

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

PATENT OWNER PRELIMINARY RESPONSE

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Patent Owner's Exhibit List for *Inter Partes* Review of
U.S. Patent No. 11,014,090

Exhibit Description	Exhibit #
Declaration of Harri Kytömaa, PH.D.	2001
Curriculum Vitae and Publications of Dr. Kytömaa	2002
Richard G. Budynas & J. Keith Nisbett, <i>Shigley's Mechanical Engineering Design</i> , Ninth Edition (2011)	2003
Andrew W. Batchelor & Gwidon W. Stachowiak, <i>Engineering Tribology</i> , Second Edition (2001)	2004
Robert C. Juvinall & Kurt M. Marshek, <i>Fundamentals of Machine Component Design</i> , 3 rd Edition (2000)	2005
Oscar J. Horger, <i>Metals Engineering Design</i> , First Edition (1953)	2006

I. INTRODUCTION

Sandvik Intellectual Property AB (“Sandvik” or “Patent Owner”) submits this Patent Owner Preliminary Response (“POPR”) in response to the Petition (Paper 2) 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). But the combination has fundamental flaws.

First, a POSITA would not be motivated to combine Harless with Polinski and Piepho to arrive at 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 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 and Piepho are directed to mitigating shaft failure and fretting wear. 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 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 a 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 as Petitioner urges. Such a groove would increase the likelihood of both fatigue failure and fretting wear, which Polinski and Piepho aim to prevent.

Second, 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.” For this limitation, Petitioner relies on the combined teachings of Polinski and Piepho, neither of which disclose a tapered region *extending from the second (top) end* of the shaft.

For at least these reasons, as detailed below and supported by the declaration of Dr. Harri Kytömaa (Ex. 2001), Sandvik requests that the Board deny institution.

II. THE ’090 PATENT

A. Background

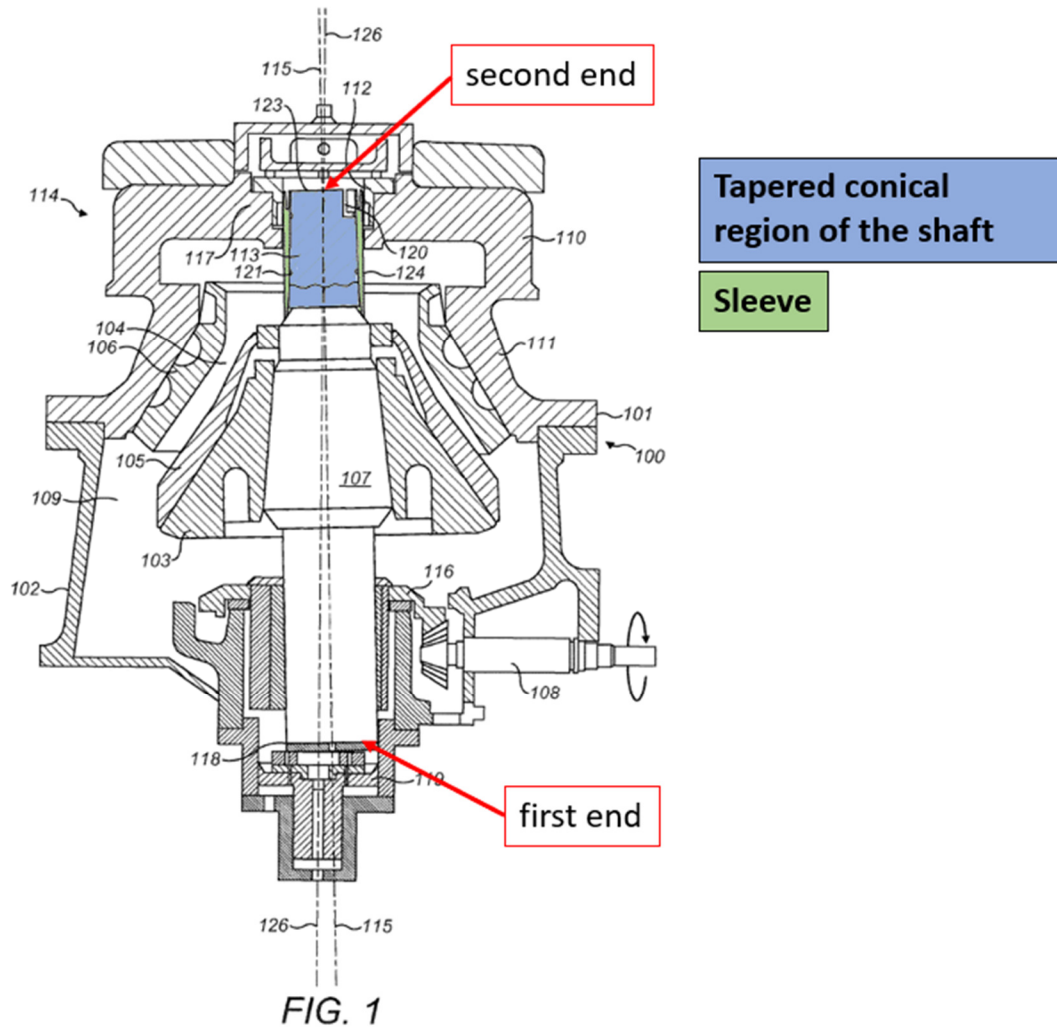
Gyratory crushers are used for crushing ore, mineral, and rock material into smaller sizes. (Ex. 1001, 1:1–2.) Cylindrical protective sleeves are commonly fit to cylindrical gyratory crusher shafts. (*Id.*, 1:35–40.) However, the assembly and

disassembly of cylindrical protective sleeves is difficult. (*Id.*, 1:42–59.) During installation, a cylindrical sleeve often cools too quickly before it can be positioned correctly on the shaft. (*Id.*) Moreover, a cylindrical sleeve must be cut before it can be removed, which poses risks of damage to the shaft during the cutting operation. (*Id.*)

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.)

