

Filed September 16, 2025

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

CMS Cepcor Limited and CMS Cepcor Americas LLC,
Petitioner

v.

Sandvik Mining and Construction USA LLC
Patent Owner

Case IPR2024-1380
US Patent 9,827,568

**SECOND DECLARATION OF DAVID G. SMITH, IN SUPPORT OF
PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT 9,827,568**

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I. INTRODUCTION

1. I, David G. Smith, submit this Second Declaration on behalf of CMS Cepcor Limited and CMS Cepcor Americas LLC (hereafter CMS, or Defendants), regarding a Petition for *Inter Partes* Review of U.S. Patent No. 9,827,568 ('568 patent or Pat '568).

2. On August 26, 2024 I provided my First Declaration on behalf of CMS Cepcor Limited and CMS Cepcor Americas LLC (hereafter CMS, or Petitioner), regarding a Petition for *Inter Partes* Review of U.S. Patent No. 9,827,568 ('568 patent or Pat '568). My First Report outlined my, qualifications, compensation and opinions on the invalidity of the original claims of the '568 Patent. My First Declaration is incorporated herein by reference.

3. In the time since issuing my First Report, it is my understanding that Sandvick has proposed changes to the original issued claims, in the form of new claims 11-19. In this declaration I have been asked to respond to comments and opinions of Sandvick's Expert Dr. Kytömaa, and provide opinions on the invalidity of the new (changed) claims. This declaration is provided after my review and analysis of the '568 patent, the prior art, relevant background technology, Patent Owners motion to amend and accompanying exhibits and is also based on my education and experience, as well as additional materials identified herein.

II. AMENDED CLAIMS OF THE '568 PATENT

4. It is my understanding that the patent owner has filed a motion to amend the claims of the '568 patent as follows:

Challenged Claim (Original)	Challenged Claim (Substitute)
1P. A gyratory crusher comprising:	11P. A gyratory crusher comprising:
1a1. a main shaft including a shaft body having a first end for positioning at a lower region of the crusher and a second end for positioning at an upper region of the crusher relative to the first end,	11a1. a main shaft including a shaft body having a first end for positioning at a lower region of the crusher and a second end for positioning at an upper region of the crusher relative to the first end,
1a2. a thickness of the shaft body being tapered in an axial direction of the main shaft at a region of the second end so as to decrease in cross-sectional area; and	11a2. a thickness of the shaft body being tapered in an axial direction of the main shaft at a <u>tapered</u> region of the second end so as to <u>taper and</u> decrease in cross-sectional area; and
1b1. a sleeve fitted over the tapered region at the second end of the main shaft,	11b1. a sleeve fitted over the tapered region at the second end of the main shaft,
1b2. the sleeve including an elongate axial wall extending around a longitudinal axis of the sleeve,	11b2. the sleeve including an elongate axial wall extending around a longitudinal axis of the sleeve,
1b3. the axial wall having an internal facing surface for positioning in contact with an outward facing surface of the main shaft, and	11b3. the axial wall having an internal facing surface for positioning in contact with an outward facing surface of the main shaft, and
1b4. an external facing surface relative to the longitudinal axis,	11b4. an external facing surface relative to the longitudinal axis,
1b5. the axial wall extending between the internal and external facing surfaces,	11b5. The axial wall extending between the internal and external facing surfaces,

1b6. the axial wall having a first end for positioning at a lower region of the main shaft and a second end for positioning at an upper region of the main shaft relative to the lower region,	11b6. the axial wall having a first <u>sleeve</u> end for positioning at a lower region of the main shaft and a second <u>sleeve</u> end for positioning at an upper region of the main shaft relative to the lower region,
1b7. wherein a thickness of the axial wall at a region between the first and second ends decreases in a direction from the second end to the first end,	11b7. wherein a thickness of the axial wall at a region between the first and second <u>sleeve</u> ends <u>tapers and</u> decreases in a direction from the second <u>sleeve</u> end to the first <u>sleeve</u> end,
1b8. in the axial direction the internal facing surface at said region between the first and second ends extending transverse to the longitudinal axis so as to taper inwardly towards the longitudinal axis in the direction from the first to the second end.	11b8. in the axial direction the internal facing surface at said region between the first and second <u>sleeve</u> ends extending transverse to the longitudinal axis so as to taper inwardly towards the longitudinal axis <u>of the sleeve</u> in the direction from the first <u>sleeve</u> end to the second <u>sleeve</u> end, <u>and</u>
	11b9. <u>wherein the external facing surface from the first sleeve end to the second sleeve end is parallel to the longitudinal axis of the sleeve such that the external facing surface of the sleeve when viewed externally has a cylindrical geometry.</u>
2P. The gyratory crusher as claimed in claim 1,	12P. The gyratory crusher as claimed in claim <u>11</u> ,
2a. wherein the region over which the thickness of the axial wall decreases extends substantially the full axial length of the sleeve.	12a. wherein the region over which the thickness of the axial wall <u>tapers and</u> decreases extends <u>substantially</u> the full axial length of the sleeve.
3P. The gyratory crusher as claimed in claim 1,	13P. The gyratory crusher as claimed in claim <u>11</u> ,

3a1. further comprising a radial wall extending perpendicular or transverse to the axial wall,	13a1. further comprising a radial wall extending perpendicular or transverse to the axial wall,
3a2. the radial wall being positioned at or towards the second end and extending inwardly towards the longitudinal axis.	13a2. the radial wall being positioned at or towards the second end and extending inwardly towards the longitudinal axis.
4P. The gyratory crusher as claimed in claim 3,	(no corresponding claim)
4a. wherein the radial wall includes a through bore positioned at the longitudinal axis of the sleeve.	
5P. The gyratory crusher as claimed in claim 1,	14P. The gyratory crusher as claimed in claim 11,
5a. wherein a cross-sectional shape profile of the external facing surface is substantially circular.	14a. wherein a cross-sectional shape profile of the external facing surface is substantially circular.
6P. The gyratory crusher as claimed in claim 1,	15P. The gyratory crusher as claimed in claim 11,
6a. wherein a cross-sectional shape profile of the internal facing surface is substantially circular.	wherein a cross-sectional shape profile of the internal facing surface is substantially circular.
7P. The gyratory crusher as claimed in claim 1,	(no corresponding claim)
7a. wherein a shape profile of the external facing surface defines a section of a cylinder in the axial direction.	
8P. The gyratory crusher as claimed in claim 1,	16P. The gyratory crusher as claimed in claim 11,

8a. wherein a shape profile of the internal facing surface defines a section of a cone in the axial direction.	16a. Wherein a shape profile of the internal facing surface defines a section of a cone in the axial direction.
9P. The gyratory crusher as claimed in claim 1,	17P. The gyratory crusher as claimed in claim 11,
9a. further comprising at least one bore provided through the axial wall to allow the passage of a fluid to the internal facing surface.	17a. Further comprising at least one bore provided through the axial wall to allow the passage of a fluid to the internal facing surface.
10P. The gyratory crusher as claimed in claim 1,	18P. The gyratory crusher as claimed in claim 11,
10a. wherein at a curved region of the first end, the internal facing surface is curved radially outward relative to the longitudinal axis in a direction towards the external facing surface such that the axial wall thickness decreases to zero at the curved region.	18a. wherein at a ~~curved~~ region ~~[[of]]~~ <u>proximal to the first sleeve end, the thickness of the axial wall reduces at an increased rate relative to a region of the axial wall proximal to the second sleeve end</u> ~~the internal facing surface is curved radially outward relative to the longitudinal axis in a direction towards the external facing surface such that the axial wall thickness decreases to zero at the curved region.~~
(no corresponding claim; substitute for claim 4)	19P. The gyratory crusher as claimed in claim 18,
	19a. wherein the thickness of the axial wall reduces at a uniform rate along an entire axial length of the sleeve other than the region proximal to the first sleeve end.

5. The most-significant change from claim 1 to claim 11 is requiring that the external facing surface of the sleeve must be cylindrical. Previously this

requirement was part of dependent claim 7. The most-significant change from claim 2 to claim 12 is that the tapered region extends the full length of the sleeve instead of substantially the full length of the sleeve. Claims 3, 5–6, 8–9 were duplicated without changes. Claims 4 and 7 were eliminated. The most-significant change from claim 10 to claim 18 was replacing the curved surface on the inside of the sleeve with a tapered surface that tapers faster than the first tapered surface. Claim 19 is new and describes the first tapered surface having a constant taper angle.

III. CLAIM CONSTRUCTION PRINCIPLES

6. It is my understanding that in an IPR the PTAB has responsibility for construing the claims and uses the "ordinary and customary meaning" standard, also known as the *Phillips* standard, the same standard that federal courts use. It is my understanding that this standard holds that a claim term is to be given the meaning it would have to a person of ordinary skill in the art in question at the time of the invention. It is also my understanding that the ultimate responsibility for adopting a claim construction rests with the PTAB, which issues a final written decision on the patentability of the challenged claims. It is also my understanding that if the PTAB adopts a new construction that was not raised by the petitioner, the petitioner must be given a chance to present new invalidity arguments under that new construction.

7. It is also my understanding that error occurs when interpreting a claim term too narrowly especially if limitations from the specification are imported into the claims. This often happens when a specific example or embodiment described in the patent's written specification is focused on and the construction mistakenly concludes that the invention is limited to that specific detail.

8. In doing so, the court fails to recognize that the claims are typically intended to cover a broader scope than just the specific examples provided in the patent. The Federal Circuit, which hears all patent appeals, has repeatedly reversed these types of errors, cautioning courts against limiting claims to only the described embodiments.

9. It is my understanding that intrinsic evidence, or how the term is used within the specification of the patent, holds more weight than extrinsic evidence, such as outside reliable sources such as dictionary definitions or expert testimony. If the claim construction cannot be resolved using the intrinsic evidence, extrinsic evidence such as dictionaries, other prior art and expert testimony may be considered. It is also my understanding that though the language in the claim determines what the patent owner has invented, the specification (including the original claims) describes what has been invented and should be the principle intrinsic evidence considered during claim construction.

IV. CLAIM CONSTRUCTION

10. In this section I will address the Patent Owner's expert, Dr.

Kytömaa's arguments that terms in the '568 patent require claim construction. As an initial matter, it is curious that the Patent Owner apparently does not believe that the specification of their own patent was adequate in being able to understand the meaning of claim terms used in their own patent. As stated in my First Declaration, it is my contention that the claim terms Dr. Kytömaa contend need construction would be understood by a POSITA using their plain and ordinary meaning. Each of Dr. Kytömaa's proposed constructions will be addressed below.

A. "End"

11. The term "end" is used in the '568 patent is used in several different ways and should therefore be given its broadest meaning which would be a region or section of the shaft or sleeve and not merely an extreme surface.

1. Intrinsic Evidence

12. There are multiple examples in the '568 specification where the term "end" is used to denote at least two meanings. Often "end" is used in '568 in conjunction with other words to form compound terms. Examples include "conical end portion"¹ and "end region"². These are used to denote when the term "end" means a portion or region. When "end" denotes "an extremity of a shaft body or

¹ 9,827,568 4:34

² 9,827,568 4:61

sleeve”, the writers often use the compound terms “end surface”, “lowermost end”, or “uppermost end”. I will discuss the intrinsic evidence for both meanings below.

13. The following are example citations from the ’568 patent where the term “end” denotes a region and not “an extremity of a shaft body or sleeve”.

“The present sleeve arrangement is configured for secure mounting in position via an interference or friction fit arrangement in direct contact with a **tapered end region** of the main shaft.” (9,827,568 2:6-9, emphasis added)

“An **upper end region** of a shaft 113 comprises an axial taper to define an upper conical section.” (9,827,568 3:64-65, emphasis added)

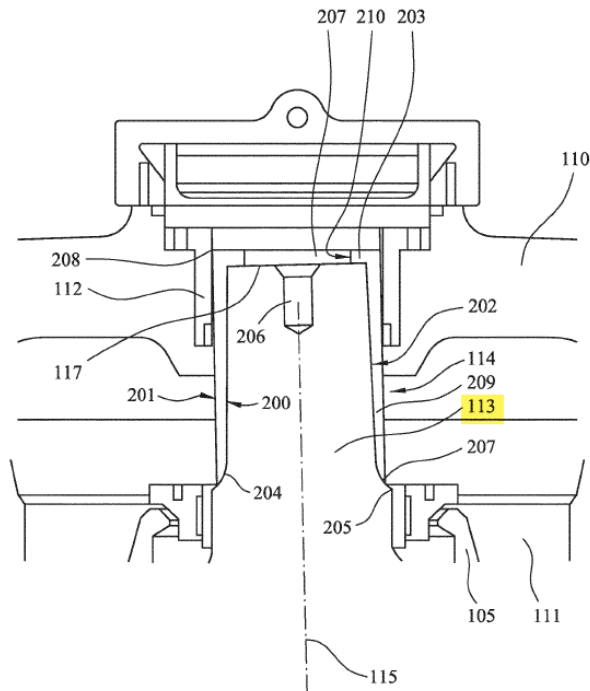


FIG. 2

(9,827,568 Figure 2)

14. The citations above use the words “region” and “tapered ... region” to clarify that the term “end” denotes more than “an extremity of a shaft body or sleeve”. Figure 2 from the ’568 patent, shown above, places the label 113 in the center of the “end region” of the shaft. The citation below clearly shows that 113 is the “shaft end,” and is not pointing to the distal surface.

“Boss 207 and pin 206 are positioned coaxially with **shaft end 113** and sleeve 114.”
(9,827,568 4:47-48)

15. As seen above, the shaft end refers to the shaft region labeled 113. The citations below are examples of the term “end” used without modifiers, but

clearly refer to this same end region 113 when taken in context.

“The gyratory pendulum movement of the crushing head is supported by a lower bearing assembly positioned below the crushing head and a top bearing into which an upper end of the main shaft is journalled.” (9,827,568 1:38-41)

“Typically, the main shaft upper end is protected against wear by a sleeve.” (9,827,568 1:41-42)

“In particular, if the time taken to friction fit the heated sleeve onto the main shaft end is too great it is not uncommon for the sleeve to cool and shrink before it is forced onto the shaft to the correct and final position.” (9,827,568 1:52-55)

“FIG. 1 is a cross - sectional side view of a gyratory crusher having a main shaft supported at its upper end by a top bearing set and having a protective sleeve mounted about the upper end of the main shaft” ((9,827,568 3:27-30)

“10 . The gyratory crusher as claimed in claim 1 , wherein at a curved region of the first end...” (9,827,568 6:22-23)

16. All of the citations above include descriptions that clarify the term “end” to mean a region and could not be referring to an extreme surface. The citation below refers to a “bottom end 118”.

“Similarly, a bottom end 118 of shaft 107 is supported by a bottom bearing assembly 119.” (9,827,568 4:2-3)

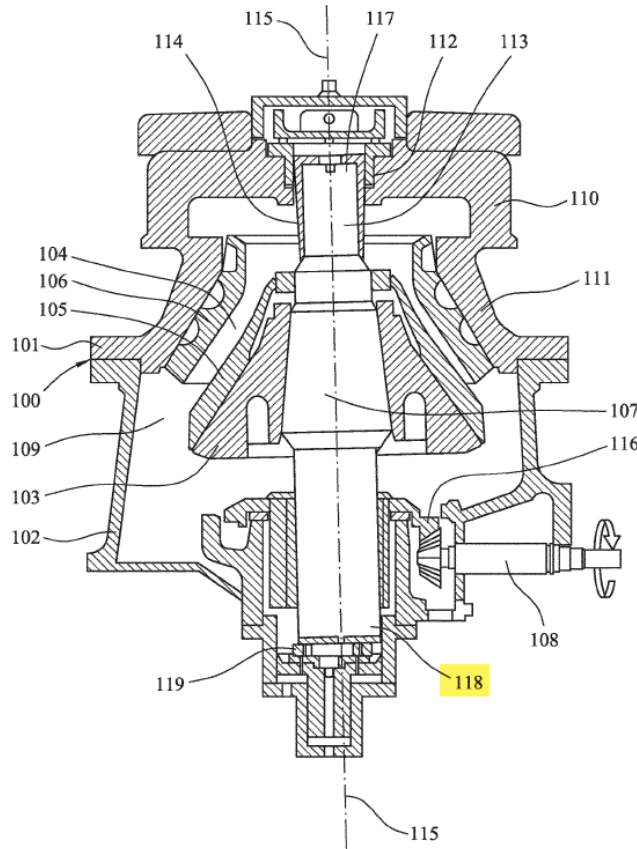


FIG. 1

(9,827,568 Figure 1, emphasis added)

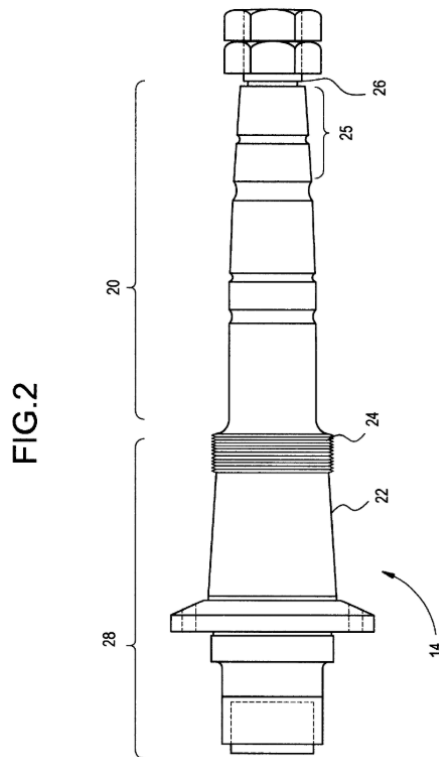
17. As seen in the figure above, 118 is not pointing to an extreme surface of the shaft, but to a region of the shaft.

