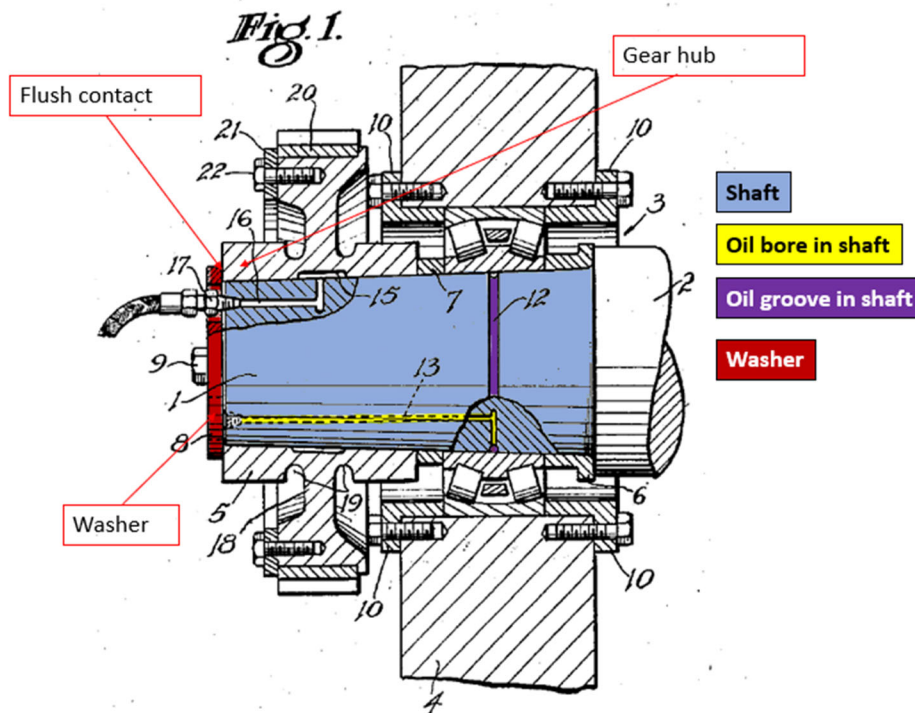


(Id., FIG. 1 (annotated).)

Harless teaches that oil under pressure is introduced into circumferential groove 12 (purple) through a bore 13 (yellow), expanding the bearing sufficiently to permit it to be pushed up against the spacer 6, by conventional means. (*Id.*, 2:19-27.) Thus, the circumferential groove 12 is used to mount a bearing to the shaft (blue).

Harless discloses a washer 8 positioned 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. Nothing in Harless discloses that the washer 8 includes a recess extending circumferentially at the perimeter region to allow axial movement of the shaft

sleeve into the recess.



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

VI. RESPONSE TO CHALLENGE

A. Summary Of Petitioner's Sole Ground

Petitioner alleges that claims 1–14 are unpatentable as obvious based on the combination of Polinski and Piepho in view of Harless. (Paper 2, 11.) Petitioner’s assertions with respect to independent claims 1, 9, and 14, and dependent claim 11, are summarized below.

1. Claim 1

Petitioner asserts that Polinski and Piepho both disclose “a shaft body having

a radially outward facing external surface, and a first end and a second end,” as recited in limitation [a] of claim 1. (Paper 2, 14.)

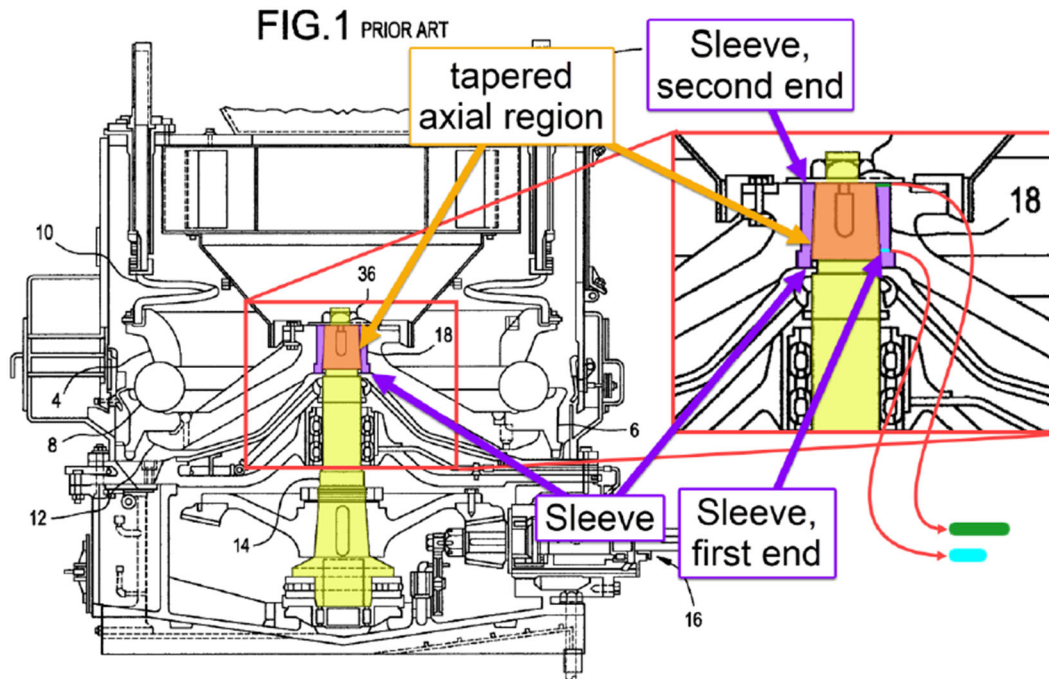
For limitations [b] and [c], Petitioner relies on the combination of Polinski and Piepho, asserting that Piepho discloses “an axial region of the shaft body extending from the second end and being tapered relative to a longitudinal axis of the shaft body such that a cross sectional area of the shaft body at the tapered axial region decreases in a direction from the first end to the second end,” and “a shaft sleeve mounted on the tapered axial region,” as claimed. (*Id.*, 15–18.) With respect to limitations [b] and [c], Petitioner argues that “[a] POSITA would have been motivated to incorporate the tapered end on the main shaft of Piepho with the main shaft on Polinski,” and that “a POSITA would be motivated to use the tapered sleeve of Piepho as it aids in alignment and fit-up.” (*Id.*, 16–18.)

For limitation [d], Petitioner relies on Harless, asserting that it discloses at least one groove indented at the external surface and positioned at the tapered axial region. Petitioner alleges a POSITA would have been motivated to combine Harless with Polinski and Piepho “to simplify the equipment and process for making and breaking interference fits . . . and would have every expectation of success as the technology was already well developed and documented.” (Paper 2, 21.)

1. Claim 9

Petitioner asserts that limitations [9pre]-[9d], which Petitioner groups as limitations 9P–9a6, are “virtually identical to a significant portion of Claim 1.” (Paper 2, 33.) Thus, Petitioner asserts that this portion of claim 9 is “not patentable as rendered obvious by Polinski, in view of Piepho and C.A. Harless.” (*Id.*, 33–34.) For limitation [9e], which Petitioner refers to as limitation 9b, Petitioner asserts that “Both Polinski and Piepho disclose a sleeve fitted over the region at the second (top) end of the main shaft. In Piepho, this portion is tapered inwards and thus the sleeve that is fitted to it is also tapered.” (*Id.*, 34.) Petitioner specifically points to Piepho asserting that the “tapered sleeve is clearest in Piepho,” and argues that the “sleeve is cylindrical on its outermost surface but mates with the tapered shaft internally. In order to accomplish this, the sleeve wall itself must be tapered.” (*Id.*, 34–35.)