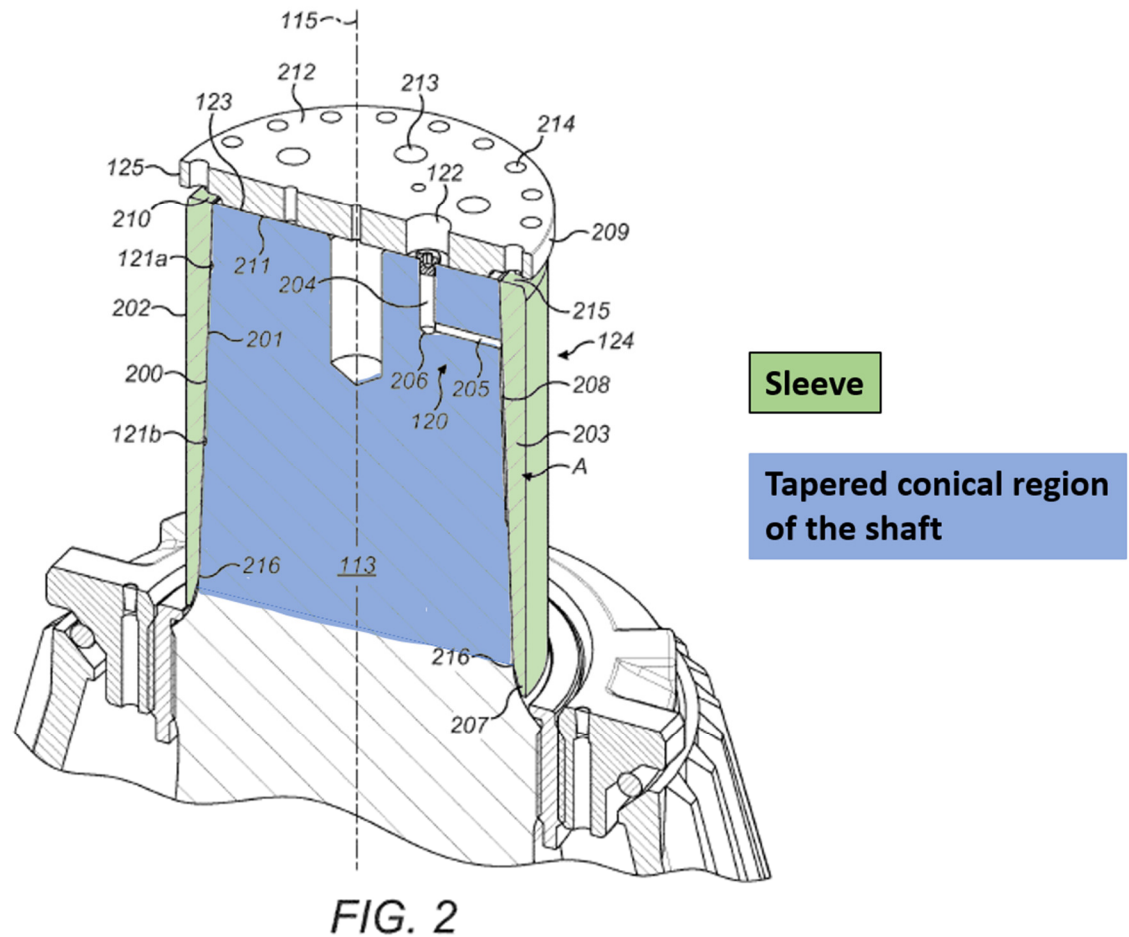
Annotated Figure 1 of the '090 Patent below shows a main shaft 107 positioned within a gyratory crusher. The shaft 107 has a first end positioned at a bottom end of the crusher and a second end positioned at the top end of the crusher, as shown in the figure below. A tapered region 113 (blue) of the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

extends from the second (top) end of the shaft 107 toward the first (bottom) end of the shaft 107.



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

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.)



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

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

(*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. (*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. For the purposes of this Preliminary Response, Sandvik focuses on independent claim 1. But the deficiencies in the Petition, as discussed in this Preliminary Response, apply equally to independent claims 9 and 14.

Claim 1 recites a number of limitations indicated by reference letters [a], [b], [c], and [d]:

1. A gyratory crusher main shaft of a crusher comprising:

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

[b] 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;

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

[d] 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.

Importantly, limitation [d] requires 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 [d]. (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 [a]–[c] 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 above limitations of claim 1 and noted that the “shaft includes a

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.

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 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. § 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. THE ASSERTED PRIOR ART REFERENCES

A. Polinski (Ex. 1017)

Polinski is directed to a gyratory crusher main shaft and cylindrical bearing sleeve arrangement. (Ex. 1017, 1:44–47.)² 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,