2. Extrinsic Evidence

18. Extrinsic evidence includes references outside the contended patent such as uses of the term in the field of the art or dictionary definitions. A POSITA is assumed to be aware of the prior art and would look to references in the field of the art for further confirmation of proper construction for the term “end”.

19. All of the cited prior art references in the field of rock crushers use the

term “end”. Piepho ’026, shown below, labels a significant portion of the main shaft of the device the “yoke end (20)” and the “top end (20)”. Piepho refers to a smaller section of the “yoke end (20)” as the “top end (25)”, “tapered end (25)”, “shaft end (25)”, and “cylindrical end (25)”. Piepho uses the term “end” to denote a region.



20. Polinski ’143 also uses end to denote a region as shown in the following citations: “a bearing sleeve fitted about the **end** of the shaft” (Abstract, emphasis added), “The **end** of the shaft is provided with a bearing journal fitted with a replaceable sleeve arrangement...” (1:51-53 emphasis added), and “...annular lip 36 on the **upper end** of the sleeve 12.” (3:26-27 emphasis added)

As with the '090 patent, Polinski uses specific language to indicate when the term “end” refers to “an extremity of a shaft body or sleeve” and not a region, “a retaining ring 51 sized to axially overlies the **outermost ends** of the journal 11 and the sleeve 50.” (3:64-66 emphasis added)

21. There are multiple dictionary definitions for “end”.

End – 3. a part or place at or adjacent to an extremity: at the end of the table; the west end of town. (Random House Webster’s Unabridged Dictionary 2001 p.641)

22. As the above definition illustrates, the term “end” has several meanings. It is easy to find many colloquial uses of “end” that agree with this particular definition. For example, a caboose is located at the end of a train. The caboose is the last part lengthwise in the train. The caboose is a region or section, and not merely the last surface or point. Another example is the end of a novel. The end is the last few pages/chapters and not merely the last period, or the back surface of the cover. Yet another example is a foot is located at the end of a leg. The foot is at the end of the leg but is also part of, or a region of, the leg. A POSITA would be aware of both definitions shown above and the colloquial uses of the term “end” as mentioned. A POSITA would rely on the intrinsic evidence to inform them which extrinsic definition is most appropriate for a given term. Again, as the claim language includes no modifier such as “end region” or “end surface”, a POSITA would conclude that the patent writers intentionally left the

modifiers off within the claims to denote the broadest possible meaning of “end”. Thus, a POSITA would interpret “end” in the claims as its plain and ordinary meaning including a “a part or place at or adjacent to an extremity” and/or “an extremity of a shaft body or sleeve.”

Inconsistencies in Dr. Kytömaa’s Declaration

23. Dr. Kytömaa admits “claims are to be given their broadest reasonable construction consistent with the specification” (§ 5), but attempts to argue for a very narrow meaning of the term “end” based solely on extrinsic evidence. Dr. Kytömaa unsuccessfully attempts to explain how his narrow construction of “end” could be consistent with the figures in the ’568 patent where the label for the bottom end 118 does not point to the end surface but to the end region of the shaft.

24. In light of the above, a POSITA would construe “end” in the claims to have its plain and ordinary meaning including a “a part or place at or adjacent to an extremity” which includes “an extremity of a shaft body or sleeve”.

I. INCONSISTENCIES OF DR. KYTÖMAA

25. Throughout Dr. Kytömaa’s second declaration he argues that a POSITA would not have the understanding necessary to combine the prior art references, as defined by Mr. Smith as “a person who has a bachelor’s degree in mechanical engineering or a related field and at least two years of experience with industrial equipment design and development.”

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

Designing the shaft for a gyratory rock crusher involves significant challenges due to demanding conditions. The shaft must withstand variable and unpredictable fatigue loads resulting from a wide range of material hardnesses. Its eccentric design introduces complexity not typically encountered by an engineer with only two years of experience.”³

26. Later Dr. Kytömaa argues that a POSITA would have extraordinary insight of stresses when he states that a POSITA would understand that “adding an oil groove to the bearing journal would have a similar effect to the threads described by Polinski”. Dr. Kytömaa goes on to attribute this extraordinary insight to the teachings of Shigley’s Mechanical Engineering Design, which is a common textbook used in undergraduate studies by Mechanical Engineering students. This same Shigley textbook addresses every one of the complexities that Dr. Kytömaa believes a POSITA would not typically encounter. These inconsistencies show how Dr. Kytömaa is attempting to use apposing arguments to support his biased opinions whenever one or the other suits him. The following table illustrates Dr. Kytömaa’s inconsistencies.

Statement of Dr. Kytömaa	Inconsistency
Things that “would not be obvious to a POSITA” and “beyond the level of skill” ⁴ :	Dr. Kytömaa argues that a POSITA would be aware of Shigley ⁵ , but Shigley addresses these very subjects.

³ Second Declaration of Dr. Kytömaa ¶ 19-20

⁴ Second Declaration of Dr. Kytömaa ¶ 20

⁵ Second Declaration of Dr. Kytömaa ¶ 78

Tribology Fracture mechanics Fluid mechanics	Shigley 9e Section 5-12 – Introduction to Fracture Mechanics Tribology – the study of friction, wear, lubrication, and the design of bearings; the science of interacting surfaces in relative motion. Shigley has a section concerning this subject as well: Shigley 9e Section 3-16 – Press and Shrink Fits As shown above, Shigley provides instruction on tribology and fracture mechanics. If Dr. Kytömaa believes a POSITA would be aware of Shigley, as it is a commonly used textbook for one of the required curriculum in undergraduate mechanical engineering studies, then all other curriculum and associated textbooks should also be something a POSITA would be aware of and capable of utilizing. Fluid mechanics is another required subject for all mechanical engineering students. A commonly used textbook is Munson’s “Fundamental of Fluid Mechanics”. Munson dedicates much of the book to aspects of fluid dynamics: Munson 3 – Fluids in Motion – The Bernoulli Equation Munson 4 – Kinematics of Fluid Motion Munson 5 – Flow Analysis Using Control Volumes
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	Munsun 6 – Flow Analysis Using Differential Methods A POSITA would be well aware of tribology, fracture mechanics and fluid mechanics.
“The shaft must withstand variable and unpredictable fatigue loads resulting from a wide range of material hardnesses. Its eccentric design introduces complexity not typically encountered by an engineer with only two years of experience.”⁶	Dr. Kytömaa attempts to diminish the capabilities of a POSITA. Again, Dr. Kytömaa implies that a POSITA would be unaware of major sections of Shigley. Chapter 6 – Fatigue Failure Resulting from variable loading Section 6-5 – The Strain-Life Method Section 6-6 – The Linear-Elastic Fracture Mechanics Method Section 2-4 – Hardness Section 5-16 – Surface Fatigue Strength Mechanical engineers are trained to deal with these exact challenges while obtaining their degree. Stresses are not unpredictable and many sources are available to quantify material properties. A POSITA would not be so intimidated to lack any motivation to combine known solutions as taught in the prior art.
“Nor would it have been obvious to modify Polinski to reduce the thickness of the threaded shoulder 28 because this would significantly increase the likelihood that the connection between the sleeve	In the previous section above Dr. Kytömaa argues that a POSITA would have no experience with fatigue or material hardness. Now he argues that it would not have been obvious to a POSITA to change the thickness of a threaded shoulder because they would know intuitively that any change would lead to failure. He goes on to say a POSITA would

⁶ Second Declaration of Dr. Kytömaa ¶ 20

and mantle would fail.”⁷ “...Adding an oil groove to the bearing journal would have a similar effect to the threads described by Polinski. This would have been evident to a person of ordinary skill in the art.”⁸	also know that an oil groove would have the same stress as a threaded connection. Dr. Kytömaa’s assumptions are not only inconsistent, but also incorrect. The many sections in Shigley dedicated to calculating fatigue failure both enables a POSITA to analyze the stress as well as educate them on the many methods to reduce high stress regions and concentrations in order to optimize a design for the intended use. No experienced mechanical engineer would immediately know the fatigue life of a component, or the fatigue life due to a change to that component, without some analysis. Again, a POSITA would be educated to solve those very stress concerns.
“Cutting oil grooves into the Polinski shaft in the bearing journal 11 would introduce stress raisers and corresponding stress concentrations into the shaft, thus increasing the chance of fracture, precisely what Polinski aims to prevent by removing threads from the shaft. Given Polinski’s teaching that discontinuities should be removed from high-stress regions of the shaft, a POSITA would not have been motivated	Dr. Kytömaa attempts to use Polinski to prove that any discontinuities “should be removed” while Polinski actually teaches that these high stress regions are “satisfactory for most crusher installations” and “normal”. “To secure the mantle to the shaft, a threaded section has generally been provided on the shaft immediately above the tapered portion supporting the mantle for receiving a head nut which forces the mantle against the tapered portion of the shaft. While this type of arrangement 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

⁷ Second Declaration of Dr. Kytömaa ¶ 73

⁸ Second Declaration of Dr. Kytömaa ¶ 78

to one or more a grooves in the journal 11 of the shaft body of Polinski.”⁹ “Because such failure would be an existential threat...”¹⁰ “Any benefits associated with the addition of a groove in Polinski would appear diminished in view of the existential risk of shaft failure...”¹¹	below the threaded section have resulted in high local stress concentrations in these regions of the shaft.” Polinki 1:15-25 (emphasis added) “The sleeve arrangement, which is releasably secured to the bearing journal at the low stressed, outermost end of the shaft, includes a head nut which abuts the mantle to secure it to the tapered portion of the shaft. From the foregoing, it can be seen that the invention contemplates an arrangement wherein abrupt structural discontinuities in the normally high-stressed regions of the main shaft have been essentially eliminated 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,” (Polinski 1:56-67, emphasis added) Polinski teaches what any POSITA would understand; that stress must be calculated and then the stress must be managed to meet the requirements of the machine operation. This is a typical and normal task for any machine design, or redesign.
“Moreover, a POSITA would not be motivated to incorporate a groove into the shaft of Polinski as modified by the proposed combination with	Dr. Kytömaa then attempts to argue a lack of motivation to combine Piepho with Polinski due to the threat of fretting wear and fatigue failure. Again, fretting is another issue that a POSITA would be aware of from textbooks

⁹ Second Declaration of Dr. Kytömaa ¶ 81

¹⁰ 2nd Declaration of Dr. Kytömaa ¶ 86

¹¹ Patent Owner Response (’090) Pg. 3

Piepho at least for the additional reason that incorporating such a groove would increase the likelihood of fretting wear and fretting induced fatigue failure.”¹²	used in obtaining their degree and prior art, such as Shigley Section 6-9 Endurance Limit Modifying Factors and Piepho. Piepho teaches that fretting issues occur in rock crushers, as well as how these high stress interactions have been mitigated and often do not produce stress concentrations. “Additionally, to abate fretting corrosion of the main shaft in the normally high stressed portion of the shaft at the base of the bearing journal 11, the sleeve is counterbored as indicated at 28' to prevent engagement between the sleeve and the main shaft in the proximity of the threaded annular shoulder 28.” (Polinski 3:9-15) “In addition, the coating should resist cracking or Separation at Surface Strains up to approximately ± 65 micro inches/inch (corresponding to +20,000 psi stress) for essentially unlimited number of cycles.” (Piepho 3:55-59, emphasis added) “Some of the advantages of the present invention include the following. The existing shaft and yoke geometries need not be changed. The application of an intervening layer of coated material allows the use of Surface treatments like shot peening which can mutilate the Surface, but the final Surface is refined with the coating material while leaving the treated Surface undisturbed. The intervening layer is of high hardness for
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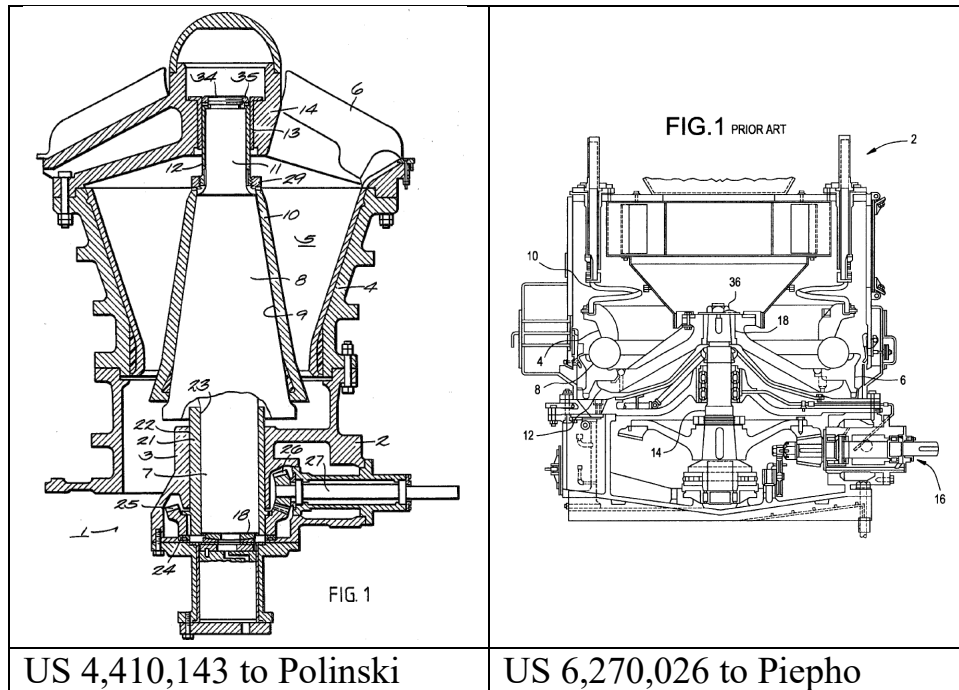
¹² Second Declaration of Dr. Kytömaa ¶ 82

	maximum resistance to fretting and wear. Minor fretting does not produce Stress concentrations in the Shaft material. The coating provides protection from mechanical and corrosion damage in the area outside the fitted joint. An additional advantage with the present invention is the ability to use lubricants Such as tungsten disulfide on the bushing and the coated tapered end.” (Piepho 4:23-36) A POSITA would not be dissuaded from combining Polinski with Piepho due to fretting concerns. Again, fretting is another well known mechanism that a POSITA would be aware of and be able to solve.
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27. Dr. Kytömaa’s arguments are biased, and appear to be litigation based as opposed to the reasonable understanding of a POSITA. His opinions on claim construction are not supported by the intrinsic evidence and the reasons that he purports would dissuade a POSITA from combining the prior art references fall short and are contradicted by the very references he says support them. Dr. Kytömaa’s arguments should be weighed accordingly.

V. INVALIDITY ANALYSIS OF THE '568 SUBSTITUTE CLAIMS

A. Polinski in View of Piepho Render Claims 11-16 Obvious



28. As discussed previously, Polinski discloses a gyrating rock crusher.

Piepho is also a rock crushing apparatus. In particular, Piepho is designed to crush coal:

“The present invention relates in general to an improved main Shaft for a coal pulverizer, and more particularly to an improved main shaft for use in B&W Type E and EL pulverizers”¹³

29. As a rock crushing apparatus, Piepho is in the same field of endeavor as the '568 Patent and Polinski and thus (being analogous art) would easily be within the purview of a POSITA. Further, Piepho teaches the interchangeability between a cylindrical joint and a tapered joint. Piepho also teaches that a tapered

¹³ US 6,270,026 to Piepho 1:5-8

joint is preferable.

*“The present invention provides an intervening material between the shaft end (25) and the mating bore in yoke bushing (18) fitted within the bore of yoke (12) to prevent fretting damage. For accurate alignment and for reliable Support of the yoke, this joint (21) must be capable of accepting radial, axial, and bending or overturning loads. **Preferably, the joint (21) is a tapered joint with the tapered end (25) of shaft (14).** The yoke bushing (18) has a mating bore similarly tapered. Shaft end (25) may be constructed for either a keyless or a keyed fit. Also, **Shaft end (25) alternatively may be cylindrical rather than tapered as seen in FIG. 4.**”¹⁴*

30. A POSITA would be motivated to combine the tapered joint of Piepho with the teachings of Polinski as Piepho teaches it is preferable. In addition to this, a POSITA would understand that a tapered joint is preferable to a cylindrical joint at least because they are easier to install and remove. A POSITA would have reasonable expectation of success in making the combination as both cylindrical and tapered interference fit joints were common in the prior art and had been used for decades. This combination is nothing more than a simple combination of known elements according to known methods to yield predictable results.