Petitioner asserts that the wall thickness of the sleeve must be is greater at the second end of the sleeve than it is at the first end of the sleeve because the internal surface of the yoke bushing is tapered and the external surface of the yoke bushing is purportedly cylindrical. (*Id.*, 34–35.) To demonstrate this point, Petitioner annotates FIG. 1 of Piepho, as shown below:



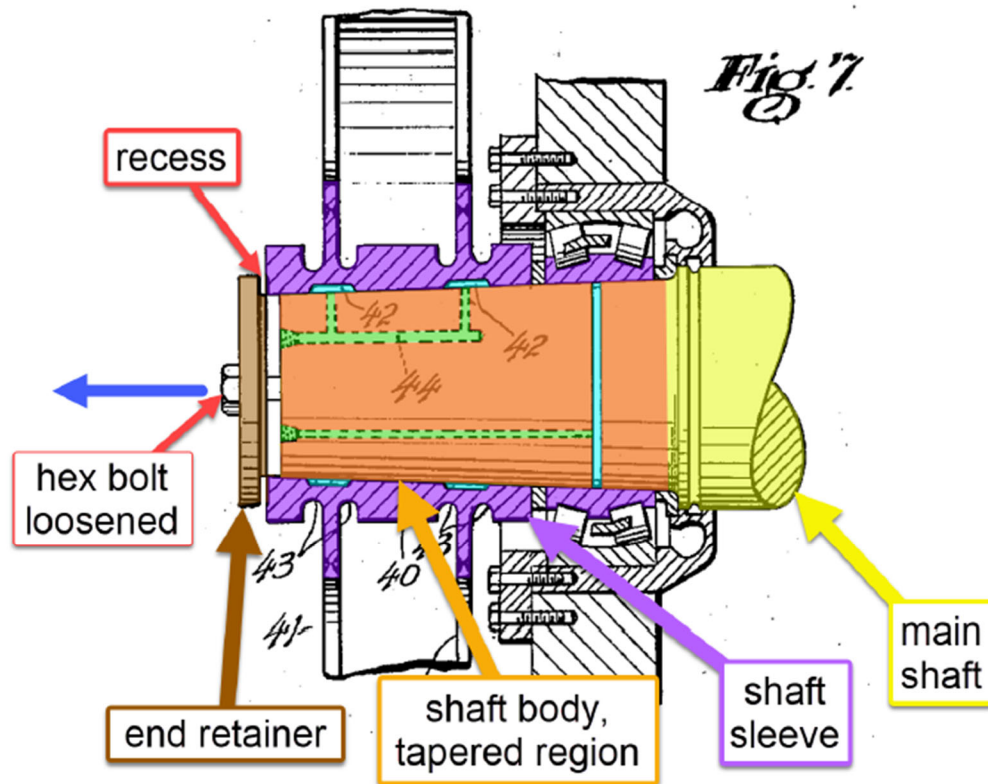
(Ex. 1018, FIG. 1 (annotated by Petitioner).)

Petitioner marks a location above the lower end of the yoke bushing 18 as the “first end.” As discussed further *infra*, Petitioner’s annotation of FIG. 1 is entirely arbitrary—Piepho does not disclose or suggest that the wall thickness at a second end of the sleeve is greater than the wall thickness at a first end of the sleeve.

2. Claim 11

Petitioner asserts that claim 11 is unpatentable as obvious over the combination of Polinski, Piepho, and Harless. (Paper 2, 39–40.) Petitioner asserts that Harless discloses that the end retainer includes a recess extending circumferentially at the perimeter region to allow axial movement of the sleeve

into the recess. (*Id.*) In support, Petitioner states that “[a]s shown in the figures of the patent, below, the end retainer has an undercut shoulder or, in other words, a recess.” However, the “figures of the patent” to which Petitioner refers have, in reality, been modified by Petitioner to illustrate features not supported by the disclosure of Harless. The modified figure prepared by Petitioner is provided below for reference.



(*Id.*, 39.)

Petitioner justifies the modifications to FIG. 7 based on Harless’ disclosure that “[t]o remove a gear, it is only necessary to back off the bolts 9 slightly and introduce oil under pressure through the bore 16 so as to expand the gear hub,

where upon the gear will slide back against the washer 8 with no difficulty and may then be removed.” (Ex. 1033, 3:16–22.) However, as discussed in further detail *infra*, Harless does not disclose or suggest any undercut shoulder in the washer 8, much less a recess extending circumferentially at the perimeter region to allow axial movement of the sleeve into the recess. (Ex. 2007, ¶¶ 57, 88–89; *see also* Ex. 2011, 88:3–8; 89:22–90:8.)

3. Claim 14

Petitioner asserts that claim 14 is unpatentable in view of Polinski, Piepho, and Harless. With reference to [14pre], Petitioner asserts that “the preamble is generally not considered limiting, [but] Polinski discloses a gyratory crusher. For limitation [14a], which Petitioner breaks into 14a1–14a4, Petitioner relies on the combination of Polinski and Piepho for substantially the same reasons asserted with reference to [1a]–[1d] and [9a]–[9c]. (*Id.*, 43–47.) Petitioner asserts that Polinski in view of Piepho discloses [14b], relying specifically on the tapered yoke bushing 18 of Piepho fit to a tapered region of a coal pulverizer shaft. (*Id.*, 47–48.) Petitioner annotated FIG. 1 of Piepho in the same manner shown above for claim 9, *i.e.*, arbitrarily marking the end of the sleeve, and asserts:

As shown above, the sleeve is fitted over the tapered axial region using an interference fit. Further, it has a tapered internal surface matching that of the tapered axial region of the main shaft and a cylindrical external surface. Thus, the sleeve has a wall thickness

that tapers from a thicker portion at the second end, to a thinner portion at the first end. (*Id.*, 48 (internal citations omitted).)

Petitioner asserts that [14c] is unpatentable as obvious over the combination of Polinski in view of Piepho and Harless for the same reasons discussed *supra* with reference to [1d].

B. The Ground Does Not Disclose Or Suggest “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”

Polinski and Piepho, taken both alone and in combination, fail to disclose or suggest “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,” as recited in claims 1, 9, and 14. (Paper 2, 15.)

As discussed *supra*, the second end of the shaft is the outermost extremity of the shaft body at the upper end. The second end, as described in the '090 Patent, corresponds to upper end surface 123, which is clearly shown in FIGS. 2 and 3 of the '090 Patent.