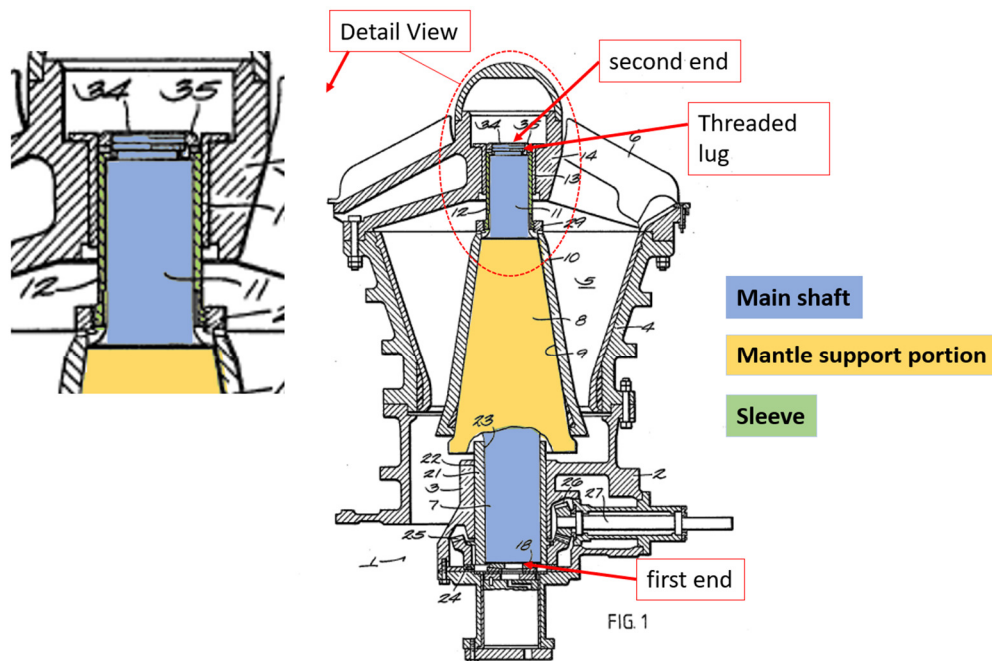
² Unless otherwise indicated, all citations in this Preliminary Response and the Declaration of Dr. Harri Kytömaa refer to the original pagination of the exhibits being cited.

experience has indicated that the relatively abrupt changes in the cross-sectional area of the shaft above and below the threaded section have resulted in high local stress concentrations in these regions of the shaft. **These stress concentrations are in addition to the *substantial stresses* generated by the *cyclic bending loads* applied to the shaft by the mantle during operation of the crusher. The result has been the development of *fatigue cracks* or fractures in the threaded section of the shaft as well as immediately above and below it where the highest stresses occur due to the abrupt changes in the cross-sectional area of the shaft. Over a period of time the cracks continue to grow and ultimately render the shaft unserviceable requiring that the crusher be taken out of service and the shaft replaced before crushing operations can be resumed.**³ (*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.)

³ In this Preliminary Response, all emphases have been added unless otherwise noted.

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 bearing journal 11 is positioned near the second end of the shaft 7. (*Id.*) Above the cylindrical bearing 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 cylindrical bearing sleeve 12. (*Id.*, 3:15–47.)



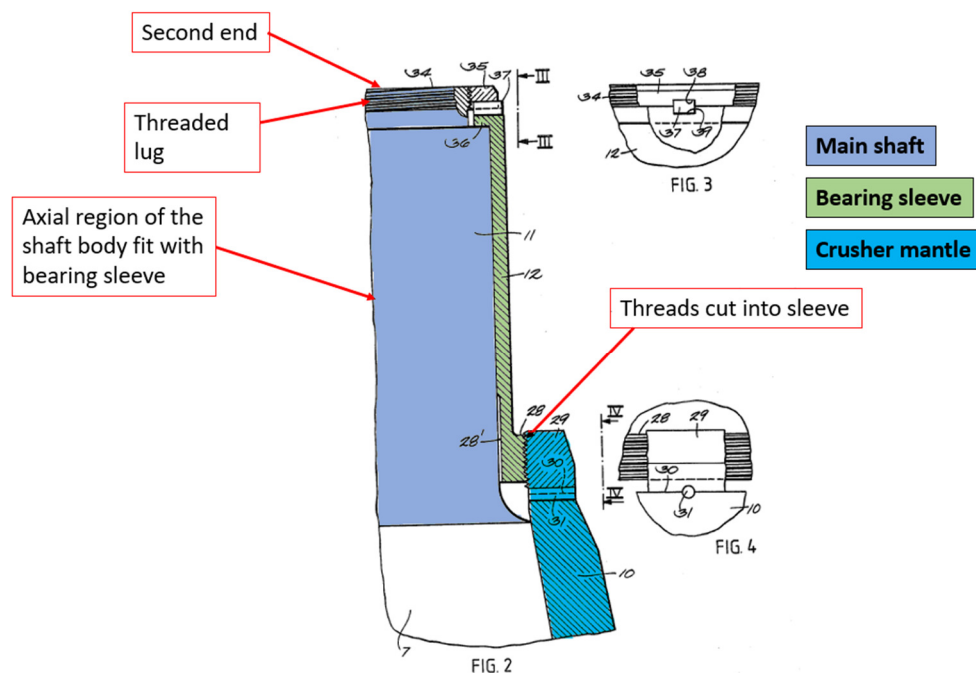
(*Id.*, FIG. 1 (cropped and annotated).)

The cylindrical bearing sleeve 12 (green) is fitted onto the cylindrical bearing 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 bearing journal 11 includes a taper extending from the second end of the shaft 7. 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.)

Figures 2-4 below depicts additional detail of the bearing journal 11 and sleeve 12.