Challenged Claim	Does the Prior Art disclose this?
11P. A gyratory crusher comprising:	YES: Although the preamble is generally not considered limiting, Polinski discloses a gyratory crusher. In particular Polinski states: <i>“The present invention relates to <u>gyratory crushers</u> and, in particular, to the main shaft supporting the crusher head or mantle within the crusher.”¹⁵</i>

¹⁴ US 6,270,026 to Piepho 3:24-35, emphasis added

¹⁵ US 4,410,143 to Polinski 1:6-8, emphasis added

Gyratory
crusher

eccentric axis

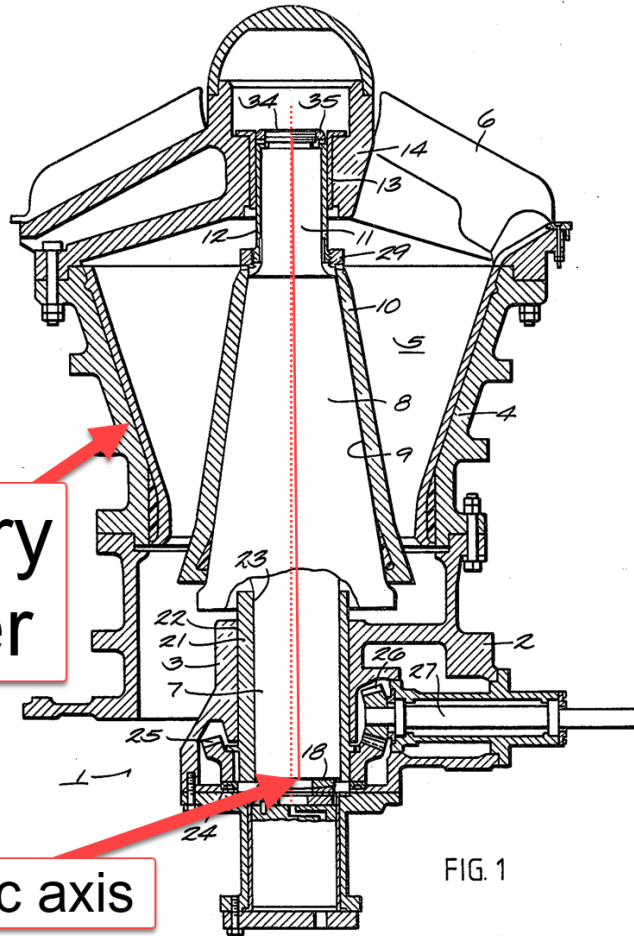


FIG. 1

16

As can be seen above, Figure 1 of Polinski shows a cross section of a conventional gyratory crusher. The central cone is part of the main shaft which is mounted on an eccentric drive which creates the gyrational crushing motion as it is driven. Specifically, Polinski states,

“The main shaft 7, which is carried on an axial thrust bearing 18 mounted on the lower frame 2 beneath the shaft, is rotatably journaled within an eccentric sleeve bearing carried within the vertical hub 3 to direct the gyratory movement of the shaft.”¹⁷

Beyond this, as discussed previously, Piepho is also a rock crushing apparatus. In particular, Piepho is designed to crush coal.

“The present invention relates in general to an improved main Shaft for a coal pulverizer, and more particularly to an improved main shaft for use in B&W Type E and EL pulverizers”¹⁸

¹⁶ US 4,410,143 to Polinski Figure 1, annotated

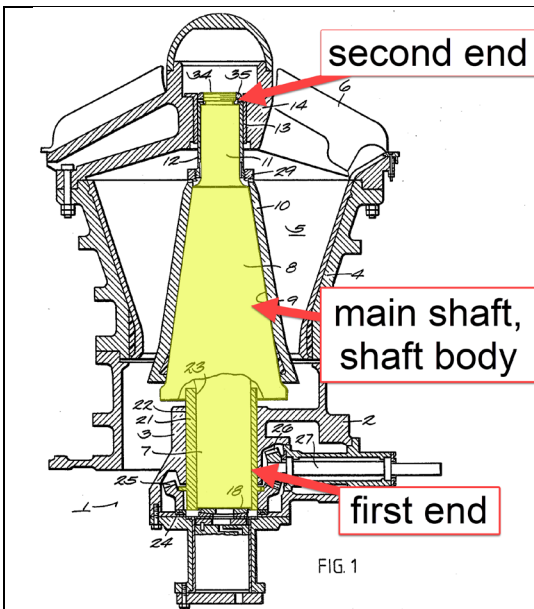
¹⁷ US 4,410,143 to Polinski 2:48-52, emphasis added

¹⁸ US 6,270,026 to Piepho 1:5-8

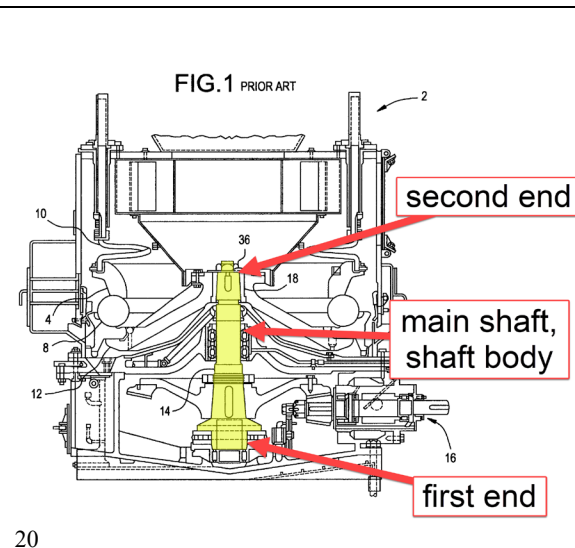
As a rock crushing apparatus, Piepho is in the same field of endeavor as Polinski.

11a1. a main shaft including a shaft body having a first end for positioning at a lower region of the crusher and a second end for positioning at an upper region of the crusher relative to the first end,

YES: As shown below, both Polinski and Piepho disclose a main shaft including a shaft body having a first end for positioning at a lower region of the crusher and a second end for positioning at an upper region of the crusher relative to the first end.



Polinski main shaft



Piepho main shaft

Polinski teaches:

*"Referring to FIG. 1, the gyratory crusher 1 embodying the invention includes a lower frame 2 provided with a vertical hub 3, an upper frame 4 forming the outer shell of the crusher chamber 5, a top frame or spider 6 mounted on the upper frame 4, and **a centrally located gyratable main shaft 7.**"²¹*

Piepho teaches:

"The bottom ring 6 is driven by the yoke 12 which is attached to a vertical main shaft assembly 14 of the pulverizer." ²²

¹⁹ US 4,410,143 to Polinski Figure 1, annotated

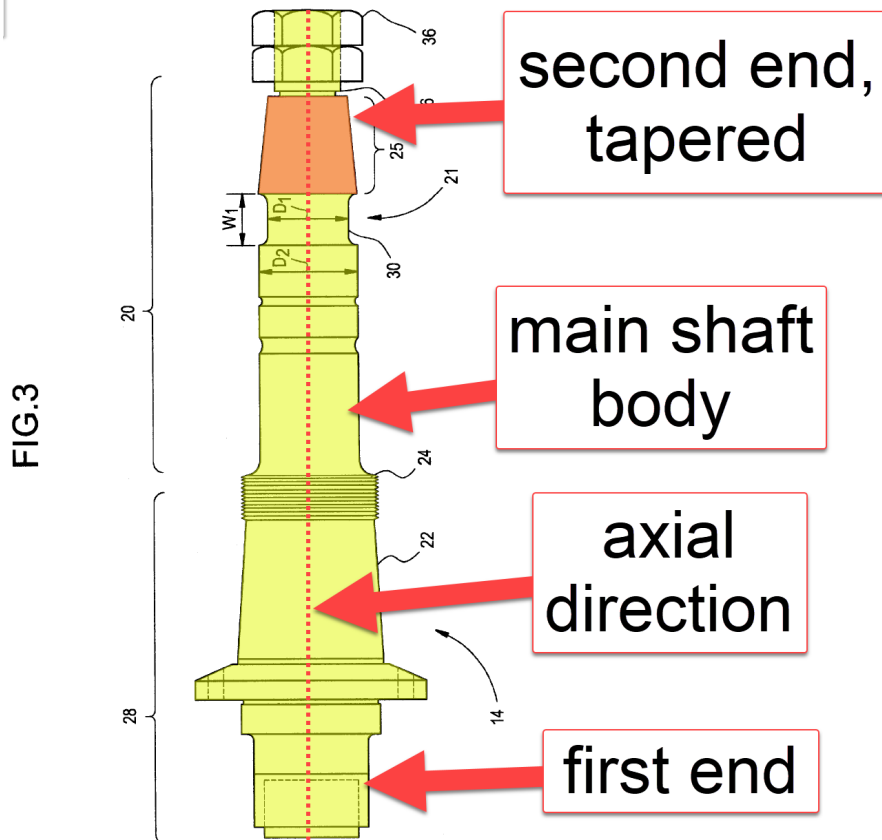
²⁰ US 6,270,026 to Piepho, Figure 1 annotated

²¹ US 4,410,143 to Polinski 2:32-37, emphasis added

²² US 6,270,026 to Piepho 1:26-27

11a2. a thickness of the shaft body being tapered in an axial direction of the main shaft at a tapered region of the second end so as to taper and decrease in cross-sectional area; and

YES: Polinski in view of Piepho discloses a thickness of the shaft body being tapered in an axial direction of the main shaft at a tapered region of the second end so as to taper and decrease in cross-sectional area.



23

As shown above, the main shaft of Piepho is tapered on the second end of the shaft body. Further, the taper is in an axial direction. Due to this taper, the cross-sectional area of the shaft body decreases as shown by the orange highlighted area above.

*“The present invention provides an intervening material between the shaft end (25) and the mating bore in yoke bushing (18) fitted within the bore of yoke (12) to prevent fretting damage. For accurate alignment and for reliable Support of the yoke, this joint (21) must be capable of accepting radial, axial, and bending or overturning loads. **Preferably, the joint (21) is a tapered joint with the tapered end (25) of shaft (14).**”*²⁴

²³ US 6,270,026 to Piepho, Figure 3 annotated

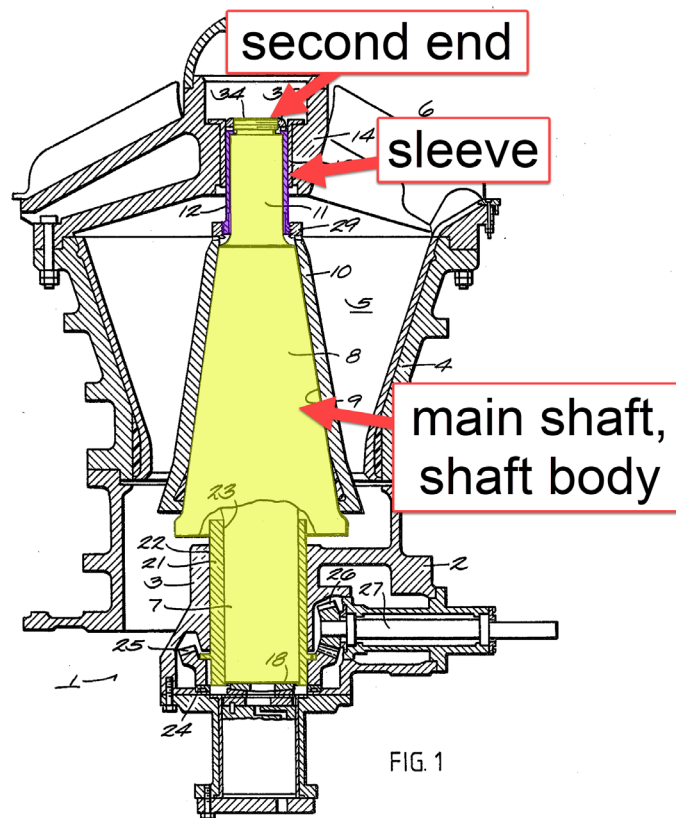
²⁴ US 6,270,026 to Piepho 3:23-31, emphasis added.

A POSITA would have been motivated to combine the tapered end on the main shaft of Piepho with the main shaft on Polinski. This combination would have been nothing more than combining known elements according to known methods to yield predictable results. A POSITA would be further motivated, as Piepho describes, as the tapered shaft aids in accurate alignment which is notoriously more difficult with purely cylindrical shafting.

11b1. a sleeve fitted over the tapered region at the second end of the main shaft,

YES: Polinski in view of Piepho discloses a sleeve fitted over the tapered region at the second end of the main shaft.

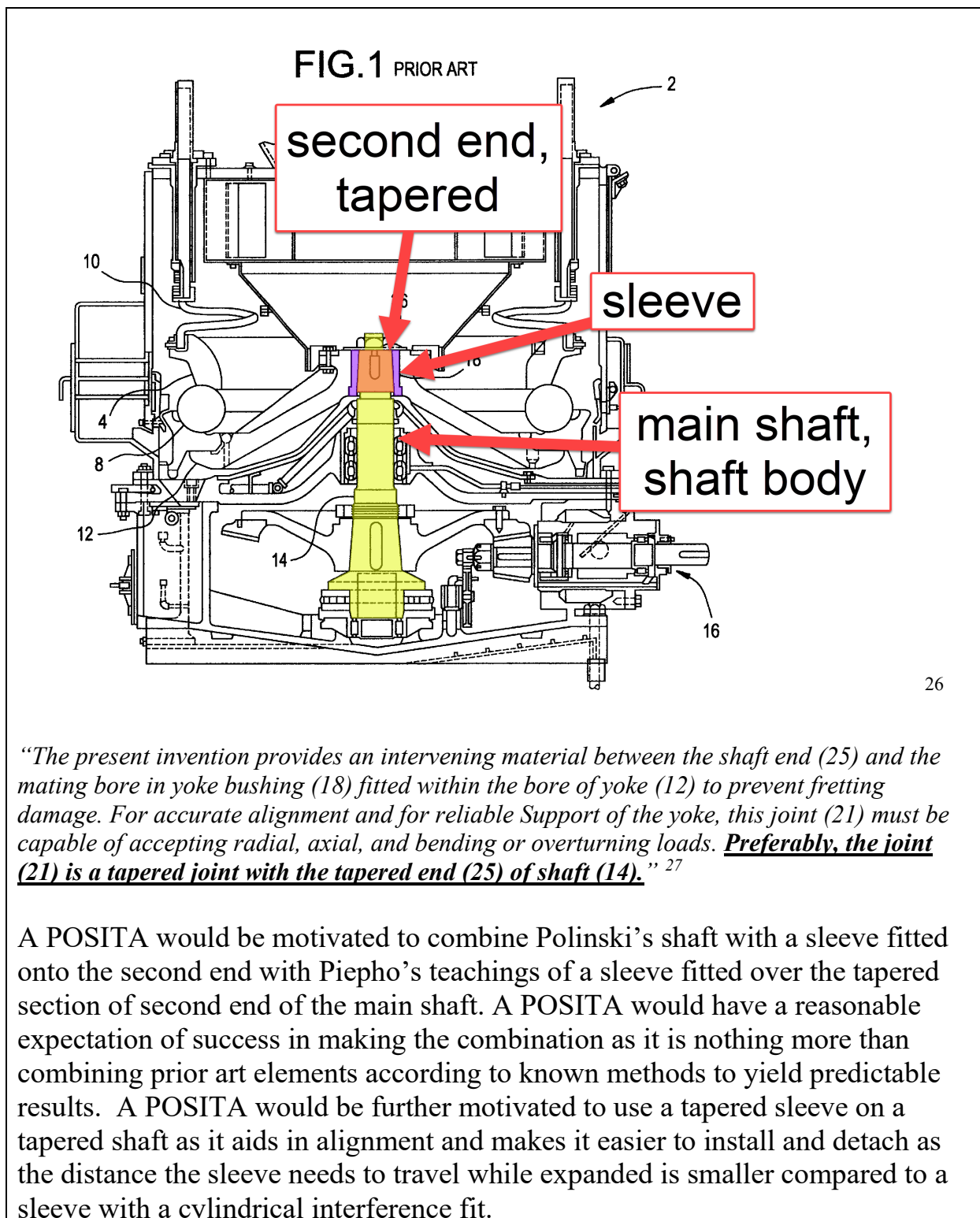
Polinski teaches a sleeve fitted over the second end of the main shaft.



25

Piepho further teaches a sleeve fitted over the tapered region at the second end of the main shaft. This sleeve is the bushing 18 (highlighted in purple below). Piepho teaches that the bushing has a tapered internal surface that is fitted over the tapered region of the main shaft.