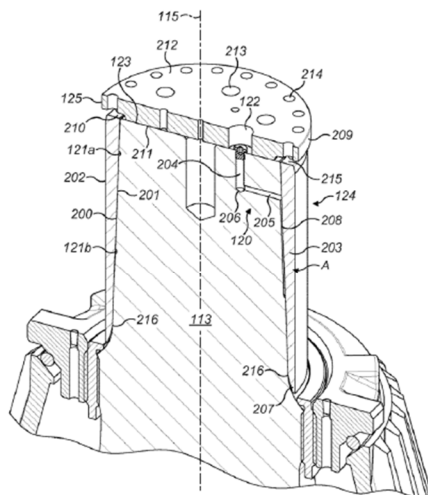


FIG. 2

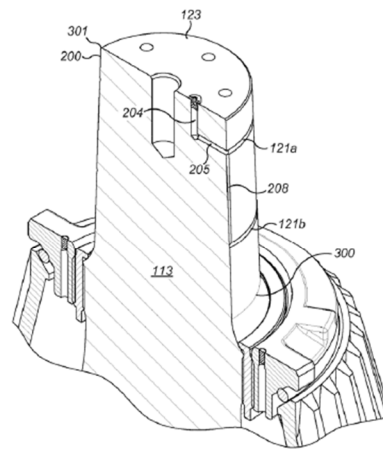


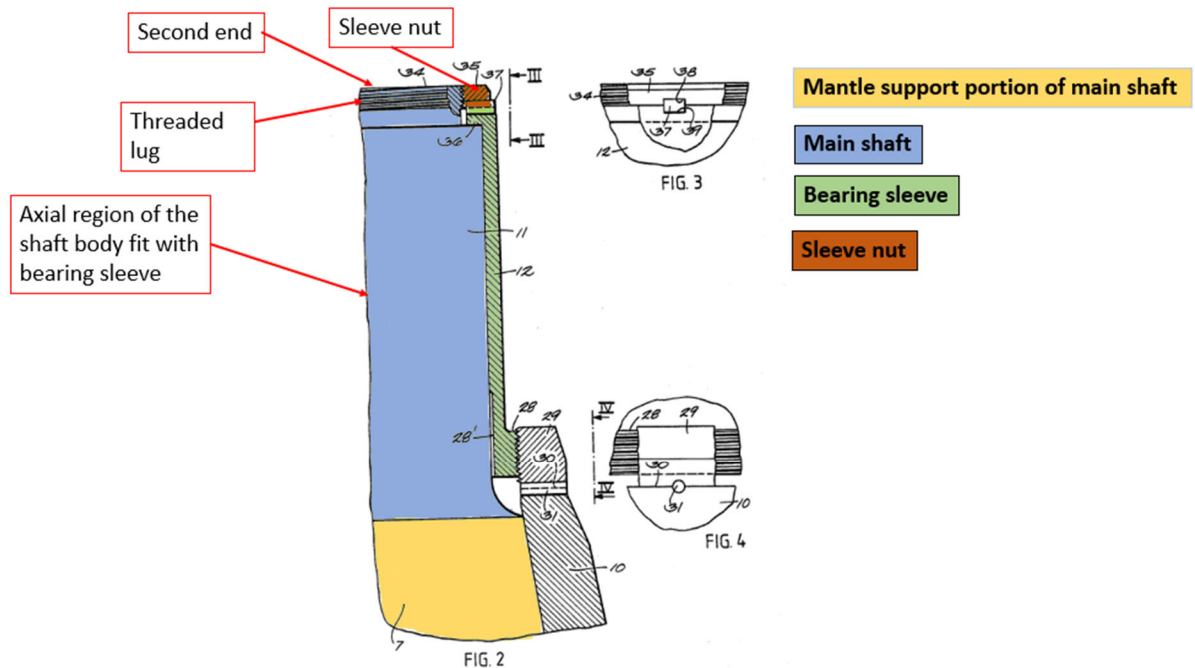
FIG. 3

(Ex. 2001, FIGS. 2–3.)

As further illustrated, a tapered axial region 113 extends from the uppermost end surface 123 of the shaft—the second end. Neither Polinski nor Piepho discloses this claim limitation. Rather, both Polinski and Piepho disclose threaded regions extending from the upper end of the shaft. (Ex. 2007, ¶¶ 58–60.)

Polinski discloses a threaded lug extending from the uppermost end of the main shaft of a gyratory crusher. FIG. 2 of Polinski, below, depicts the second (upper) end of the main gyratory crusher shaft. The second (upper) end of the shaft of Polinski is defined by the top end of a threaded lug 34. The threaded lug extends from the second end to a bearing journal 11. (Ex. 1017, 3:23–25.) The threaded lug is adapted to receive a sleeve nut 35 of a sleeve 12. (*Id.*, 3:15–48.) The sleeve nut, in turn, secures annular lip 36 of sleeve 12 to the journal 11 of the shaft 7. (Ex. 2001, ¶ 28; Ex. 1017, 2:30–47, 3:15–47.) This arrangement places

sleeve nut 35 in contact with annular lip 36 of sleeve 12, securing the sleeve 12 to the bearing journal 11. (Ex. 2007, ¶¶ 59–60.)



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

Specifically, as shown in FIG. 2 above, 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.) The threaded lug 34 thus operates to secure the sleeve 12 on the journal 11. (Ex. 2001, ¶ 61.) Nothing in FIG. 2 nor elsewhere in Polinski discloses or suggests an axial region of the shaft body *extending from the second end* and being tapered relative to a

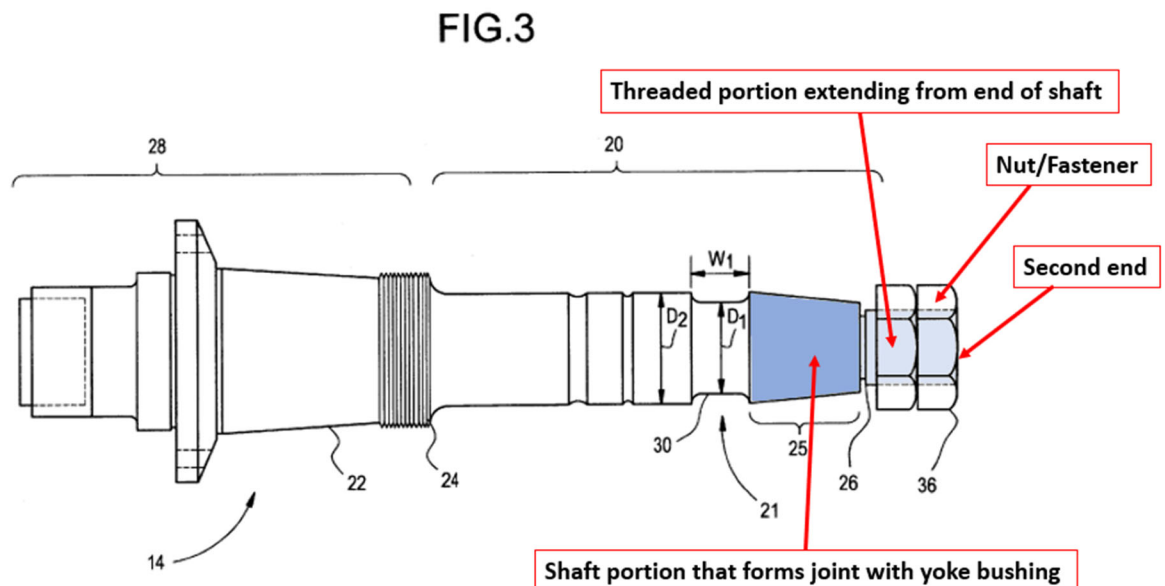
longitudinal axis of the shaft body. (*See id*; *see also* Ex. 2007, ¶¶ 59–60.)

Piepho also fails to disclose or suggest an axial region of the shaft body *extending from the second end* and being tapered relative to a longitudinal axis of the shaft body. Figure 3 of Piepho, shown below, depicts an axial region being tapered relative to a longitudinal axis of the shaft body (region labeled 25).