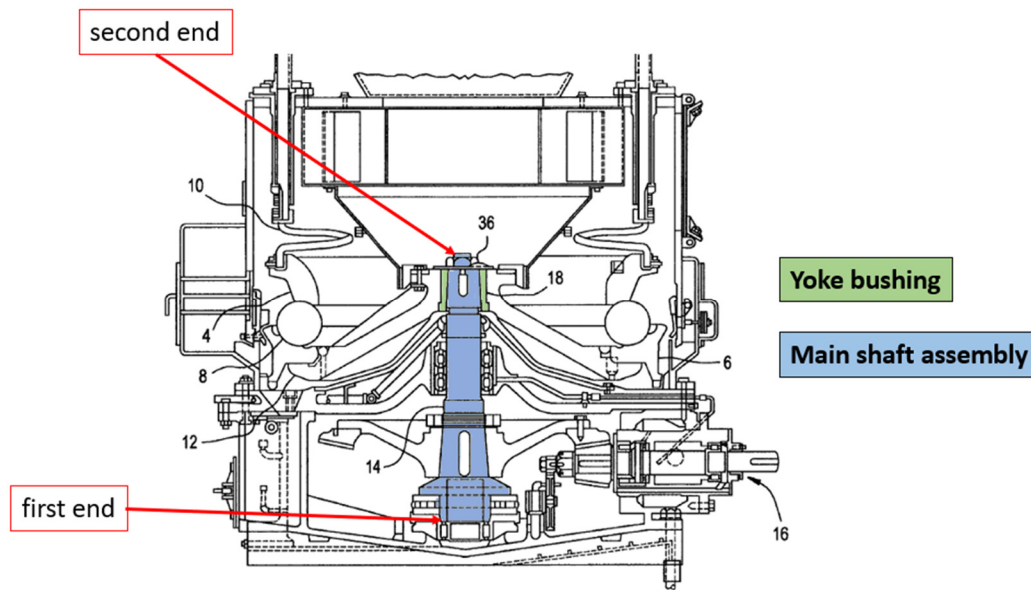


(*Id.*, FIG. 2 (annotated) and FIGs 3-4.)

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. Bearing 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) at its second (upper) end. (*Id.*, 1:45–50.)



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

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.)

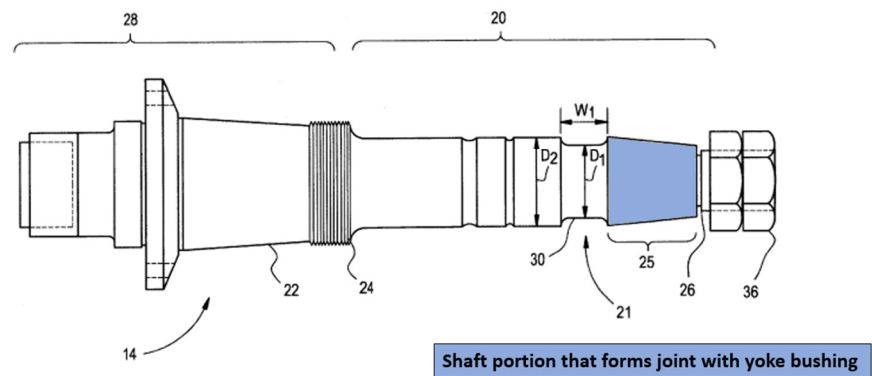
Piepho teaches that shaft failures occur most likely as the result of deterioration of the finely machined shaft surfaces within a joint between the shaft and the bore of the yoke. (*Id.*, 3:12–23.) Piepho further teaches that remedial efforts, including employing an anti-seize compound at a tapered 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.)

Piepho teaches that the intervening material must be suitable for refinement of its surface to a high finish for accurate fit-up. (*Id.*, 3:36–41.) The portion coated with the intervening material and refined to a high finish is joined with corresponding yoke bushing using an interference fit. (*Id.*, 3:6-10.) The portion (25) of the shaft forming the joint with the yoke bushing 18 may be tapered, as

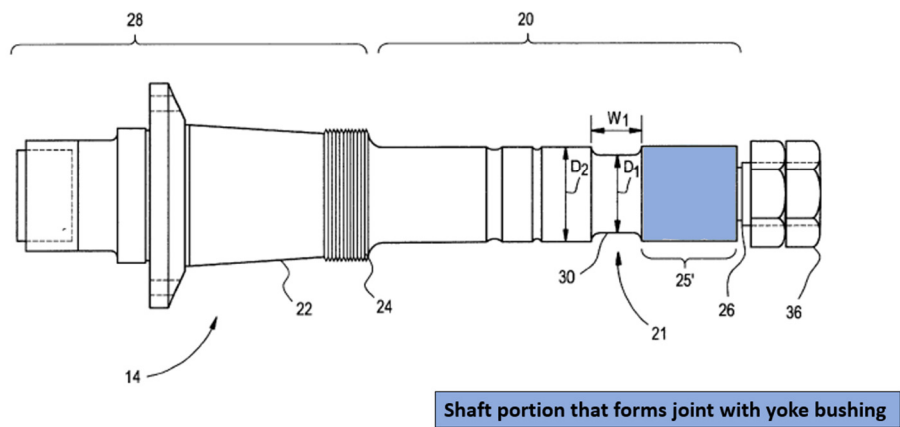
shown in Figure 3 of Piepho below, or cylindrical, as shown in Figure 4 of Piepho below.

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 person of skill in the art would understand that the cylindrical portion 26 is configured such that a that a corresponding fastener component 36 can be attached to secure the yoke to the shaft, as depicted in Figure 1, shown above. (Ex. 2001, ¶ 62.)

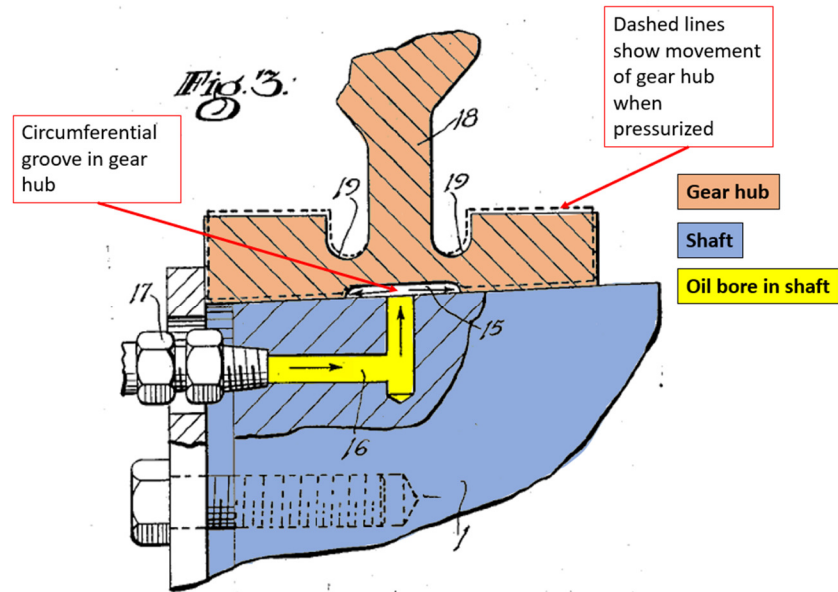
C. Harless (Ex. 1033)

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.)