²⁵ US 4,410,143 to Polinski Figure 1, annotated

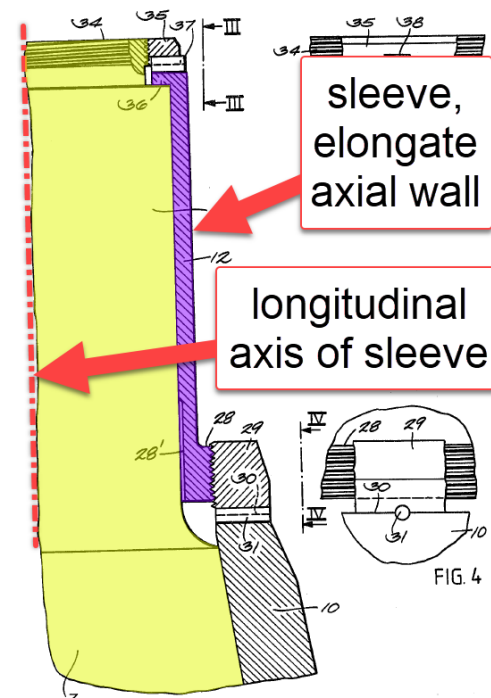


²⁶ US 4,410,143 to Polinski Figure 1, annotated

²⁷ US 6,270,026 to Piepho 3:23-31, emphasis added.

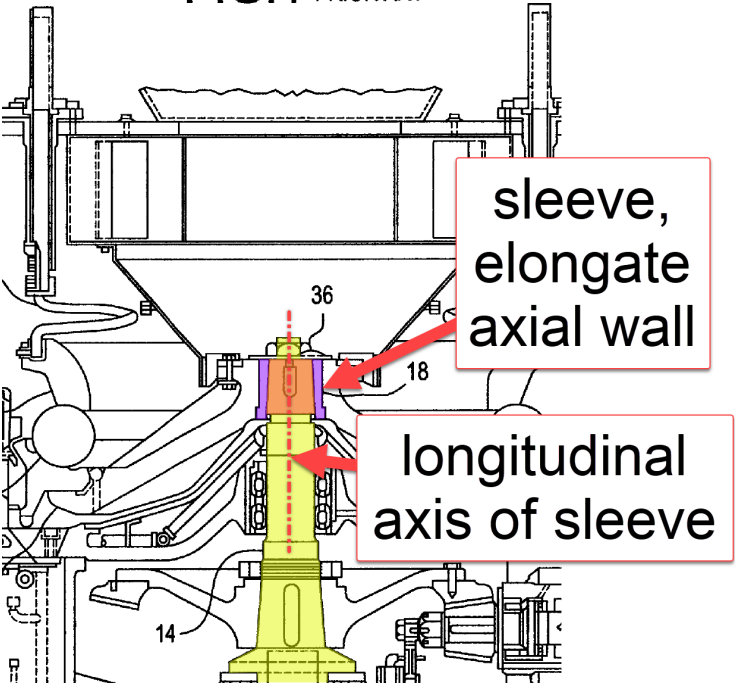
11b2. the sleeve including an elongate axial wall extending around a longitudinal axis of the sleeve,

YES: Polinski in view of Piepho discloses a sleeve including an elongate axial wall extending around a longitudinal axis of the sleeve.

 sleeve, elongate axial wall longitudinal axis of sleeve FIG. 2 FIG. 4	Polinski sleeve <i>“As will be described, the cross-section of the upper end of the shaft 7 gradually converges to form a bearing journal 11 extending from the tapered portion of the shaft <u>which is fitted with a cylindrical bearing sleeve 12</u> rotatably retained within a bearing bushing 13 secured within a coaxially aligned hub 14 in the spider 6.”²⁹</i>
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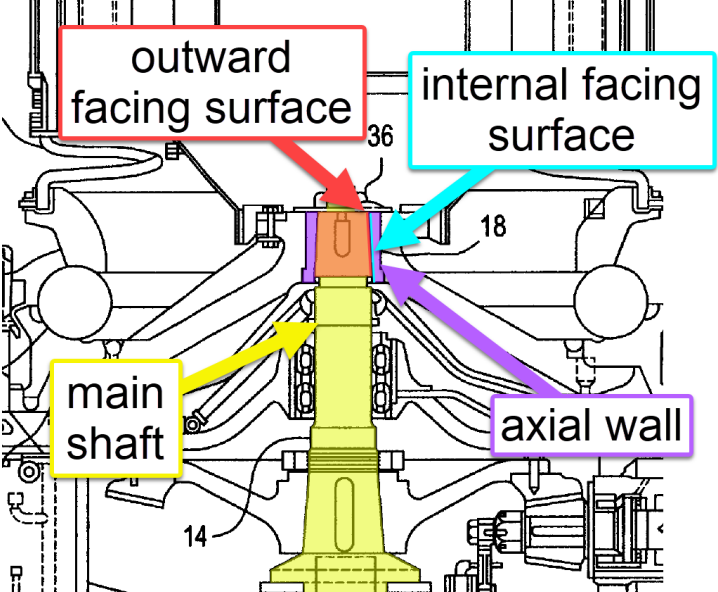
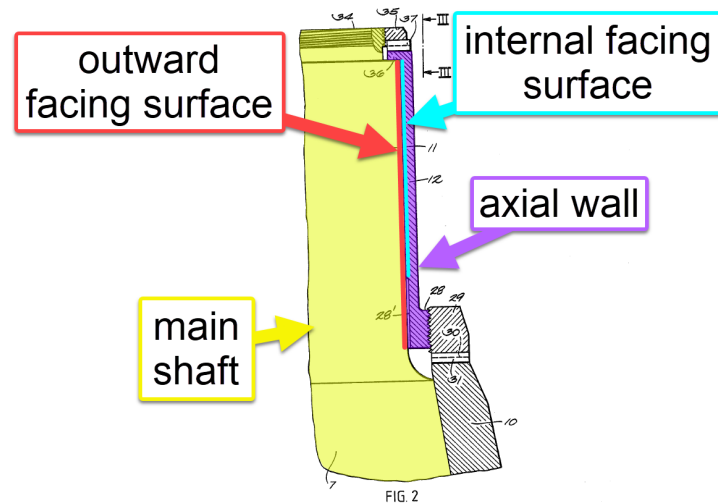
²⁸ US 4,410,143 to Polinski Figure 2, annotated

²⁹ US 4,410,143 to Polinski 2:41-47, emphasis added.

FIG.1 PRIOR ART  sleeve, elongate axial wall longitudinal axis of sleeve 30	Piepho sleeve <i>“The present invention provides an intervening material between the shaft end (25) and the mating bore in yoke bushing (18) fitted within the bore of yoke (12) to prevent fretting damage. For accurate alignment and for reliable Support of the yoke, this joint (21) must be capable of accepting radial, axial, and bending or overturning loads. Preferably, the joint (21) is a tapered joint with the tapered end (25) of shaft (14).”³¹</i>
As shown above, both Polinski and Piepho have a sleeve with an elongate axial wall. Further, as shown, the axial wall of the sleeve extends around the longitudinal axis of the sleeve. In either sleeve, the length is greater than the diameter of the sleeve, demonstrating it is elongate in shape. However, even if the sleeve was shorter, the axial wall would still be elongated along the longitudinal axis of the sleeve.	
11b3. the axial wall having an internal facing surface for positioning in contact with an outward facing surface of the main shaft, and	YES: Both Polinski and Piepho disclose a sleeve with an axial wall having an internal facing surface for positioning in contact with an outward facing surface of the main shaft.

³⁰ US 4,410,143 to Polinski Figure 1, annotated

³¹ US 6,270,026 to Piepho 3:23-31

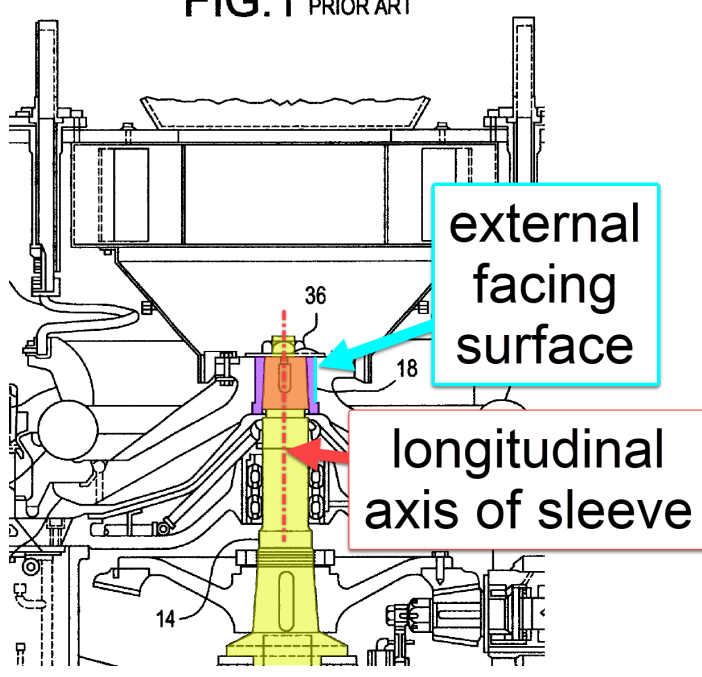
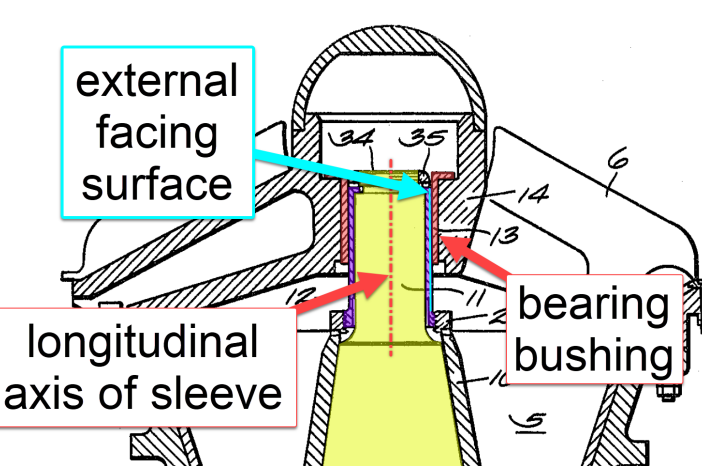
	Piepho <i>“The fit or joint between the yoke bushing (18) and upper taper (25) is an interference type fit.”³³</i>
	Polinski <i>“When the bearing sleeve 12 is installed on bearing journal 11, it is initially heated so that as it cools it forms a heat-shrink type fit releasably securing it to the journal 11”³⁵</i>
As shown above, both Piepho and Polinski teach that the axial wall of the sleeve has an internal facing surface which is positioned in contact with an outward facing surface of the main shaft. Each of the sleeves of Piepho and Polinski have an interference fit which generates contact pressure between the inside face of the axial wall and the outside face of the main shaft.	
11b4. an external facing surface relative to the longitudinal axis,	YES: Both Polinski and Piepho disclose a sleeve with an external facing surface relative to the longitudinal axis.

³² US 6,270,026 to Piepho, Figure 1 annotated

³³ US 6,270,026 to Piepho 3:6-7

³⁴ US 4,410,143 to Polinski Figure 2, annotated

³⁵ US 4,410,143 to Polinski 3:15-18

FIG.1 PRIOR ART  external facing surface longitudinal axis of sleeve 36	Piepho <i>“The present invention provides an intervening material between the shaft end (25) and the mating bore in yoke bushing (18) fitted within the bore of yoke (12) to prevent fretting damage.”³⁷</i> As shown and described, the bushing (18) is fitted into a bore on the yoke (12). This fit-up involves contact between an external facing surface of the bushing (18) and the bore of yoke (12).
 external facing surface longitudinal axis of sleeve bearing bushing 38	Polinski <i>“As will be described, the cross-section of the upper end of the shaft 7 gradually converges to form a bearing journal 11 extending from the tapered portion of the shaft which is fitted with a cylindrical bearing sleeve 12 rotatably retained within a bearing bushing 13 secured within a coaxially aligned hub 14 in the spider 6.”³⁹</i>

³⁶ US 6,270,026 to Piepho, Figure 1 annotated

³⁷ US 6,270,026 to Piepho 3:24-27

³⁸ US 4,410,143 to Polinski Figure 2, annotated

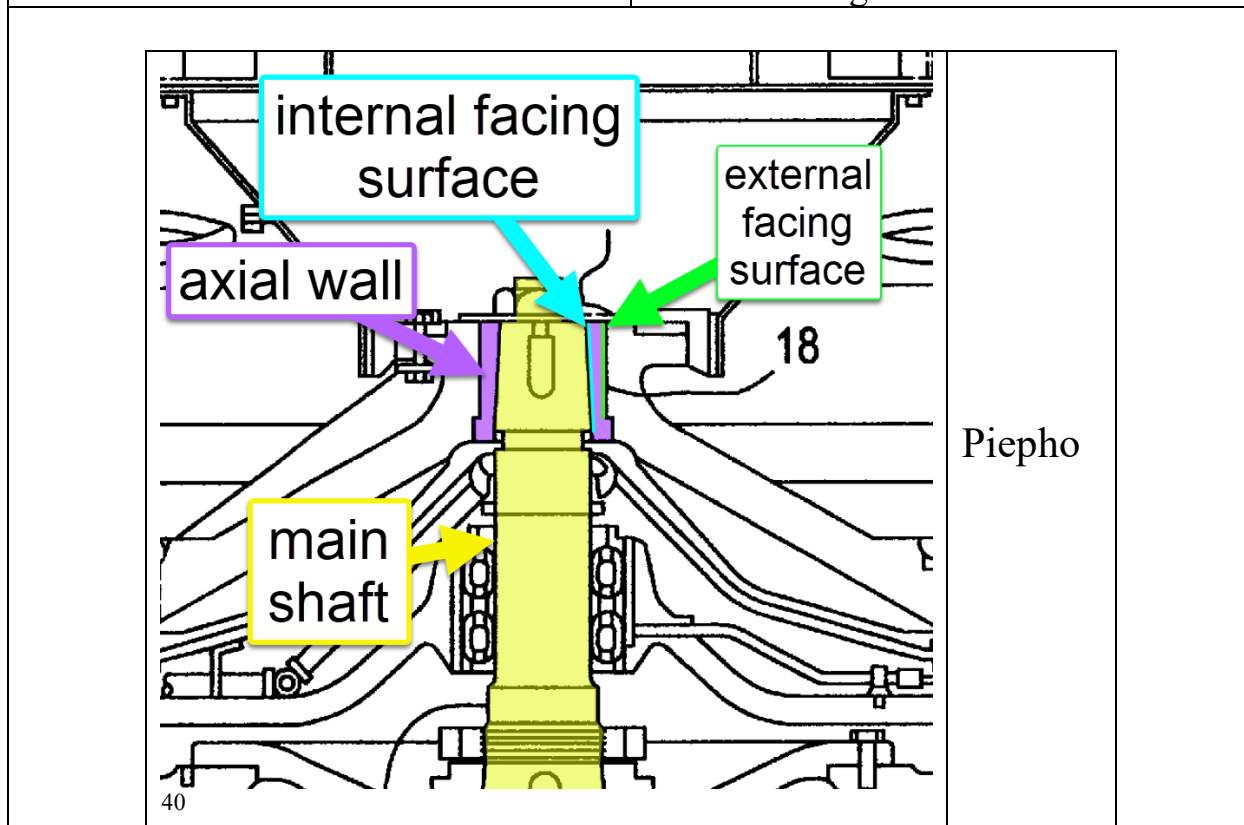
³⁹ US 4,410,143 to Polinski 2:41-47

	As shown and described, the sleeve 12 is fitted within a bearing bushing 13. This fit-up involves contact between the externally facing surface of the sleeve and the bearing bushing.
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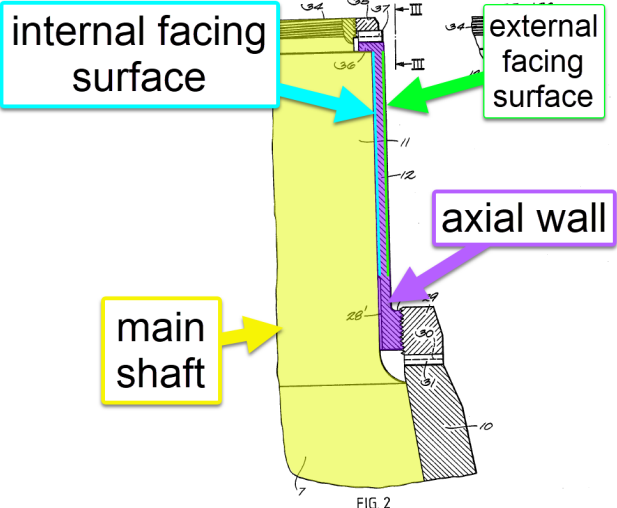
As shown above, both Polinski and Piepho disclose a sleeve with an external facing surface relative to the longitudinal axis of the sleeve.