However, the tapered region 25 does not extend from the end of Piepho's shaft.

Instead, a threaded region labeled 26 extends from the second (top) end of the shaft disclosed by Piepho between the top end and the tapered portion 25. (Ex.

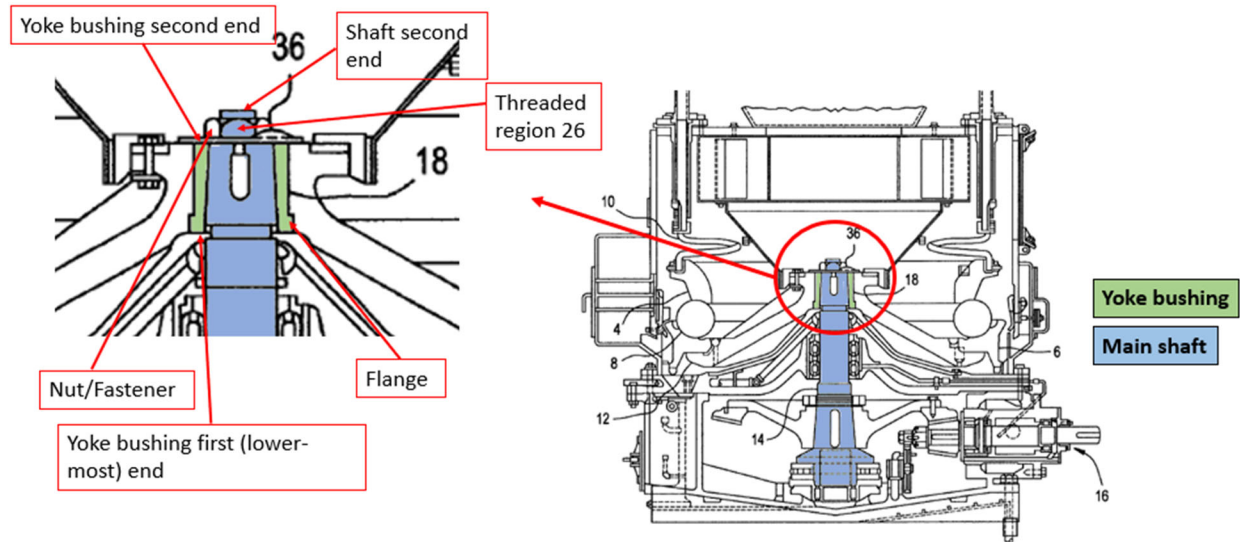
2007, ¶¶ 61–63.)



(Ex. 1018, FIG. 3.)

FIG. 1 of Piepho, below, shows that the cylindrical region 26 extends above

the yoke and is connected to an element labeled 36. A POSITA would understand that element 36 is a fastener secured to the cylindrical portion 26 of the shaft to secure the yoke to the shaft of the coal pulverizer. (Ex. 2007, ¶¶ 61–63.)



(Ex. 1018, FIG. 1.)

Mr. Smith agreed that the region labeled 26 is a threaded region used to attach the yoke:

Q. What is yoke 12 in Figure 1 of Piepho attached to?

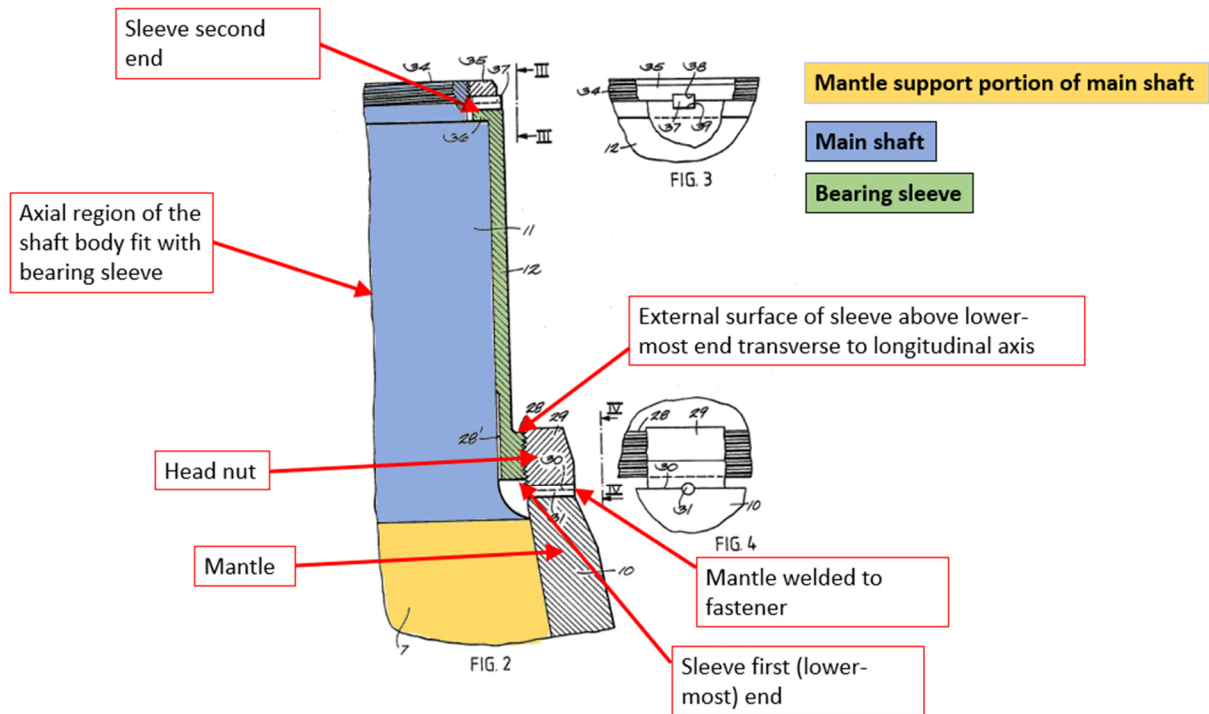
A. Attached to the vertical main shaft assembly 14 of the pulverizer.

Q. Do any portions of the main shaft 14 extend above the yoke 12 within the pulverizer shown in Figure 1?

A. It does appear that there is, again, a threaded portion that extends above that. (Ex. 2011, 77:18–78:1.)

Thus, neither Polinski nor Piepho, taken both alone and in combination, disclose “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,” as recited in claims 1, 9, and 14. (Ex. 2007, ¶¶ 61–63.)

Moreover, there is no motivation to modify Polinski to meet the above claim limitation because it would render Polinski’s purported invention inoperable for its intended purpose. *See Polaris Indus. v. Arctic Cat, Inc.*, 882 F.3d 1056, 1061, 1067–69 (Fed. Cir. 2018). As discussed above, the threaded lug and sleeve nut secure the sleeve to the journal 11 of the shaft. This is necessary because Polinski’s sleeve acts as an axial support for the mantle. Specifically, Polinski discloses that a sleeve 12, relied on by Petitioner for the sleeve recited in challenged claims 1, 9, and 14, 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, as shown below in FIG. 2 of Polinski. (Ex. 1017, 3:1–8; *see also* Ex. 2011, 54:3–55:4.)



Ex. 1017, FIG. 2 (annotated).