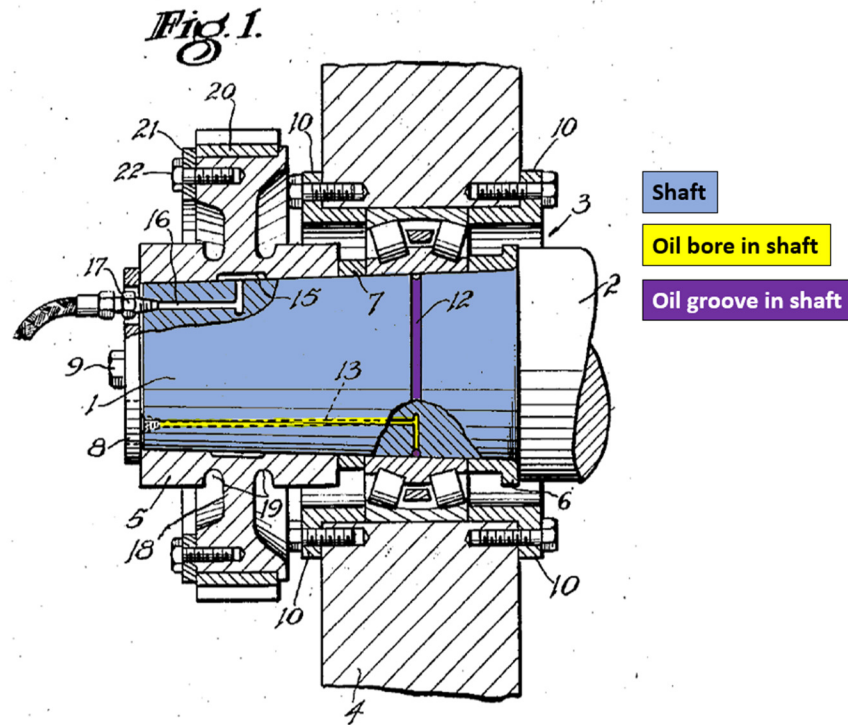
The purported invention disclosed by Harless reduces the amount of pressure needed to push a gear hub radially away from the shaft to dismount the gear, as illustrated in the annotated version of Figure 3 of Harless below. (*Id.*, 1:30–34.)



(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 Figure 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).

IV. CLAIM CONSTRUCTION AND LEVEL OF SKILL IN THE ART

The Board construes claims under *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005) (en banc). For the purposes of this Preliminary Response, Patent Owner submits that the Board need not construe any claim terms as the claims are patentable under any reasonable construction.

For the purposes of this Preliminary Response, Sandvik does not object to Petitioner's position on the level of skill in the art. (Paper 2, 3; Ex. 2001, ¶ 27.)

V. 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.)

Specifically, 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.)

B. A POSITA Would Not Have Been Motivated to Combine Polinski and Piepho in view of Harless

1. Petitioner’s proposed combination would render both Polinski and Piepho inoperable for their intended purpose of preventing shaft failure

It would not have been obvious to modify the combination of Polinski and Piepho in view of Harless, as asserted by Petitioner. (Ex. 2001, ¶ 47–58.) 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).

Petitioner relies upon the proposed combination of Polinski and Piepho to meet limitations [a] and [b]. Whether Polinski's shaft is being modified by Piepho or whether Piepho's shaft is being incorporated into Polinski, in either case, the stated purpose of both Polinski and Piepho is to mitigate shaft fatigue failure. (Ex. 2001, ¶¶ 48–59.)

Polinski mitigates shaft fatigue failure by reducing stress concentrations in a gyratory crusher shaft, specifically by omitting threads that are typically cut into gyratory shafts to attach a crusher mantle. (Ex. 1017, 1:61–67.) More specifically, Polinski discloses a particular joint between a crusher mantle and bearing sleeve. (*Id.*, 1:44–67) In conventional gyratory crushers, the mantle is attached to the main shaft using threads cut into the shaft. (*Id.*, 1:1–67.) Polinski provides that “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.” (*Id.*, 1:26–29.) Polinski further indicates that:

[t]he result [of the aforementioned abrupt changes in the cross-sectional area of the shaft] has been the development of fatigue cracks or fractures in the threaded section of the shaft as well as immediately above and below it where the highest stresses occur due to the abrupt changes in the cross-sectional area of the shaft.

Over a period of time the cracks continue to grow and ultimately render the shaft unserviceable requiring that the crusher be taken out of service and the shaft replaced before crushing operations can be resumed. (*Id.*, 1:29–37)

Polinski teaches that stress concentrations in the main shaft can be reduced by cutting threads into a bearing sleeve instead of the shaft and attaching the mantle to the bearing sleeve. (*Id.*, 1:1–67.) That is, Polinski teaches that geometric discontinuities, such as threads, should be omitted from the main shaft to mitigate fatigue failure. (Ex. 2001, ¶¶ 49–50.)

Piepho mitigates shaft failure by coating a portion of the shaft joined to a yoke bushing with an intervening material designed to prevent fretting wear. (Ex. 1018, 2:55–57.) 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.)

Introducing a groove, as taught by Harless, into the tapered portion of the shaft purportedly disclosed by the combination of Polinski and Piepho would be contrary to the teachings of both Polinski and Piepho for at least three reasons.

First, it was well known that adding a groove to a shaft would introduce stress concentrations, contrary to the teachings of both Polinski and Piepho. (Ex.