11b5. the axial wall extending between the internal and external facing surfaces,

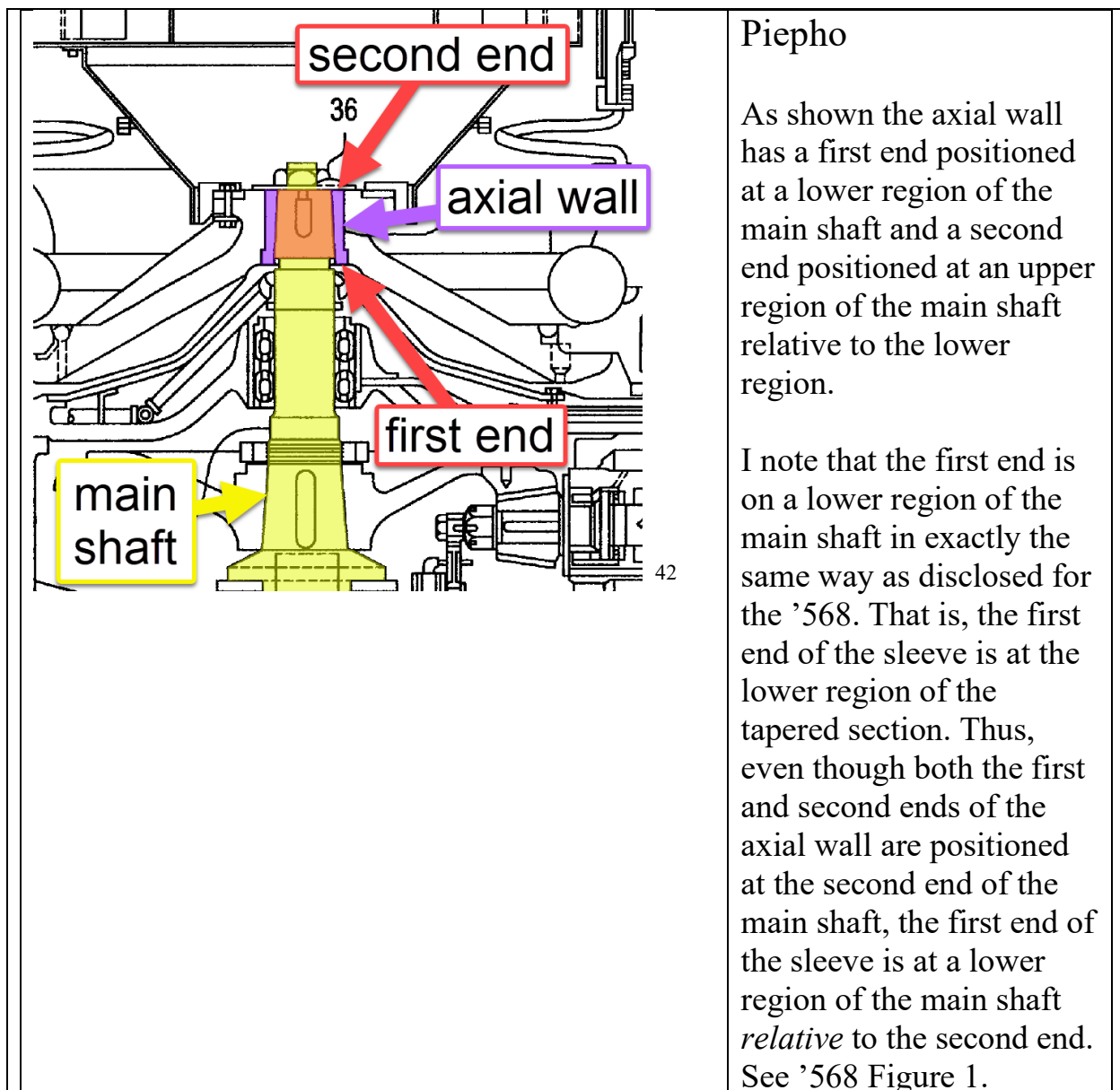
YES: Both Polinski and Piepho disclose a sleeve with an axial wall extends between the internal and external facing surfaces.



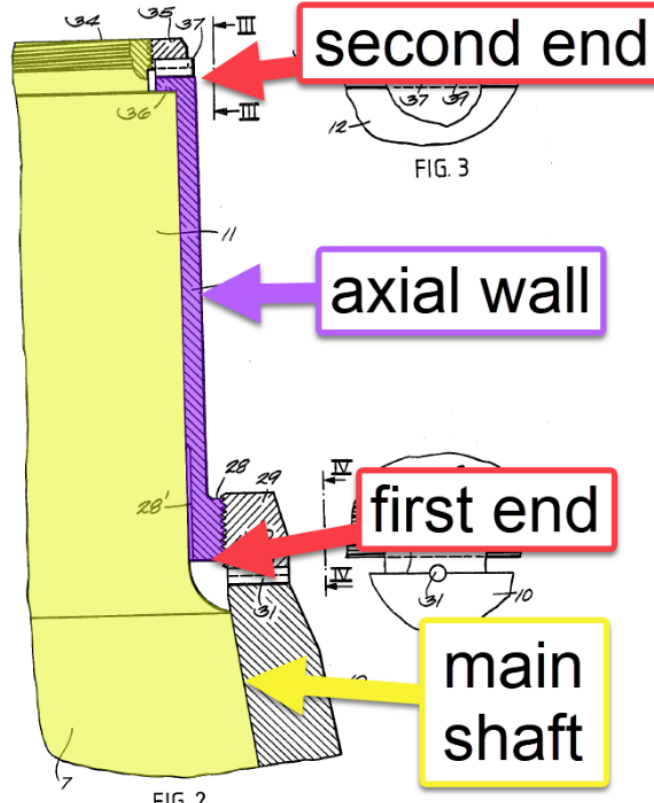
⁴⁰ US 6,270,026 to Piepho, Figure 1 annotated

		Polinski	
As shown above, both the sleeve of Piepho and of Polinski are arranged in a way such that the axial wall of the sleeve extends between the internal and external facing surfaces.		11b6. the axial wall having a first <u>sleeve</u> end for positioning at a lower region of the main shaft and a second <u>sleeve</u> end for positioning at an upper region of the main shaft relative to the lower region, YES: Both Polinski and Piepho discloses an axial wall having a first sleeve end for positioning at a lower region of the main shaft and a second sleeve end for positioning at an upper region of the main shaft relative to the lower region.	

⁴¹ US 4,410,143 to Polinski Figure 2, annotated

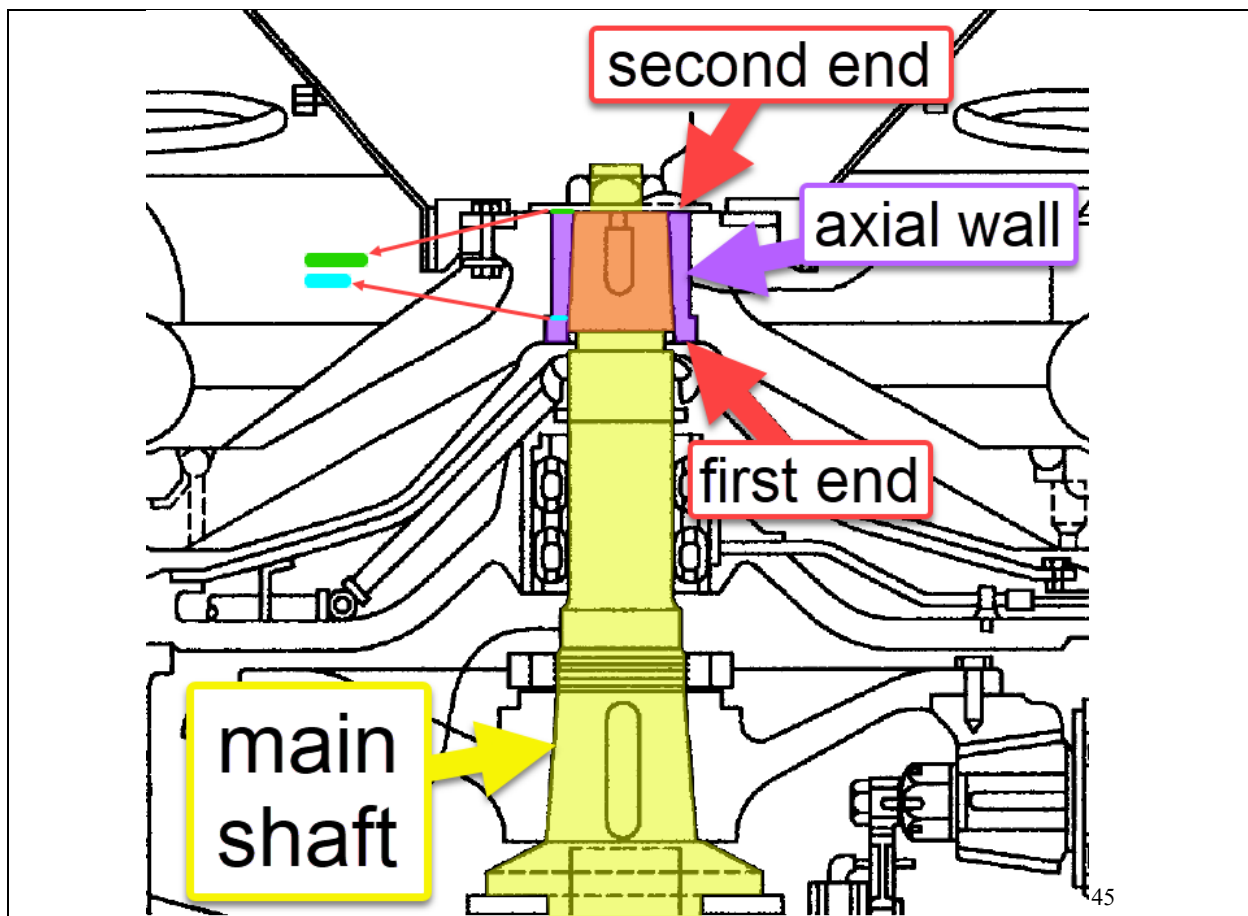


⁴² US 6,270,026 to Piepho, Figure 1 annotated

 FIG. 2 FIG. 3 second end axial wall first end main shaft	Polinski As shown, the axial wall of Polinski has a first end at a lower region of the main shaft, and a second end at an upper region of the main shaft. Thus, Polinski is the same as Piepho in this regard except that the shaft/sleeve joint is cylindrical rather than tapered. Piepho teaches the interchangeability between a cylindrical joint and a taper joint as would be well understood by a POSITA. <i>“As shown in FIGS. 1 and 2, the bearing sleeve 12 extends generally coextensively with the bearing journal 11 and includes an externally threaded annular shoulder 28 about its lower periphery threadably receiving a head nut 29.”⁴⁴</i>
As shown above, both Piepho and Polinski have an axial wall with a first end at a lower region of the main shaft and a second end at an upper region of the main shaft.	
11b7. wherein a thickness of the axial wall at a region between the first and second <u>sleeve ends tapers and decreases in a direction from the second <u>sleeve</u> end to the first <u>sleeve</u> end,</u>	YES: Piepho discloses that the thickness of the axial wall at a region between the first and second sleeve ends tapers and decreases in a direction from the second sleeve end to the first sleeve end.

⁴³ US 4,410,143 to Polinski Figure 2, annotated

⁴⁴ US 4,410,143 to Polinski 2:67-3:3



As shown above the thickness of the axial wall decreases from the second end to the first end. This is demonstrated by the figure above which shows the turquoise line at the first end is shorter than the green line at the second end. This is because the sleeve bushing (18) is tapered to match the tapered portion of the main shaft.

“Preferably, the joint (21) is a tapered joint with the tapered end (25) of shaft (14). The yoke bushing (18) has a mating bore similarly tapered.”⁴⁶

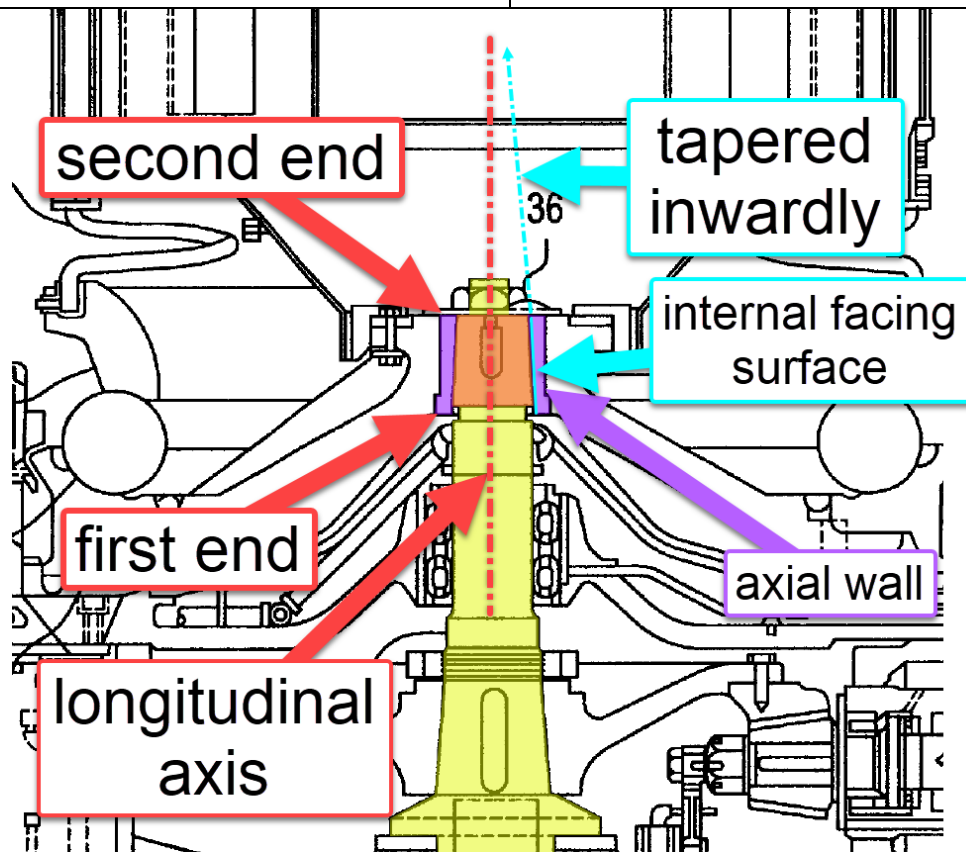
A POSITA would have been motivated to combine the sleeve (including the axial wall) and tapered shaft of Piepho with the main shaft of Polinski. This combination would have been nothing more than combining known elements according to known methods to yield predictable results. A POSITA would be further motivated, as Piepho describes, as the tapered shaft aids in accurate alignment which is notoriously more difficult with purely cylindrical shafting. Piepho further teaches that a tapered joint is preferable to a cylindrical joint.

⁴⁵ US 6,270,026 to Piepho, Figure 1 annotated

⁴⁶ US 4,410,143 to Polinski 3:30-31

11b8. in the axial direction the internal facing surface at said region between the first and second sleeve ends extending transverse to the longitudinal axis so as to taper inwardly towards the longitudinal axis of the sleeve in the direction from the first sleeve end to the second sleeve end, and

YES: Piepho discloses that in the axial direction, the internal facing surface at said region between the first and second sleeve ends extends transverse to the longitudinal axis so as to taper inwardly towards the longitudinal axis of the sleeve in the direction from the first to sleeve end the second sleeve end.



47

As shown above the internal facing surface at the region between the first and second sleeve ends of the axial wall tapers inwardly towards the longitudinal axis in the direction from the first end of the sleeve to the second end of the sleeve. This is because the sleeve bushing (18) is tapered to match the tapered portion of the main shaft.

*“Preferably, the joint (21) is a tapered joint with the tapered end (25) of shaft (14). The yoke bushing (18) has a mating bore similarly tapered.”*⁴⁸

⁴⁷ US 6,270,026 to Piepho, Figure 1 annotated

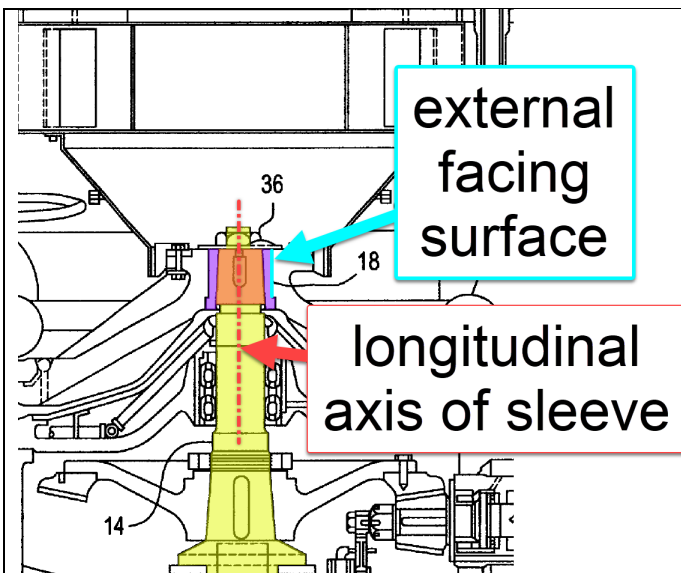
⁴⁸ US 4,410,143 to Polinski 3:30-31

As the citation above describes, the bushing has a tapered bore that spans the entire axial length.