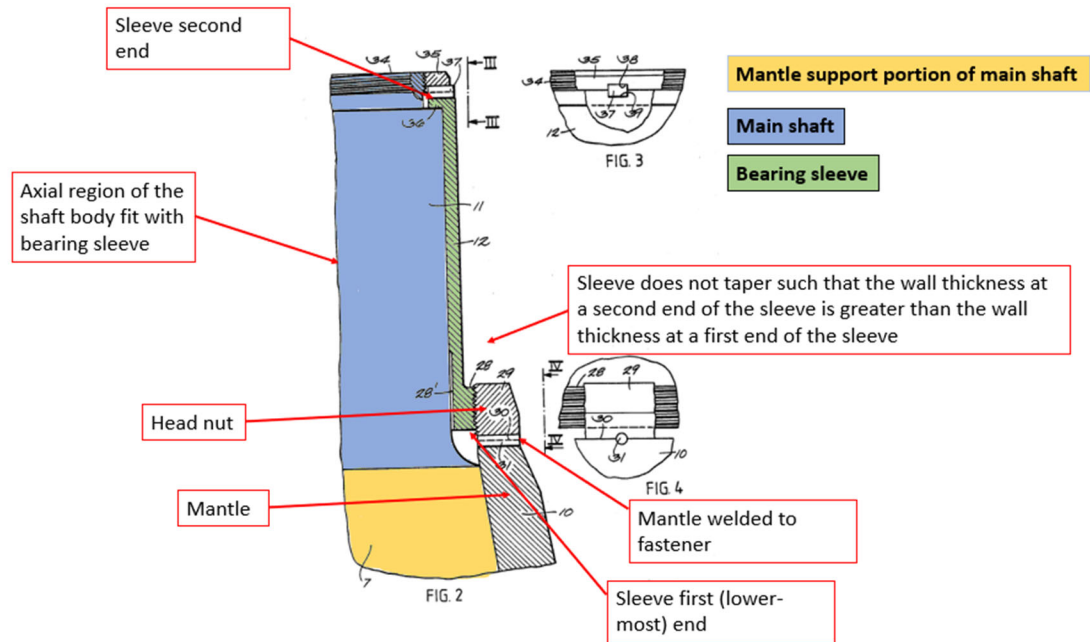
Torsional and axial loads on are exhibited on the sleeve via threaded shoulder 28. (See Ex. 1017, 3:1-45; *see also* Ex. 2007 ¶¶ 64–65.) The sleeve nut 35 and threaded lug 34 counteract these loads to maintain the sleeve 12 on the shaft and prevent excessive rotation or axial motion. (See Ex. 1017, 3:1-45; *see also* Ex. 2007, ¶¶ 64–65.) Modifying Polinski to remove the threaded lug such that a tapered axial region extends from the second end would render the purported invention of Polinski—the ability to secure the crusher mantle to the shaft 7 using the sleeve 12—inoperable because the sleeve would lack a support at the upper end to counteract the axial and torsional forces exhibited on the sleeve by the crusher

mantle during operation. (See Ex. 2007 ¶¶ 64–65.)

C. The Ground Does Not Disclose Or Suggest “the sleeve having a tapered wall thickness, such that the wall thickness at a second end of the sleeve is greater than the wall thickness at a first end of the sleeve”

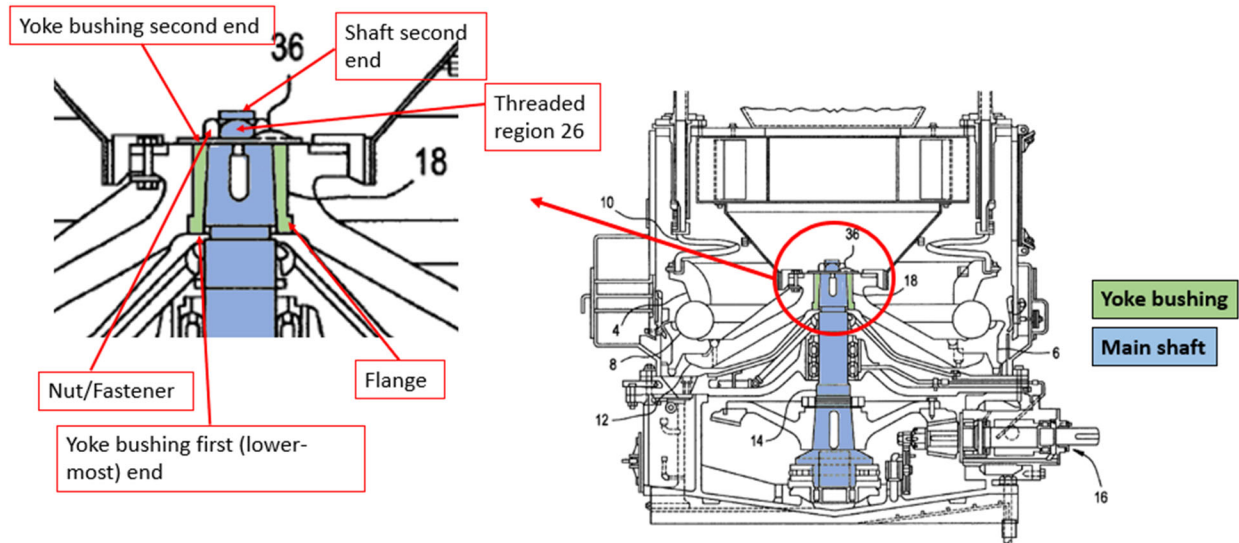
Polinski, Piepho, and Harless fail to disclose or suggest that “the sleeve having a tapered wall thickness, such that the wall thickness at a second end of the sleeve is greater than the wall thickness at a first end of the sleeve,” as recited in claims 9 and 14. As discussed *supra*, the first end of the sleeve is the outermost extremity of the sleeve at the lower end.

Polinski does not disclose a tapered sleeve. Accordingly, Polinski does not disclose or suggest a sleeve having a tapered wall thickness, such that the wall thickness at a second end of the sleeve is greater than the wall thickness at a first end of the sleeve, as recited in claims 9 and 14. Polinski discloses that a sleeve 12, relied on by Petitioner for the sleeve recited in challenged claims 9 and 14, 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, as shown below in FIG. 2 of Polinski. (Ex. 1017, 3:1–8.)



Ex. 1017, FIG. 2 (annotated).

Piepho discloses a yoke bushing 18 that is tapered on its internal facing surface. However, Piepho's sleeve is not tapered "*such that the wall thickness at a second end of the sleeve is greater than the wall thickness at a first end of the sleeve,*" as required by claims 9 and 14. Rather, Piepho discloses a flange extending from the lowermost end of a yoke bushing 18, shown in annotated FIG. 1 of Piepho below.



Moreover, a POSITA would not have been motivated to modify Polinski in view of Piepho or Harless “such that the wall thickness at a second end of the sleeve is greater than the wall thickness at a first end of the sleeve,” as recited in claims 9 and 14, because such a modification would change Polinski’s principle of operation. *In re Ratti*, 270 F.2d 810, 813, 123 USPQ 349, 352 (CCPA 1959). 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.) To that end, Polinski discloses a sleeve with a threaded annular shoulder 28 that receives a head nut 29 to secure the crushing mantle 10 to the tapered portion of the main shaft 7. (Ex. 1017, 3:1–9; *see also* Ex. 2011, 54:3–55:4.)