2001, ¶ 51.) For instance, as described in Shigley’s *Mechanical Engineering Design* (“Shigley”), dated January 29, 2010 and excerpted below, grooves are stress raisers that cause stress concentrations, which are locations in a shaft where the stress is significantly greater than the surrounding region. (Ex. 2003, 110; Ex. 2001, ¶ 51.)

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.)

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 instructs that 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*. (See Ex. 2003, 112.) 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, both 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 or the tapered portion 25 of Piepho would increase the likelihood of brittle fracture of both shafts. (Ex. 2001, ¶ 52.) Accordingly, a POSITA would not be motivated to add such oil grooves, and their corresponding stress concentrations, to the combination of Polinski and Piepho, especially given their teachings. (Ex. 2001, ¶ 59.)

Second, 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. (Ex. 2001, ¶¶ 54–58.) Specifically, introducing grooves into the shaft increases the relative motion adjacent to the grooves between the shaft and the sleeve (or yoke bushing) joined to the shaft, and such relative motion induces fretting wear. This would have been evident to a person of ordinary skill in the art based on well-known engineering design concepts. (Ex. 2001, ¶ 54.)

For example, Andrew W. Batchelor & Gwidon W. Stachowiak's *Engineering Tribology*, dated November 9, 2000, discusses fretting wear and fretting induced fatigue failure and describes how contact edges between two surfaces in hertzian contact (e.g., two surfaces fit together via an interference fit) are particularly vulnerable to fretting wear:

Contacts which seem to be devoid of relative movement such as **interference fits** do in fact allow sliding on the scale of 1 [μm] when alternating and oscillating loads are carried. It is very difficult to eliminate such movements and the resultant fretting. Fretting wear and fretting fatigue are present in almost all machinery and are the cause of total failure of some otherwise robust components. (Ex. 2004, 593.)

Engineering Tribology teaches that when two solids are pressed together (e.g., in the case of an interference fit), “the contact is characterized by a central no slip region surrounded by an annular slip region. Slip, which reciprocates along with the tangential force, **is the source of fretting damage and the edges of the contact are most vulnerable.**” (*Id.*, 595; Ex. 2001, ¶ 56.)

The tapered region 25 of the Piepho shaft is joined to a yoke bushing via an interference fit. (Ex. 1018, 1:51–55.) The bearing journal 11 of the Polinski shaft is likewise joined to a sleeve 12 via an interference fit. (Ex. 1017, 3:15–18.) The interference-fit contact between the shaft end and yoke bushing (or sleeve)

includes high pressure no-slip regions and low-pressure slip regions. Slip is the source of fretting damage, and the edges of the contact are most vulnerable. (Ex. 2004, 595; Ex. 2001 ¶ 56.) Adding grooves to the surface of the shaft that is fit to the yoke bushing adds corresponding edges of contact (e.g., the edges of contact next to the groove), and thus additional slip regions (susceptible to small-scale relative movements that lead to fretting wear) to the interface between the shaft and yoke bushing. (Ex. 2001, ¶¶ 54–57.) This runs contrary to Piepho’s stated purpose of preventing fretting wear and would also increase the likelihood of fretting wear in the shaft disclosed by Polinski.

Third, an increase in fretting wear would increase the likelihood of fatigue failure. Fretting is directly linked to fatigue failure. As discussed in *Fundamentals of Machine Component Design* by Robert C. Juvinall & 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.) Introducing a groove into a portion

of the shaft joined to a sleeve, as Petitioner urges with its three-way combination, adds edges of contact along the contact region, increasing fretting wear, and raising the likelihood of fatigue failure. (Ex. 2001, ¶¶ 58–59.) Fatigue failure is another failure mode that the purported inventions of both Polinski and Piepho aim to prevent.

A person of ordinary skill in the art would not be motivated to combine Harless with Polinski and Piepho as asserted by Petitioner because it would undermine the stated purpose of both Polinski and Piepho. Polinski and Piepho teach that geometrical discontinuities, including grooves, in the region of the shaft fit with a sleeve (or yoke bushing) are undesirable and lead to shaft failure. Moreover, the purported inventions of both Polinski and Piepho are each directed to techniques for mitigating shaft failure. Introducing a groove to the shaft as disclosed by Harless would detract from the purportedly inventive shaft failure mitigation techniques of Polinski and Piepho.

2. Petitioner’s proposed combination of Polinski and Piepho in view of Harless relies on impermissible hindsight, failing to consider what the references would suggest to persons of ordinary skill in the art

The mere fact that references can be combined or modified does not render the resultant combination obvious. *See KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 417 (2007). “It is impermissible within the framework of section 103 to pick and choose from any one reference only so much of it as will support a given

position, to the exclusion of other parts necessary to the full appreciation of what such reference fairly suggests to one of ordinary skill in the art.” *In re Wesslau*, 353 F.2d 238, 241 (CCPA 1965). Petitioner’s proposed modification is based on improper hindsight and fails to consider the teachings of the references to a person of ordinary skill in the art.

As discussed above, both Polinski and Piepho teach that geometric discontinuities in high stress regions of a shaft surface are undesirable because they lead to shaft failures. Polinski counsels that any such geometrical discontinuities should be removed from the shaft and instead placed in a sleeve. (Ex. 1017, 1:61–68; 2:67–68; 3:1–9.) Piepho is particularly concerned with mitigating fretting wear and corresponding fretting induced bending fatigue, which, as outlined above with reference to *Engineering Tribology*, are both caused by geometric discontinuities, such as grooves. (Ex. 1018, 2:56–58; Ex. 2001 ¶¶ 53-57.)