A POSITA would have been motivated to combine the sleeve (including the tapered internal surface) and tapered shaft of Piepho with the main shaft of Polinski. This combination would have been nothing more than combining known elements according to known methods to yield predictable results. A POSITA would be further motivated, as Piepho describes, as the tapered shaft aids in accurate alignment which is notoriously more difficult with purely cylindrical shafting. Piepho further teaches that a tapered joint is preferable to a cylindrical joint.

11B9. wherein the external facing surface from the first sleeve end to the second sleeve end is parallel to the longitudinal axis of the sleeve such that the external facing surface of the sleeve when viewed externally has a cylindrical geometry.

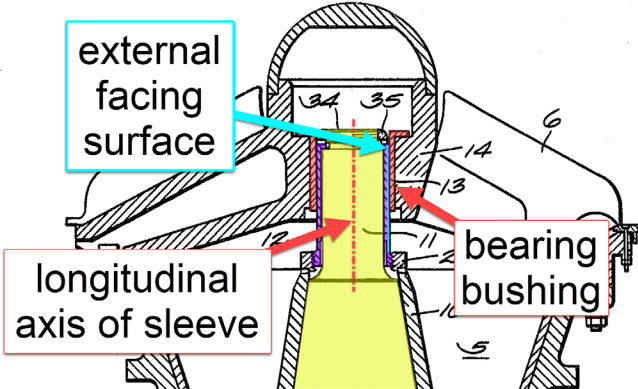
YES: Both Polinski and Piepho disclose that the external facing surface from the first sleeve end to the second sleeve end is parallel to the longitudinal axis of the sleeve such that the external facing surface of the sleeve when viewed externally has a cylindrical geometry.



Piepho

As shown in the figure, Piepho discloses an external facing surface that defines a section of a cylinder in the axial direction from the first end to the second end. The ends being the regions near the end as discussed in the claim construction section above.

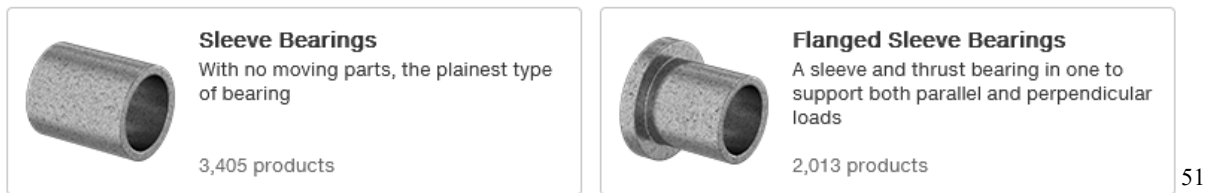
*"The present invention provides an intervening material between the shaft end (25) and the mating bore in yoke **bushing (18) fitted within***

	<i>the bore of yoke (12) to prevent fretting damage.”⁴⁹</i> As described above, the sleeve bushing (18) is fitted in a bore of yoke (12). A POSITA would understand that the bore feature in yoke 12 would be cylindrical in shape. As shown in the figure, the cylindrical shape is oriented in the axial direction of the main shaft.
	Polinski As shown in the figure, the cross section of Polinski is consistent with a cylindrically shaped external facing surface. <i>“As will be described, the cross-section of the upper end of the shaft 7 gradually converges to form a bearing journal 11 extending from the tapered portion of the shaft which is fitted with a <u>cylindrical bearing sleeve 12</u> rotatably retained within a bearing bushing 13 secured within a coaxially aligned hub 14 in the spider 6.”⁵⁰</i> As described, the bearing sleeve (12) is cylindrical in shape. Further, the components are used in power transmission shafting which is generally cylindrical in shape.

⁴⁹ US 6,270,026 to Piepho 3:24-27, emphasis added

⁵⁰ US 4,410,143 to Polinski 2:41-47, emphasis added

As shown above, both Piepho and Polinski have external facing surfaces that a section of a cylinder and further that such a cylinder is oriented in the axial direction. To the extent it might be argued that because the diameter of the cylindrical outer surfaces change, in Polinski and Piepho, that this element is not met, it would be obvious to a POSITA that the inclusion of a flange on a bushing, such as that of Piepho, is a design choice and typically dependent on features external to the shaft and bushing. For example, McMastercarr.com, an online catalogue sells bushings with and without flanges and both are common and known.

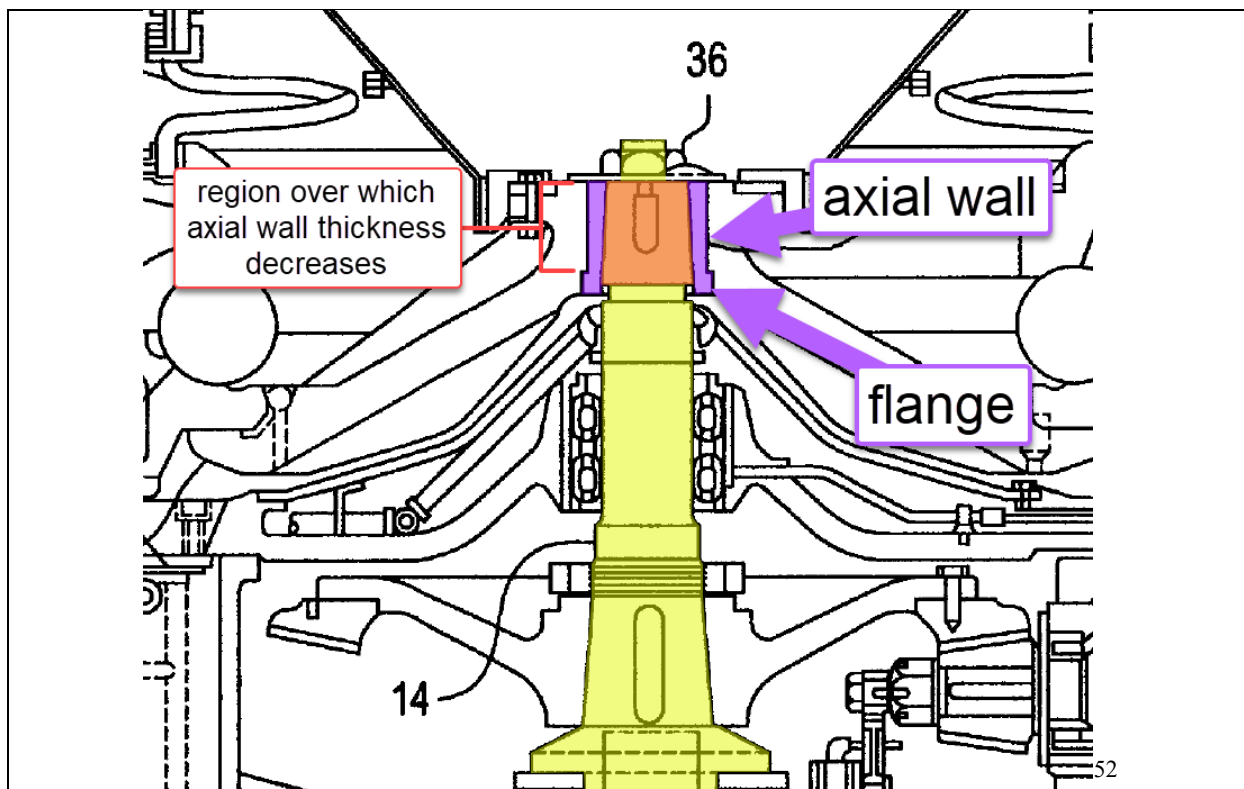


Further, a POSITA would recognize that the threads on the end of Polinski are a design choice and bushings for rock crushers can include or not include them as shown in US 4,060,205 to Pollak.

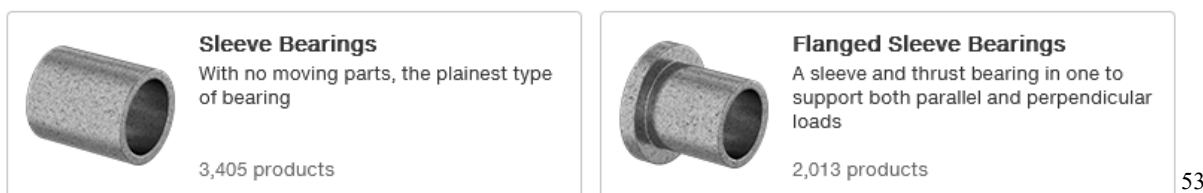
A POSITA would recognize that Piepho without the flange meets this limitation and Polinski without the threads meets this limitation. Alternatively, this element is further obvious in view of US 4,060,205 to Pollak.

12P. The gyratory crusher as claimed in claim 11,	YES: As shown above, Polinski in view of Piepho and Pollak discloses the gyratory crusher as claimed in claim 11.
12a. wherein the region over which the thickness of the axial wall <u>tapers and decreases</u> extends <u>substantially</u> the full axial length of the sleeve.	YES: Polinski in view of Piepho and Pollak discloses that the region over which the thickness of the axial wall tapers and decreases extends the full axial length of the sleeve.

⁵¹ <https://www.mcmaster.com/products/bushings/>



The bushing above (purple) comprises an axial wall (sleeve) and a flange. As shown above the internal wall is tapered along its full axial length. The external surface is cylindrical with a flange at the bottom. The thickness of the axial wall decreases along the full axial length until it reaches the flange. A POSITA would recognize that bushings (also called bearings) are commonly made both with and without flanges. For example, McMastercarr.com, an online catalogue sells bushings with and without flanges and both are common and known.



A POSITA might choose to include a flange depending on other features that the bearing might be expected to interact with, or to provide a shoulder bearing surface which can transmit axial loads. A POSITA would recognize that the teachings of Peipho, if the bushing was provided without the flange, meets this limitation

⁵² US 6,270,026 to Piepho, Figure 1 annotated

⁵³ <https://www.mcmaster.com/products/bushings/>

Further, a POSITA would recognize that the threads on the end of Polinski are a design choice and bushings for rock crushers can include or not include them as shown in US 4,060,205 to Pollak. A POSITA would recognize that Polinski without the threads meets this limitation.

Alternatively, this element is further obvious in view of US 4,060,205 to Pollak which teaches bearings without flanges or threads on the end. Combining either of these with the tapered bearing of Piepho would meet the limitations of this claim.

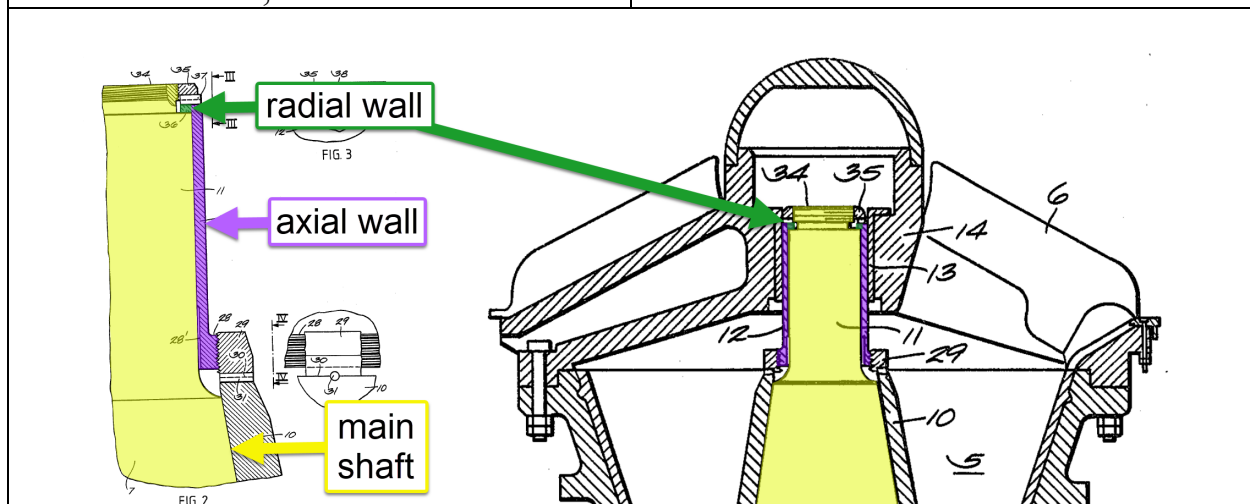
A POSITA would have been motivated to combine the sleeve (including the axial wall with decreasing thickness) and tapered shaft of Piepho with the main shaft of Polinski, Pollak or Coxhill. A POSITA would have a reasonable expectation of success in making the combination as it is nothing more than combining prior art elements according to known methods to yield predictable results. A POSITA would be further motivated to use a tapered sleeve on a tapered shaft as it aids in alignment and makes it easier to install and detach as the distance the sleeve needs to travel while expanded is smaller compared to a sleeve with a cylindrical interference fit.

13P. The gyratory crusher as claimed in claim 11,

YES: As shown above, Polinski in view of Piepho discloses the gyratory crusher as claimed in claim 11.

13a1. further comprising a radial wall extending perpendicular or transverse to the axial wall,

YES: Polinski discloses a radial wall extending perpendicular or transverse to the axial wall.



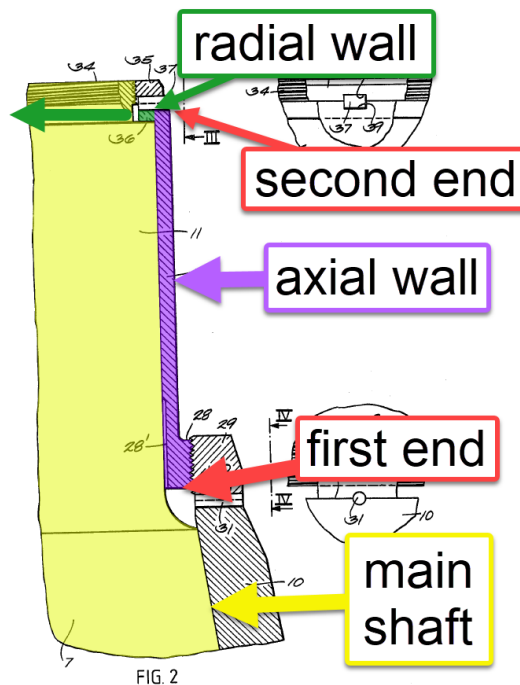
As shown above Polinski discloses a radial wall that extends transversely to the axial wall. This feature serves as a shoulder that sets the depth of the sleeve during fit-up and provides a shoulder for potentially bearing axial loads.

*“As best shown in FIGS. 2 and 3, a threaded lug 34 is provided on the end of the journal which is adapted to receive a sleeve nut 35 which axially overlies **an inwardly projecting annular lip 36** on the upper end of the sleeve 12.”*⁵⁴

A POSITA would be motivated to include this radial wall in the combination of Polinski in view of Piepho as it makes for a more predictable assembly process and provides additional bearing surface for the top sleeve securing nut.

13a2. the radial wall being positioned at or towards the second end and extending inwardly towards the longitudinal axis.

YES: Polinski discloses that the radial wall is positioned at or towards the second end and extends inwardly towards the longitudinal axis.



As shown above the radial wall of Polinski is positioned at the second end of the sleeve. Further it extends inwardly towards the longitudinal axis.

⁵⁴ US 4,410,143 to Polinski 3:25-29, emphasis added.

“As best shown in FIGS. 2 and 3, a threaded lug 34 is provided on the end of the journal which is adapted to receive a sleeve nut 35 which axially overlies an inwardly projecting annular lip 36 on the upper end of the sleeve 12.”⁵⁵

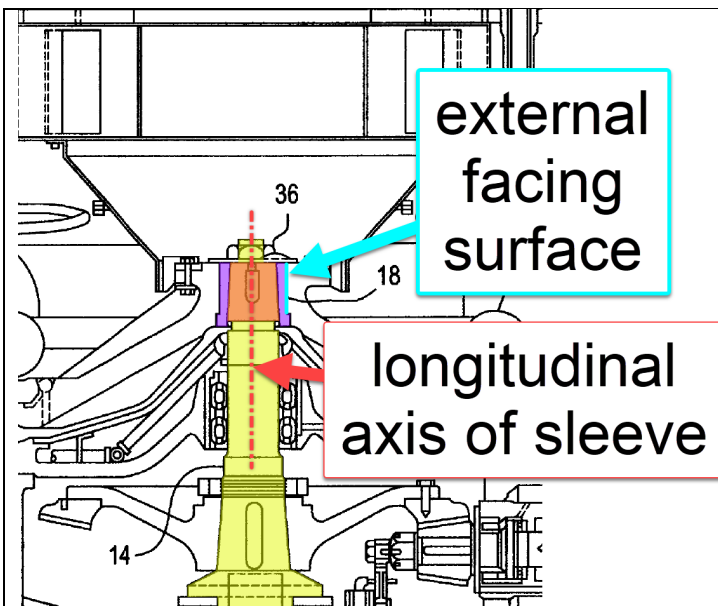
A POSITA would be motivated to include this radial wall in the combination of Polinski in view of Piepho as it makes for a more predictable assembly process and provides additional bearing surface for the top sleeve securing nut.

14P. The gyratory crusher as claimed in claim 11,

YES: As shown above, Polinski in view of Piepho discloses the gyratory crusher as claimed in claim 11.

14a. wherein a cross-sectional shape profile of the external facing surface is substantially circular.