Modifying Polinski “such that the wall thickness at a second end of the sleeve is greater than the wall thickness at a first end of the sleeve” would eliminate the sleeve’s threaded shoulder 28 that is used to secure, via head nut 29, the mantle 10 to a tapered mantle support portion 8 of the shaft 7. (Ex. 2007, ¶¶ 70–71.) But, as Mr. Smith admits, Polinski’s design rests on engagement of the sleeve’s threaded shoulder 28 with head nut 29:

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. 2011, 53:20–54:2.)

Thus, to eliminate the threaded shoulder 28 of Polinski’s sleeve would change the very principle of operation of Polinski’s purported invention and would not have been obvious to a POSITA. (Ex. 2007, ¶¶ 70–72.)

Nor would it have been obvious to modify Polinski to reduce the thickness of the threaded shoulder 28. The threads in the shoulder 28 would introduce stress concentrations into the sleeve if the thickness of the shoulder were reduced to align with the remainder of the sleeve’s axial wall. That would significantly increase the likelihood that the sleeve would fail during operation. (*Id.*, ¶¶ 73–76.) Indeed, the

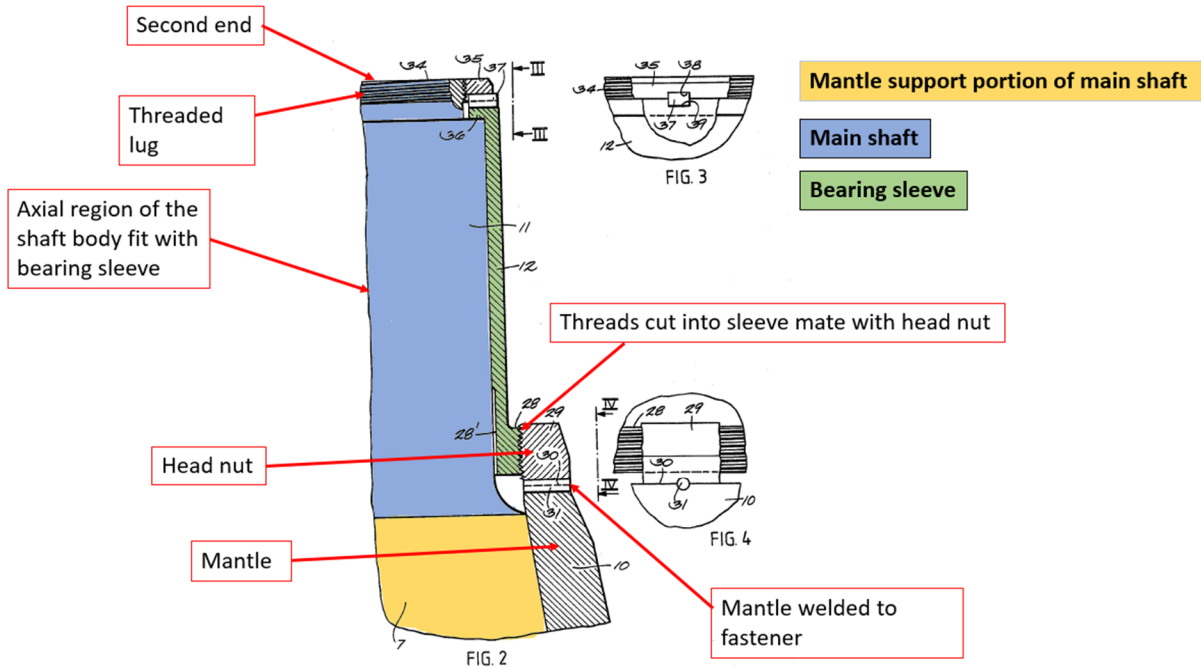
additional material provided by the shoulder 28 relative to the remainder of the sleeve's axial wall is needed to distribute the stresses exerted on the sleeve by the mantle. Stated differently, the threaded shoulder is a core feature of Polinski's disclosure that a POSITA, with two years of industry experience, would not be motivated to remove. (*Id.*)

D. There Would Have Been No Motivation To Include At Least One Groove In Polinski

It would not have been obvious to modify Polinski in view of Piepho and Harless to include at least one groove indented at the external surface—as properly construed—and in a tapered axial region of the shaft, as asserted by Petitioner. (Ex. 2001, ¶ 47–58; Ex. 2007 ¶¶ 77–87.) Modifications that undermine the intended purpose of a reference counsel against a finding of obviousness. *See Polaris Indus. v. Arctic Cat, Inc.*, 882 F.3d 1056, 1061, 1067–69 (Fed. Cir. 2018) (vacating Board decision that failed to consider whether modifying prior art reference would “run contrary to one of [the reference’s] stated purposes”); *Medtronic, Inc. v. Teleflex Innovations S.à.r.l.*, 69 F.4th 1341, 1349 (Fed. Cir. 2023) (affirming Board decision that the destruction of a reference’s entire premise counseled strongly against obviousness).

Here, Polinski's stated purpose is mitigating shaft fatigue failure. (Ex. 1017, 1:61–67; Ex. 2001, ¶ 30; Ex. 2007, ¶ 77.) Polinski teaches that structural

discontinuities increase the likelihood of fatigue failure and counsels that discontinuities should be removed from the journal 11 fit with sleeve 12. (*See* Ex. 1017, 1:15–20; Ex. 2007, ¶¶ 77–78.) Polinski teaches that stress concentrations in the main shaft can be reduced by cutting threads into a sleeve instead of the shaft and attaching the mantle to the sleeve. (Ex. 1017, 1:1–67.) Specifically, as discussed *supra*, and as shown in FIG. 2 of Polinski below, Polinski teaches that a threaded shoulder 28 is provided on a bearing sleeve 12. (*Id.*, 2:67–68; 3:1–10.) The threaded shoulder 28 is configured to receive a head nut 29 that abuts the upper end of the mantle 10 to secure the mantle to the bearing sleeve 12. (*Id.*) Thus, the threading is not cut into the shaft to secure the mantle to the shaft. Instead, it is provided on the threaded shoulder 28 of the bearing sleeve. Polinski thus omits abrupt changes in the cross-sectional area in the journal 11 to avoid fatigue crack initiation. (*See id.*, 1:60–68; *see also* Ex. 2007 ¶¶ 41, 44, 77–78.)



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

Given Polinski's teaching that discontinuities should be removed from high-stress regions of the shaft, a POSITA would not have been motivated to add a groove in the journal 11 of the shaft body of Polinski. Doing so would create structural discontinuities that would increase the likelihood of fatigue failure in Polinski. *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 even 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.”).)

3-13 Stress Concentration

In the development of the basic stress equations for tension, compression, bending, and torsion, it was assumed that no geometric irregularities occurred in the member under consideration. But it is quite difficult to design a machine without permitting some changes in the cross sections of the members. Rotating shafts must have shoulders designed on them so that the bearings can be properly seated and so that they will take thrust loads; and the shafts must have key slots machined into them for securing pulleys and gears. A bolt has a head on one end and screw threads on the other end, both of which account for abrupt changes in the cross section. Other parts require holes, oil grooves, and notches of various kinds. Any discontinuity in a machine part alters the stress distribution in the neighborhood of the discontinuity so that the elementary stress equations no longer describe the state of stress in the part at these locations. Such discontinuities are called *stress raisers*, and the regions in which they occur are called areas of *stress concentration*. Stress concentrations can also arise from some irregularity not inherent in the member, such as tool marks, holes, notches, grooves, or threads.