Harless, meanwhile, discloses a groove cut into a shaft to assist with mounting of gears and similar components. (Ex. 1033, 1:14-25; Ex. 2001 ¶ 44.) Harless does not disclose that its shaft is used for crushing applications, much less in a gyratory crusher, as claimed. Moreover, Harless does not disclose that its shaft is subjected to the same substantial stresses generated by the cyclic loading as the shafts disclosed by Polinski and Piepho. Harless is the only reference of the three relied on by Petitioner against claim 1 for meeting a groove indented into a

shaft at a location where a sleeve is mounted to the shaft, as claimed. (Ex. 2001, ¶ 47.)

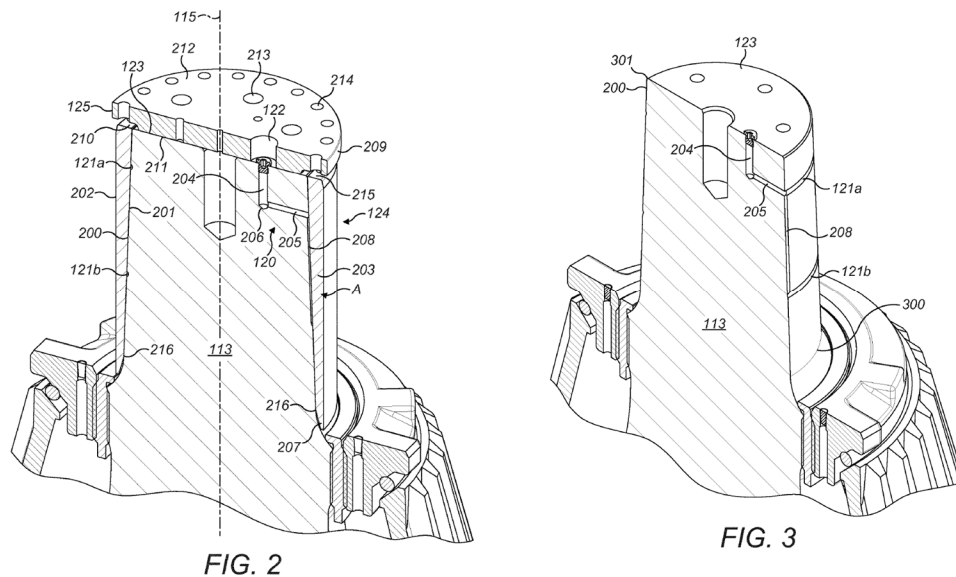
Petitioner alleges that “A POSITA would be [sic] motivated to combine [the groove disclosed by Harless with the teachings of Polinski and Piepho] to simplify the equipment and process for making and breaking interference fits.” (Paper 2, 21.) In so doing, Petitioner impermissibly picks and chooses aspects of the three references that allegedly support a conclusion of obviousness, while ignoring what the references teach to persons of ordinary skill in the art. As discussed *supra*, Polinski and Piepho are both directed to mitigating shaft failure. However, introduction of an oil groove, as disclosed by Harless, into the shaft at the tapered interface between the shaft and the sleeve as taught by the combination of Polinski and Piepho would add stress raisers to the shaft, induce fretting wear, and increase the likelihood of fatigue failure—contrary to the teachings of Polinski and Piepho (Ex. 2001, ¶¶ 48–59.). A person of ordinary skill in the art would not have been motivated to combine Harless with Polinski and Piepho as asserted by Petitioner.

C. Polinski and Piepho Do Not 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 Claimed

Petitioner argues that Polinski in view of 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,” as recited in claims 1, 9, and 14. (Paper 2, 15.)

As described in the '090 Patent, “[u]pper end region 113 comprises a radial taper that defines an upper conical region of main shaft 107. The conical region 113 is tapered so as to decrease in cross sectional area in a direction from shaft [sic] (lower) end 118 to an upper end surface 123 [the second end] **positioned uppermost within the crusher.**” (Ex. 1001, 5:1–5.) Upper end surface 123 is clearly shown in Figures 2 and 3 of the '090 Patent.



(*Id.*, FIGS. 2–3.)

As shown in Figure 2 above of the '090 Patent, sleeve 124 comprises “a second (upper) end 215 for positioning at uppermost end 301 substantially

coplanar with shaft end surface 123.” (*Id.*, 5:33–35.) Thus, when mounted, the upper end of the sleeve is positioned substantially coplanar with the second end of the shaft. Further, as illustrated in FIG. 3 above, a disc-like retainer 125 is releasably mounted over shaft end surface 123 during mounting and dismounting of sleeve 124 at main shaft region 113. (*Id.*, 5:56–58.) An underside surface 211 of disc-like retainer 125 sits co-planar with the shaft end surface 123, and an annular recess extends circumferentially around the retainer perimeter 209 such that a small annular gap is provided within which the sleeve 124 can move. (*Id.*, 6:5–14.) When a pressurized fluid is applied to the groove(s) 121a, 121b, 208, the sleeve 124 slides up into the annular recess, allowing for safe and easy removal of the sleeve 124:

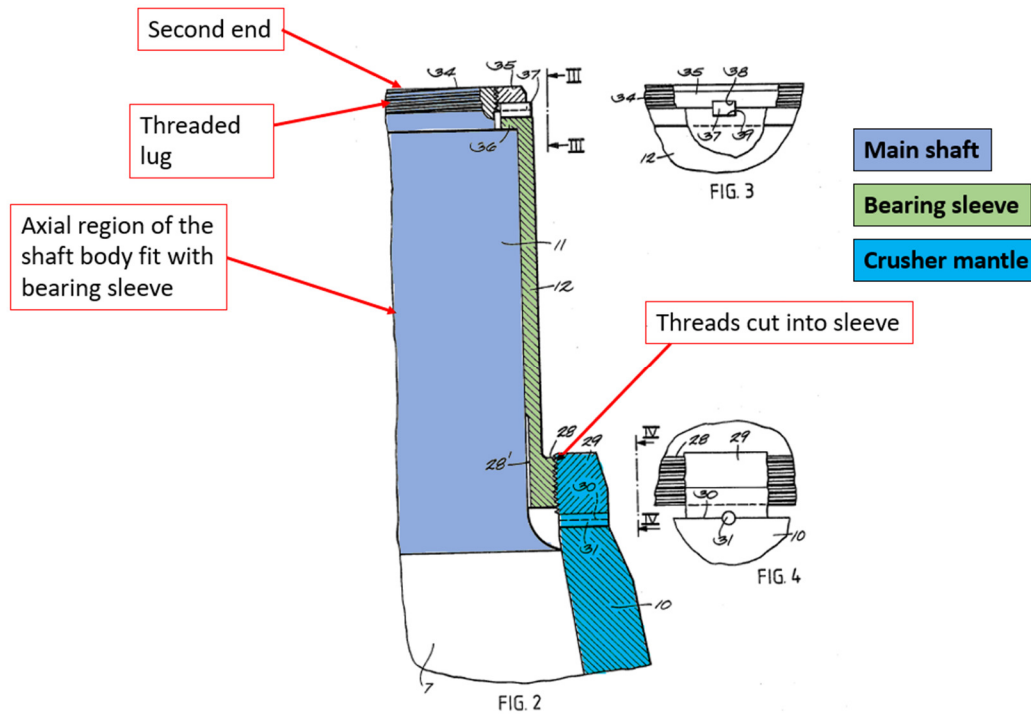
Accordingly, during a sleeve dismounting operation, the sleeve attachment bolts (not shown) are removed. Sleeve 124 is capable of sliding axially into the gap region defined by recess 210 to contact the underside surface 211 (at the recess 210) when fluid pressure is applied. In an alternative mounting operation, retainer 125 is inverted such that disc surface 212 is mated against sleeve end 215 and main shaft end surface 123 to force sleeve 124 axially over and about region 113 as the attachment bolts (not shown) are tightened. (*Id.* 6:14–23.)

Thus, the upper end surface 123 corresponding to the claimed second end, the second (upper) end 215 of the sleeve 124, and the underside surface 211 of retainer 125 are configured to be positioned substantially co-planar with one another. This alignment of components enables the efficient positioning and

attachment of the retainer 125, and corresponding efficient and safe removal of the sleeve 124 from shaft 107, as discussed in the '090 Patent.

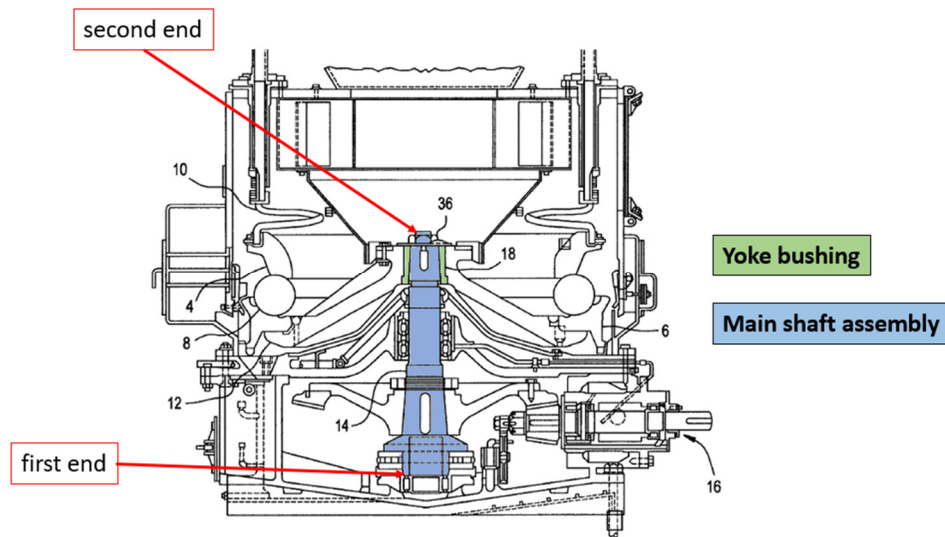
Neither Polinski nor Piepho, taken both alone and in combination, disclose “an axial region of the shaft body extending from the second end and being tapered relative to a longitudinal axis of the shaft body such that a cross sectional area of the shaft body at the tapered axial region decreases in a direction from the first end to the second end,” as recited in claims 1, 9, and 14. .

Figure 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 cylindrical bearing sleeve 12. (*Id.*, 3:15–48.) The threaded lug 34 thus operates to secure the sleeve 12 on the bearing journal 11. (Ex. 2001, ¶ 61.) Nothing in Figure 2 or Polinski, 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. (*Id.*)



(Ex. 1017, FIG. 2 (annotated).)

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 cylindrical portion labeled 26 extends from the second (top) end of the shaft disclosed by Piepho between the top end and the tapered portion 25. (Ex. 2001, ¶¶ 62–63.)



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

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.”

VI. PATENT OWNER’S FINAL COMMENTS

Patent Owner does not concede the legitimacy of any of Petitioner’s arguments not specifically addressed in this Preliminary Response. Patent Owner reserves the right to rebut those arguments in any further permitted briefing. Patent Owner also reserves the right to raise further arguments.

VII. CONCLUSION

For the foregoing reasons, the Board should not institute this *inter partes* review.

Dated: December 23, 2024

Respectfully submitted,

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Certification of Word Count (37 C.F.R. § 42.24)

I hereby certify that this PATENT OWNER PRELIMINARY RESPONSE has 6,902 words (as counted by the “Word Count” feature of the Microsoft Word™ word-processing system), exclusive of “a table of contents, a table of authorities, mandatory notices under § 42.8, a certificate of service or word count, or appendix of exhibits or claim listing.”

Dated: December 23, 2024

By /Mehran Arjomand/
Mehran Arjomand

CERTIFICATE OF SERVICE

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

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