YES: Both Polinski and Piepho discloses that the cross-sectional shape profile of the external facing surface is substantially circular.



Piepho

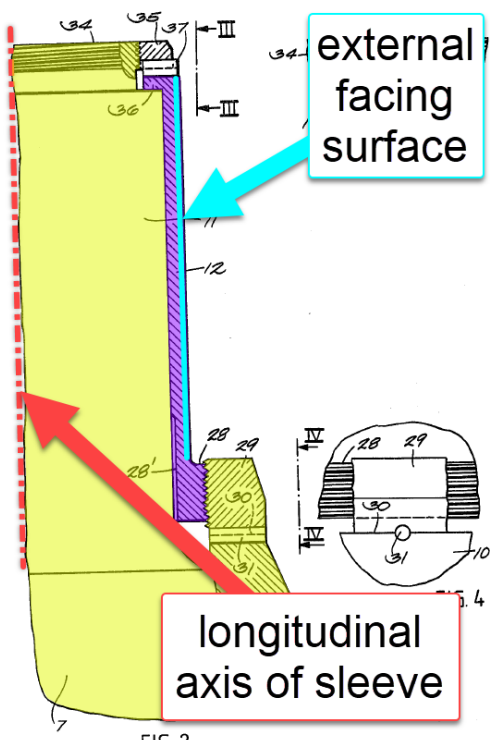
As shown in the figure, the cross section of Piepho is consistent with a circularly shaped external facing surface.

“The present invention provides an intervening material between the shaft end (25) and the mating bore in yoke bushing (18) fitted within the bore of yoke (12) to prevent fretting damage.”⁵⁶

As described above, the sleeve bushing (18) is fitted in a bore of yoke (12). A POSITA would understand that the bore feature in yoke 12 would be circular in

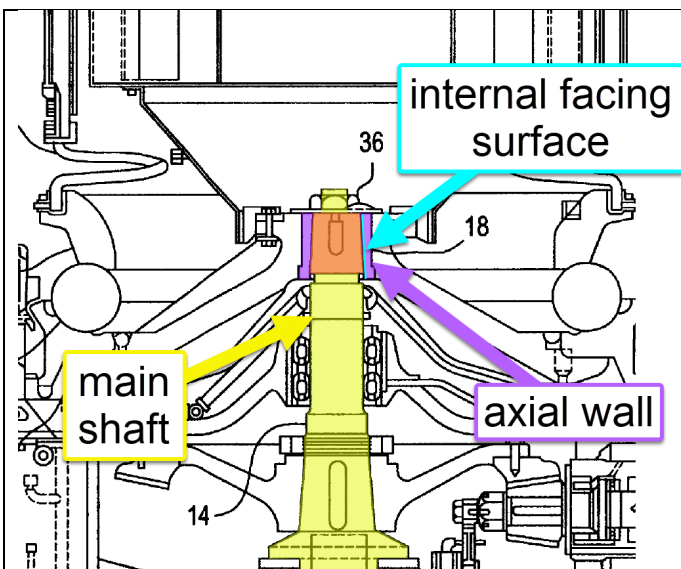
⁵⁵ US 4,410,143 to Polinski 3:25-29, emphasis added.

⁵⁶ US 6,270,026 to Piepho 3:24-27, emphasis added

	shape. Further, the components are used in power transmission shafting which is generally circular in shape.
 FIG. 2	Polinski As shown in the figure, the cross section of Polinski is consistent with a circularly shaped external facing surface. <i>“As will be described, the cross-section of the upper end of the shaft 7 gradually converges to form a bearing journal 11 extending from the tapered portion of the shaft which is fitted with a <u>cylindrical bearing sleeve 12</u> rotatably retained within a bearing bushing 13 secured within a coaxially aligned hub 14 in the spider 6.”⁵⁷</i> As described, the bearing sleeve (12) is cylindrical in shape. A POSITA would understand that a cylindrical shape has a circular cross section. Further, the components are used in power transmission shafting which is generally circular in shape.
As shown above, the external facing surface of both Piepho and Polinski has a circular cross-sectional shape.	

⁵⁷ US 4,410,143 to Polinski 2:41-47, emphasis added

15P. The gyratory crusher as claimed in claim 11,	YES: As shown above, Polinski in view of Piepho discloses the gyratory crusher as claimed in claim 11.
15a. wherein a cross-sectional shape profile of the internal facing surface is substantially circular.	YES: Both Polinski and Piepho disclose that the cross-sectional shape profile of the internal facing surface is substantially circular.



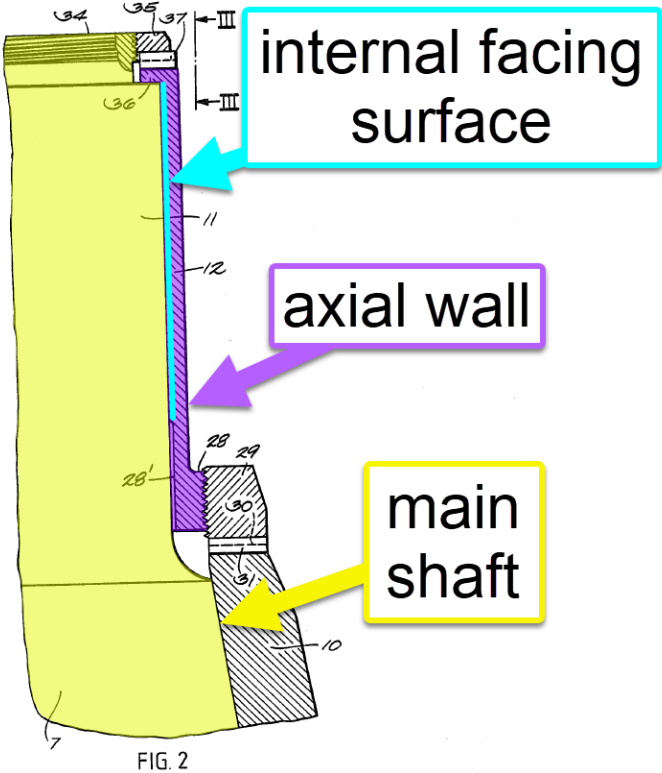
Piepho

As seen in the figure, the cross section of Piepho shows the internal facing surface engages with the tapered portion of the main shaft. As such the internal bore of the bushing (18) has a conical taper. A POSITA would understand that a conical bore has a cross-sectional profile that is circular when it is sectioned on any plane that is perpendicular to the axis of the cone.

“Preferably, the joint (21) is a tapered joint with the tapered end (25) of shaft (14). The yoke bushing (18) has a mating bore similarly tapered.”⁵⁸

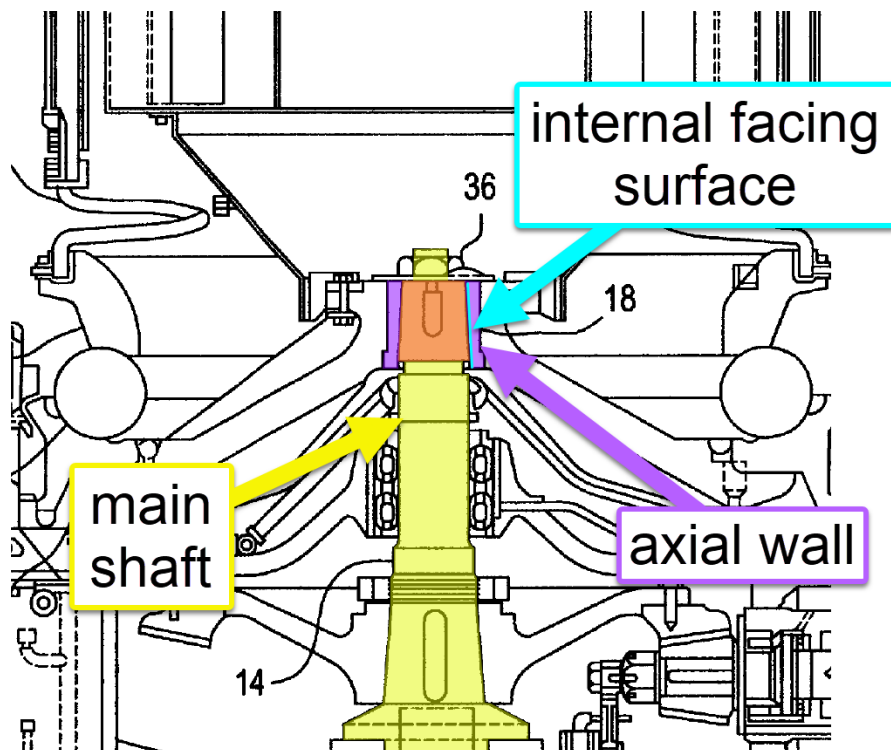
As described in the above citation, the sleeve bushing (18) has a mating bore that is similarly tapered to the tapered end of the shaft. This is consistent with the figures and just as discussed

⁵⁸ US 6,270,026 to Piepho 3:30-32

	above, a conically tapered bore has a circular cross-section.
	Polinski As shown in the figure, the cross section of Polinski is consistent with a circularly shaped internal facing surface. <i>“As will be described, the cross-section of the upper end of the shaft 7 gradually converges to form a bearing journal 11 extending from the tapered portion of the shaft which is fitted with a <u>cylindrical bearing sleeve 12</u> rotatably retained within a bearing bushing 13 secured within a coaxially aligned hub 14 in the spider 6.”⁵⁹</i> As described, the bearing sleeve (12) is cylindrical in shape. A POSITA would understand that a cylindrical shape has a circular cross section. Further, the components are used in power transmission shafting which is generally circular in shape.
As shown above, both Piepho and Polinski have internal facing surfaces that have a circular cross-sectional shape. Thus, the combination of Polinski in view of Piepho would have an internal facing surface has a circular cross-sectional shape.	

⁵⁹ US 4,410,143 to Polinski 2:41-47, emphasis added

16P. The gyratory crusher as claimed in claim 11,	YES: As shown above, Polinski in view of Piepho discloses the gyratory crusher as claimed in claim 11.
16a. wherein a shape profile of the internal facing surface defines a section of a cone in the axial direction.	YES: Piepho discloses that the shape profile of the internal facing surface defines a section of a cone in the axial direction.



As shown above the shape of the internal facing surface of the sleeve bushing (18) is tapered to fit up with the tapered portion of the main shaft. A tapered internal facing surface is a section of a cone and it is oriented in the axial direction. This is consistent with the description in the specification of Piepho.

“Preferably, the joint (21) is a tapered joint with the tapered end (25) of shaft (14). The yoke bushing (18) has a mating bore similarly tapered.”⁶⁰

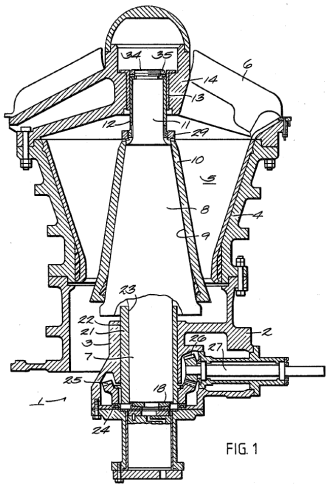
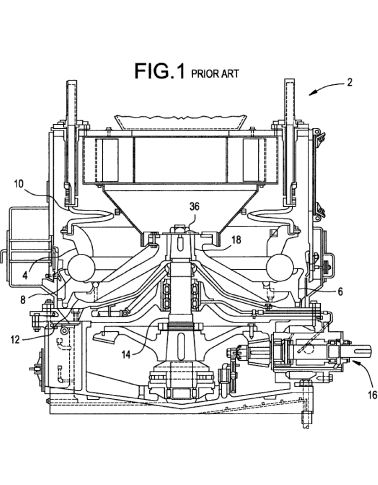
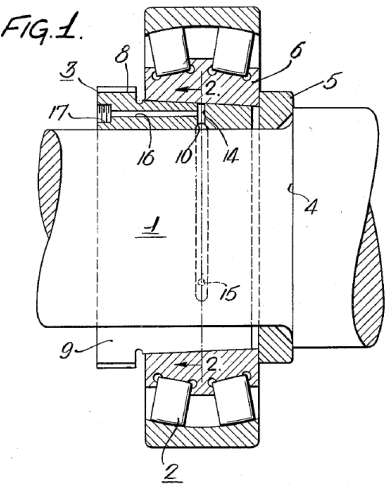
A POSITA would be motivated to combine Polinski’s shaft and sleeve with Piepho’s teachings of a tapered shaft end and tapered sleeve (with an internal facing surface that defines a section of a cone) fitted over the tapered section of second end of the main shaft. A POSITA would have a reasonable expectation of

⁶⁰ US 6,270,026 to Piepho 3:30-32

success in making the combination as it is nothing more than combining prior art elements according to known methods to yield predictable results. A POSITA would be further motivated to use a tapered sleeve on a tapered shaft as it aids in alignment and makes it easier to install and detach as the distance the sleeve needs to travel while expanded is smaller compared to a sleeve with a cylindrical interference fit.

31. As shown above, Polinski in view of Piepho renders claims 11-19 obvious.

B. Polinski in view of Piepho, and in further view of A.E. Bratt Render Claim 17 Obvious

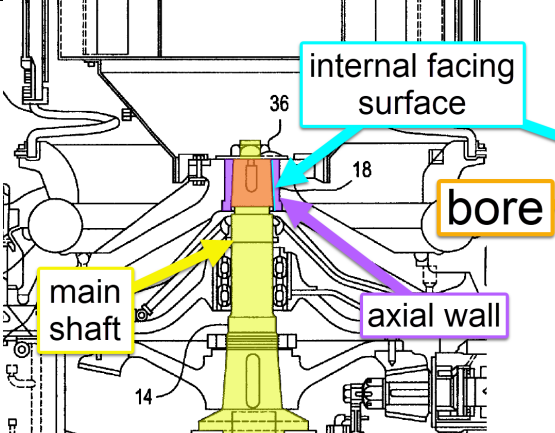
 FIG. 1	 FIG. 1 PRIOR ART	 FIG. 1
US 4,410,143 to Polinski	US 6,270,026 to Piepho	US 2,764,437 to A. E. Bratt

32. As discussed above A POSITA would be motivated combine Polinski in view of Piepho to create the apparatus claimed in claim 1 of the '568. A POSITA would be further motivated to combine Polinski in view of Piepho, and in further view of US 2,764,437 to A.E. Bratt and/or the knowledge of a POSITA based on the teachings of the prior art. The use of lubricating oil to assist with

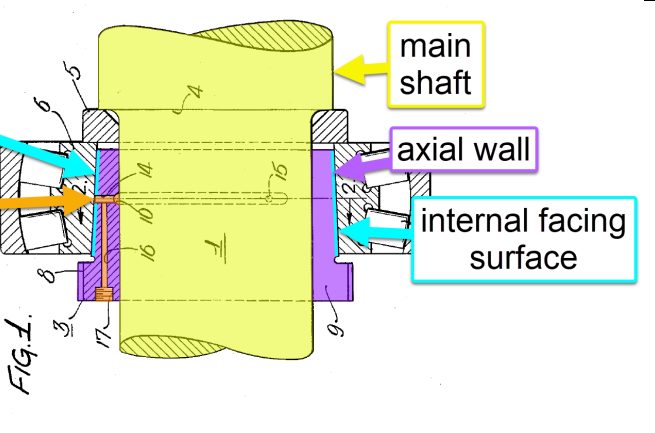
making or breaking tapered interference fit joints is extremely well-known.

Further, the use of lubrication ports of various styles including through the axial wall of the sleeve is well known. For example A.E. Bratt discloses a tapered sleeve for an interference-fit joint and a bore through the sleeve wall to deliver lubricating oil to the internal facing surface.

Challenged Claim	Does the Prior Art disclose this?
17P. The gyratory crusher as claimed in claim 11,	YES: As shown above, Polinski in view of Piepho discloses the gyratory crusher as claimed in claim 11.
17a. further comprising at least one bore provided through the axial wall to allow the passage of a fluid to the internal facing surface.	YES: Polinski in view of Piepho and further in view of A.E. Bratt discloses further comprising at least one bore provided through the axial wall to allow the passage of a fluid to the internal facing surface.



Piepho



A.E. Bratt

As shown above, A.E. Bratt discloses a tapered sleeve on a shaft, and a bore provided through the axial wall allow the passage of a fluid to the internal facing surface between the sleeve and the shaft.

“The present invention relates to a press fitted or shrunk joint and has for its purpose to facilitate the making of the joint or the separation thereof.

...

*According to the present invention arrangements are made for introducing under pressure a fluid, either liquid or gaseous, between the engaging surfaces so that the metallic contact is relieved over at least the greater part of the surfaces whereby **these may be more easily displaced relative each other.***

...

A passage 16, extending from the flanged end of the sleeve axially to the hole 14, establishes a channel of communication between the groove 10, and holes 13, 14 and 15, and an exposed surface of the assembly.

...