(Ex. 2003, 110 (annotated).)

According to *Shigley*, when a material contains a geometrical discontinuity, it will experience an increase in stress near the discontinuity. (*Id.*) *Shigley* expressly points to grooves as a common stress raiser. (*Id.*) Thus, a POSITA would know that adding a groove (a geometrical discontinuity) to a shaft would add stress concentrations, which as taught by both Polinski and Piepho, increase the likelihood of shaft failure. (Ex. 1017, 1:20–33; Ex. 1018, 1:51–60; Ex. 2001, ¶ 48.)

Moreover, *Shigley* counsels that stress concentrations pose particularly severe risks under cyclic loading. (See Ex. 2003, 112 (“while ductile materials under *static* loading are not typically at high risk of fracture due to stress raisers and corresponding stress concentrations, ductile materials are at risk of brittle fracture under *cyclic loading*”).) *Shigley* specifically provides that “[f]or *dynamic loading*, the stress concentration effect is significant for *both* ductile and brittle

materials and must always be taken into account.” (*Id.*) As noted above, the Polinski shaft (and the Piepho shaft) are subjected to cyclic (*i.e.*, dynamic) loading. (See Ex. 1017, 1:26–29; Ex. 1018 1:51–60.)

Thus, adding stress raisers such as oil grooves to the bearing journal 11 of Polinski would increase the likelihood of shaft failure. (Ex. 2001, ¶ 52.) This proposed modification is in direct contradiction to the stated objective of mitigating shaft fatigue failure set forth by Polinski. It is also contrary to the means by which Polinski describes that objective being achieved—by *removing* discontinuities from the shaft. With limited experience and facing a “fairly complex machine” (Ex. 1002, ¶ 27), a POSITA would not have been motivated to undermine the intended—and express—purpose of Polinski by adding one or more grooves that would introduce discontinuities into the bearing journal. (Ex. 2007, ¶¶ 77–87.)

Moreover, a POSITA would not be motivated to incorporate a groove into the shaft of Polinski as modified by the proposed combination with Piepho at least for the additional reason that incorporating such a groove would increase the likelihood of fretting wear and fretting induced fatigue failure. Piepho is specifically directed to shaft failure mitigation techniques that include coating a portion of the shaft fit into a yoke bushing (which Petitioner alleges is a sleeve) with a ceramic coating to prevent fretting wear and corresponding fatigue failure

by reducing relative movement between the shaft and the yoke bushing. (*Id.*, 2:15–25; Ex. 2001, ¶¶ 42–43.) Polinski is also concerned with mitigating the risk of fretting wear. (Ex. 1017, 3:9–14.) Incorporating a groove into the tapered portion of the shaft disclosed by the purported combination of Polinski and Piepho would lead to increased fretting wear due to increased relative motion (*e.g.*, slip) between the shaft and sleeve at the edges of the contact region defined by the grooves. (Ex. 2001, ¶¶ 54–58; Ex. 2004, 593–595.)

Fretting and fatigue failure go hand in hand. As discussed in *Fundamentals of Machine Component Design* by Robert C. Juvinal & Kurt M. Marshek, dated January 5, 2000, “[t]he roughness and pitting caused by fretting make the surface more vulnerable to fatigue failure. Reducing fatigue strength is a major consequence of fretting.” (Ex. 2005, 373.) Furthermore, fatigue failure is more likely at the edges of contact regions between two surfaces. As discussed in *Metals Engineering Design* by Oscar J. Horger, dated January 1, 1953, “[f]atigue failure, under conditions where fretting is present occurs in all instances either at the edge of the contact area between the two contacting members or close to it but within the contact surface.” (Ex. 2006, 231.)

Mr. Smith agreed that incorporating grooves to the shaft in a region fit to a sleeve with an interference fit would both add edges along the contact region and increase the likelihood of fretting wear:

Q. And specifically, do you agree that fatigue failure is most likely to occur at edges of contact area between two surfaces?

A. I think that's a reasonable statement.

Q. And would you agree that adding grooves to a shaft in a region fit to a sleeve with an interference fit, would add edges along the contact region?

A. I expect that that would create an edge in a contact region.

Q. Okay. And do you agree that adding such grooves would increase the likelihood of fretting?

A. I think it's possible. I'm not sure that it would lead to a failure, but it would likely increase the likelihood of fretting. (Ex. 2011, 45:3–16.)

Thus, introducing a groove would further exacerbate the fatigue failure problem that Polinski attempts to solve by placing threads in the sleeve shoulder, rather than the shaft. A POSITA would not be motivated to introduce grooves into the shaft of Polinski in view of Piepho and Harless for at least these reasons. (Ex. 2007, ¶¶ 77–87.)

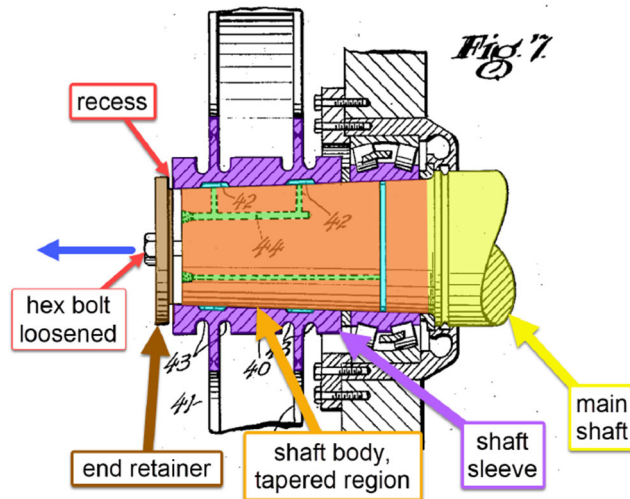
Petitioner contends that the groove in Harless would simplify making and breaking interference fits. (*See* Paper 2, 21.) In the Decision on Institution, the Board found that Sandvik had not contested the advantages associated with the introduction of a single groove in a shaft and that the weighing 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. (Ex. 2007, ¶ 86.) Whatever advantages that a groove in a shaft may provide, *shaft failure* would be an existential threat and would be a front and center consideration for the POSITA. (*Id.*, ¶ 86.) Mr. Smith, Petitioner’s expert, 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.) A POSITA would thus not have been motivated to introduce grooves that run directly contrary to the primary concern of Polinski, to wit, shaft failure. (Ex. 2007, ¶¶ 86–87.)

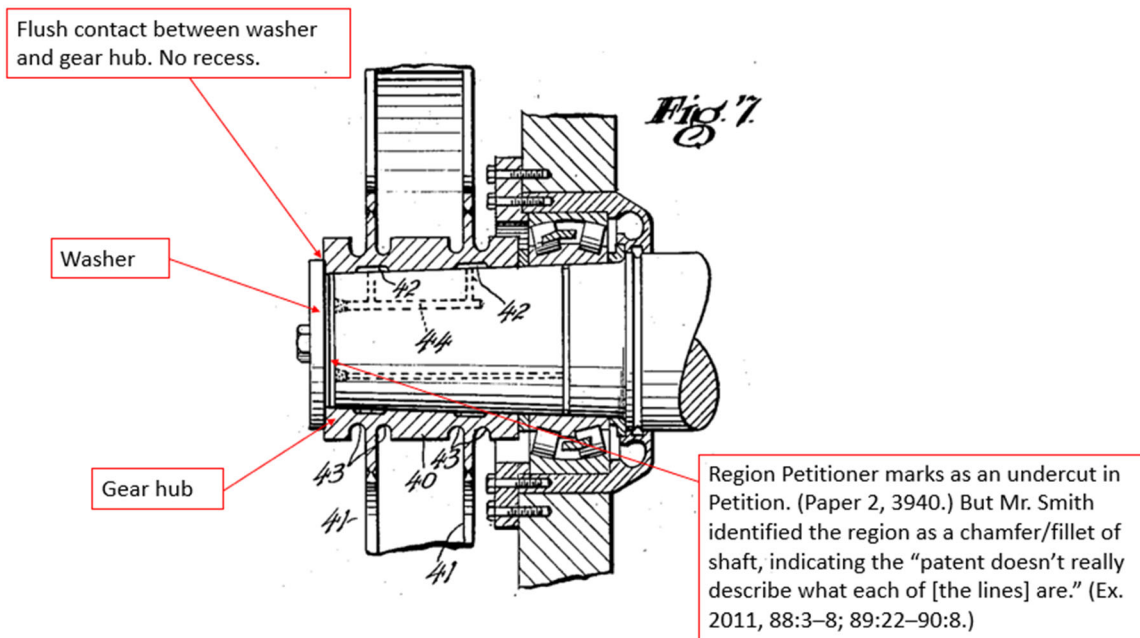
E. The Ground Does Not Disclose Or Suggest The Recess Of Claim 11

Claim 11 recites “wherein the end retainer includes a recess extending circumferentially at the perimeter region to allow axial movement of the sleeve into the recess.” (Ex. 1001.) As discussed *supra*, Petitioner asserts that claim 11 is unpatentable as obvious over the combination of Polinski, Piepho, and Harless. (Paper 2, 39–40.) Petitioner does not rely upon Polinski or Piepho for the recited

recess. Instead, turning to Harless, Petitioner asserts that “[a]s shown *in the figures of the patent [Harless]*, below, the end retainer has an undercut shoulder or, in other words, a recess.” (*Id.*) The recess, in Petitioner’s view, would reveal itself when bolts 9 are loosened. (*Id.*; Ex. 1033, 3:16–22.) To that end, Petitioner submitted a modified and annotated version of FIG. 7, below, illustrating a “recess.” (*Id.*)

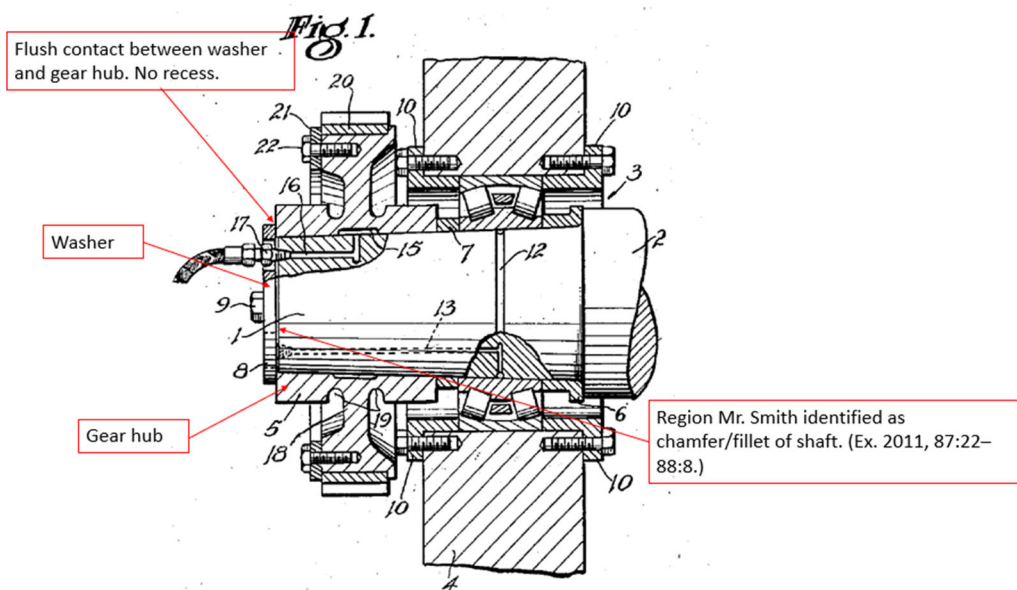


But the recess is a creation of Petitioner. The original version of FIG. 7 from Harless is shown annotated below, lacking the recess and undercut shoulder created in Petitioner’s modified FIG. 7. (Ex. 2007, ¶¶ 88–89.)



(Ex. 1033, FIG. 1 (annotated).)

FIG. 1 of Harless, annotated below, also lacks any supposed recess. Indeed, none of the embodiments shown in Harless depict a recess between the washer and the gear hub. (Ex. 2007, ¶¶ 88–89.)



(Ex. 1033, FIG. 1 (annotated).)

Moreover, there is nothing in Harless to suggest that, if bolts 9 were loosened, that washer 8 would shift away from the shaft. (Ex. 2007, ¶¶ 88–89.)

Even if it did, it would not reveal an end retainer with a recess, as required by claim 11. Petitioner appears to believe the lines below washer 8 reflect a portion of the retainer that allows it “to seat itself in a centered condition.” (Paper 2, 39.) Mr. Smith made the same assertion in his declaration. (Ex. 1002, 83.) Under this view, once the washer is separated from the shaft, that seat reveals itself, along with accompanying annular recess. But, on cross-examination, Mr. Smith believed those lines were not a seat of a washer, but could be a chamfer or fillet of the shaft.

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. (Ex. 2011, 88:3–8; 89:22–90:1.)

If those lines under the washer are a chamfer or fillet of the shaft, as opposed to a retainer seat, the washer—once separated from the shaft—would merely be a disc, without the recited recess associated with any seat. (Ex. 2007, ¶¶ 57, 88–89.)

Further contradicting Petitioner and his testimony in Ex. 1002, Mr. Smith was not even able to definitively state what the lines under the washer were:

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, 90:2–8.)

Thus, Petitioner's argument boils down to a figure that either its expert is unable to read (contrary to his initial declaration) or discloses a chamfered shaft that undermines the assertions in the Petition. Accordingly, the instituted Ground does not disclose an end retainer that includes a recess extending circumferentially at the perimeter region to allow axial movement of the sleeve into the recess, as recited in claim 11. (Ex. 2007, ¶¶ 88–89.)

VII. CONCLUSION

For the foregoing reasons, challenged claims 1–14 of the '090 Patent are not unpatentable over the reasons as set forth above.

Dated: June 24, 2025

Respectfully submitted,

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Certification of Word Count

Pursuant to 37 C.F.R. § 42.24, Patent Owner certifies that the word count of the foregoing PATENT OWNER RESPONSE is 11,400 words (as counted by the “Word Count” feature of the Microsoft Word™ word-processing system), excluding the parts of the brief exempted by 37 C.F.R. § 42.24(a).

Dated: June 24, 2025

By /Mehran Arjomand/
Mehran Arjomand

Certificate of Service (37 C.F.R. § 42.6(e)(4))

I hereby certify that the foregoing PATENT OWNER RESPONSE and supporting materials were served as of the below date on the Petitioner via email (by agreement) to the following counsel of record:

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