The outer end of the passage 16 is then connected to a source of a suitable pressure fluid, for example oil, such connection being facilitated by the threads 17 at the outer end of the passage. The pressure of the oil must be as great at least as the specific pressure between the engaging surfaces of the sleeve and shaft and of the sleeve and bearing so that the oil may force its way between the said surfaces. The oil thus introduced and distributed by way of the groove 10 and holes 13, 14 and 15, forms films between the inner and outer surfaces of the sleeve and the confronting surfaces of the shaft and bearing respectively and make it possible to displace the sleeve axially with respect both to the shaft and bearing by application of forces of relatively low order and without damage to the said surfaces. The oil film may be so thin that it relieves the metallic contact between the surfaces but does not materially expand or contract the engaging parts.

The same procedure may be used in obvious manner to aid in effecting the force fit between [sic] the sleeve and the shaft and bearing. The oil introduced in this operation quickly disappears from between the surfaces and does not affect the strength of the joint and its ability to transmit power.”⁶¹

As described above, A.E. Bratt discloses an apparatus for delivering lubricating oil through a bore in the axial wall of a tapered sleeve to assist in the making or braking of a tapered interference-fit joint. A POSITA would understand that this is the only reasonable function of adding lubricating oil to the mating surfaces of a tapered interference-fit joint.

A POSITA would be motivated to implement the well-known hydraulic processes for making and breaking interference fits, for example between the sleeve and the shaft, as they are well known to protect the shaft from damage,⁶² they are able to be used in more locations as they do not require presses and gear pullers,⁶³ does not require the maintenance that presses and gear pullers do,⁶⁴ and make removing components on a tapered shaft particularly easy.⁶⁵

⁶¹ US 2,764,437 to A.E. Bratt 1:19-21, 29-34, 69-72, 2:6-29, emphasis added

⁶² Behm 1:13-15, 1:35-42

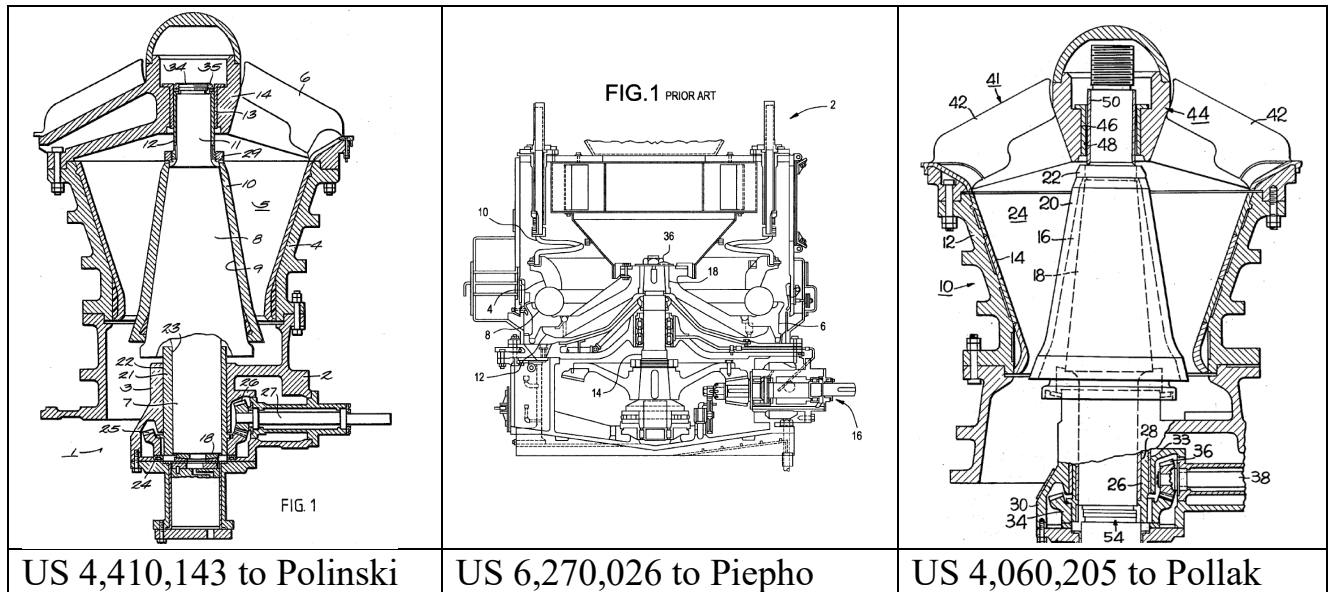
⁶³ Sillett 1:15-24

⁶⁴ Sillett 1:35-40

⁶⁵ Harless 3:15-22

33. As shown above, Polinski in view of Piepho and in further view of A.E. Bratt renders claim 17 obvious to a POSITA.

C. Polinski in view of Piepho, and in further view of Pollak Render Obvious Claims 18 and 19



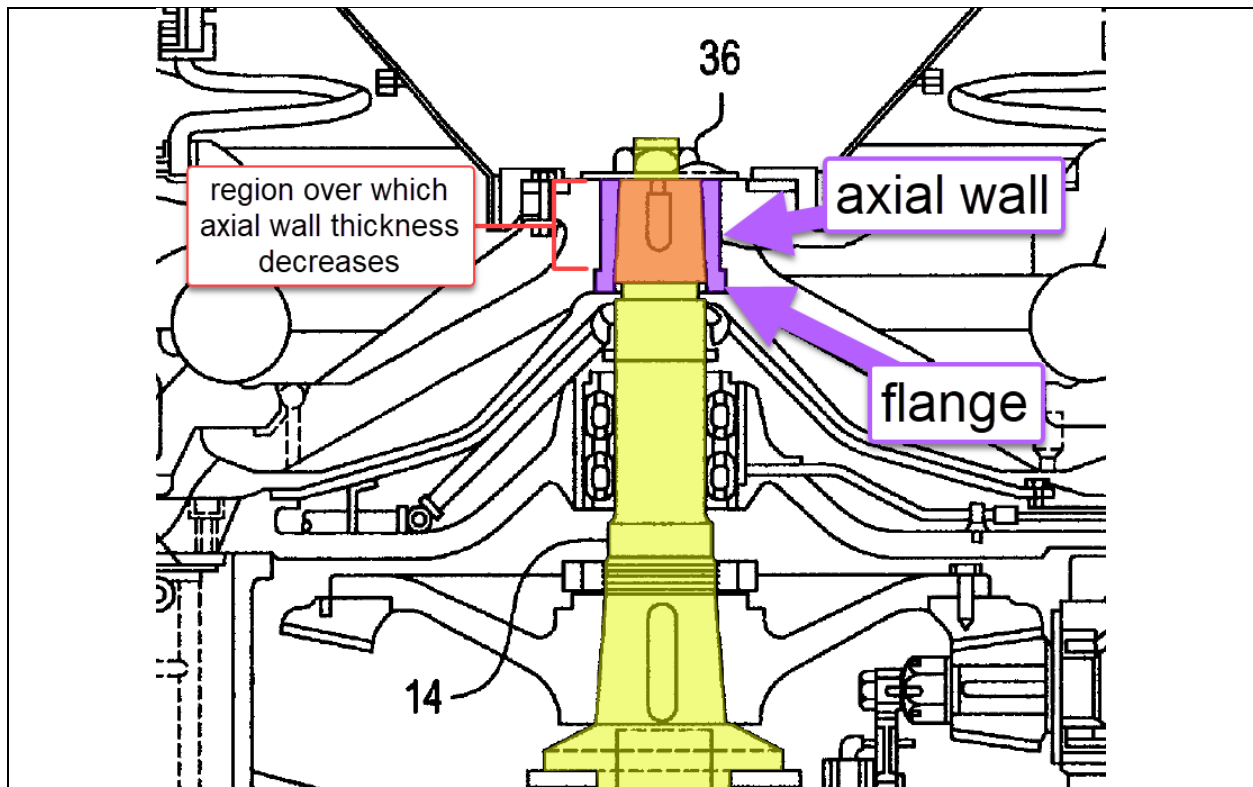
34. As discussed previously A POSITA would have been motivated to combine Polinski in view of Piepho. A POSITA would further be knowledgeable about the design of power transmission shafting as well as stress and fatigue analysis. As such, they would be motivated to make certain design choices that would enhance the assembly process, as well as improve the part fit-up and stress flow. One such choice a POSITA would be motivated to make would be to flare the internal bore of the upper wear sleeve so as to permit the sleeve to sit lower and more evenly distribute loads and stresses thereby improving the expected fatigue

the wall thickness of the sleeve allowing it to fully seat on the corresponding geometry of the main shaft. As discussed, this flare also acts to more evenly distribute the flow of loads and stresses from the sleeve to the main shaft and within the main shaft itself. This flare feature is a design choice that improves the mechanical performance and lifespan of the components. This design choice is not always made because the flared bore can be more expensive to manufacture.

Challenged Claim	Does the Prior Art disclose this?
18P. The gyratory crusher as claimed in claim 11,	YES: As shown above, Polinski in view of Piepho discloses the gyratory crusher as claimed in claim 11.
18a. wherein at a ~~curved~~ region ~~[[of]]~~ <u>proximal to the first sleeve end, the thickness of the axial wall reduces at an increased rate relative to a region of the axial wall proximal to the second sleeve end</u> ~~the internal facing surface is curved radially outward relative to the longitudinal axis in a direction towards the external facing surface such that the axial wall thickness decreases to zero at the curved region.~~	YES: Polinski in view of Piepho and in further view of Pollak or the knowledge of a POSITA discloses wherein at a region proximal to the first sleeve end, the thickness of the axial wall reduces at an increased rate relative to a region of the axial wall proximal to the second sleeve end.

A POSITA would be motivated to combine the internal facing surface that is curved radially outward relative to the longitudinal axis in a direction towards the external facing surface of Pollak with the sleeve on the end of the shaft shown by the combination of Polinski in view of Piepho. A POSITA would have a reasonable expectation of success in making the combination as it is nothing more than combining prior art elements according to known methods to yield predictable results. A POSITA would be further motivated to use curved internal facing surface as it aids in alignment and makes it easier to install as the sleeve is fitted over the shaft.

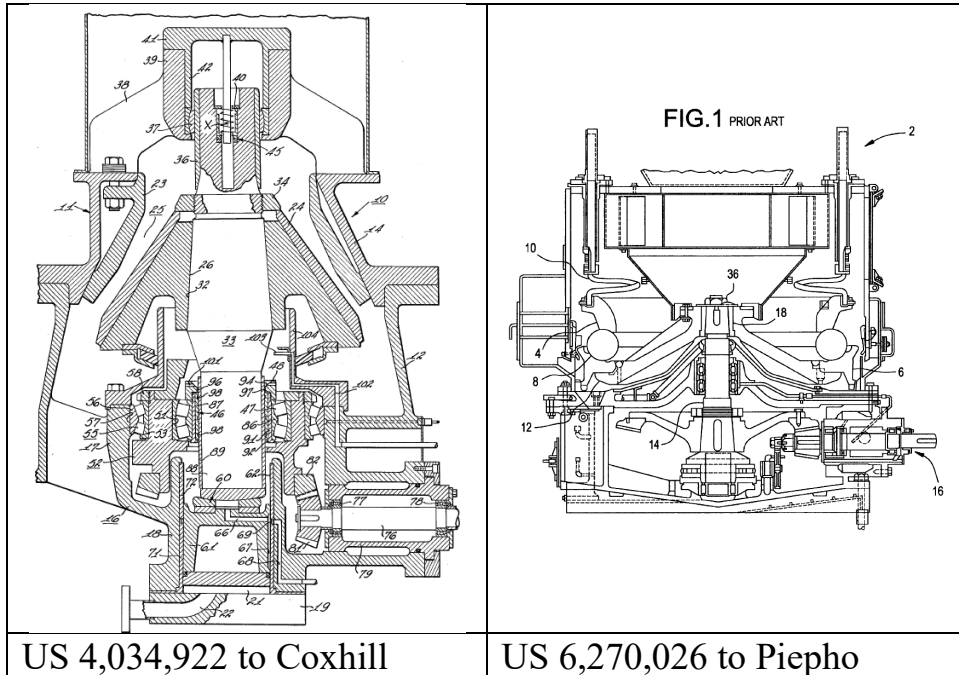
Challenged Claim	Does the Prior Art disclose this?
19P. The gyratory crusher as claimed in claim 18,	YES: As shown above, Polinski in view of Piepho and Pollak discloses the gyratory crusher as claimed in claim 18.
19a. wherein the thickness of the axial wall reduces at a uniform rate along an entire axial length of the sleeve other than the region proximal to the first sleeve end.	YES: Polinski in view of Piepho and in further view of Pollak or the knowledge of a POSITA discloses wherein the thickness of the axial wall reduces at a uniform rate along an entire axial length of the sleeve other than the region proximal to the first sleeve end.



As shown above, Piepho discloses where in the thickness of the axial wall reduces at a uniform rate along an entire axial length of the sleeve other than the region proximal to the first sleeve end.

36. As shown above, Polinski in view of Piepho and in further view of Pollak renders claims 18 and 19 obvious.

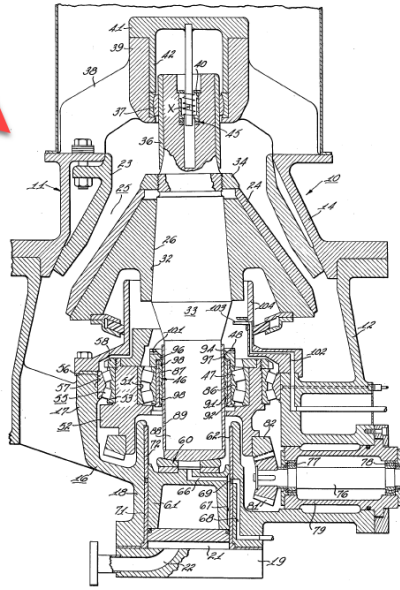
D. Coxhill in View of Piepho Render Claim 11-12, 14-16, 18-19 Obvious



Challenged Claim	Does the Prior Art disclose this?
11P. A gyratory crusher comprising:	YES: Although the preamble is generally not considered limiting, Coxhill discloses a gyratory crusher. In particular Coxhill states: <i>Referring to the drawing, there is shown a gyratory crusher 10 having a frame generally indicated at 11 and including a lower frame section 12 and an upper frame section 14.</i>⁶⁷

⁶⁷ 4,034,922 to Coxhill 1:54-57

gyratory
crusher



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As can be seen above, Figure 1 (the only figure) of Coxhill shows a cross-section of a conventional gyratory crusher.

Beyond this, as discussed previously, Piepho is also a rock crushing apparatus. In particular, Piepho is designed to crush coal.

“The present invention relates in general to an improved main Shaft for a coal pulverizer, and more particularly to an improved main shaft for use in B&W Type E and EL pulverizers”⁶⁹

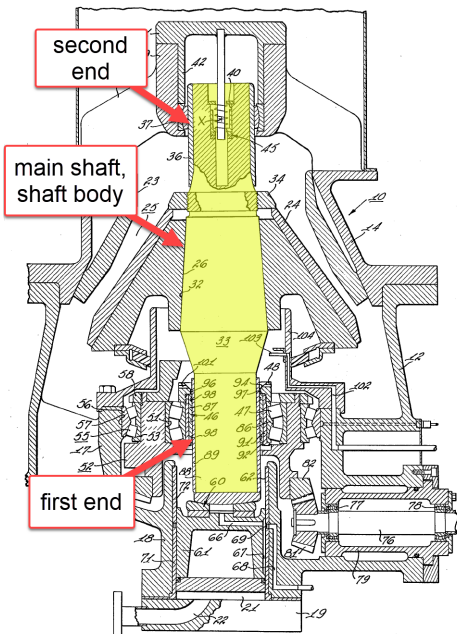
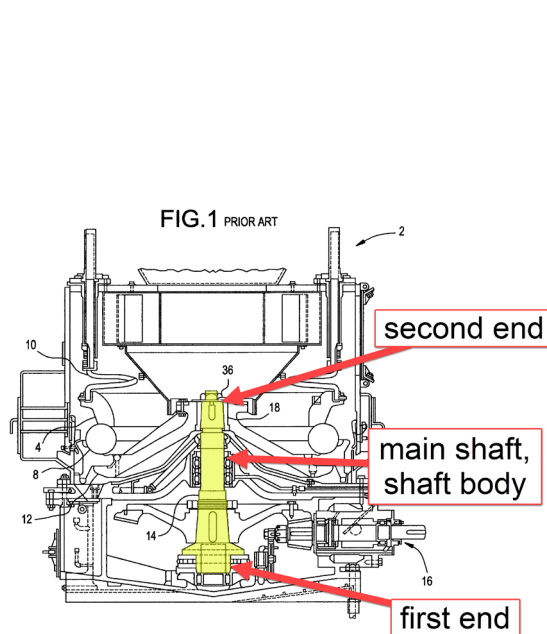
As a rock crushing apparatus, Piepho is in the same field of endeavor as Coxhill.

11a1. a main shaft including a shaft body having a first end for positioning at a lower region of the crusher and a second end for positioning at an upper region of the crusher relative to the first end,

YES: As shown below, both Coxhill and Piepho disclose a main shaft including a shaft body having a first end for positioning at a lower region of the crusher and a second end for positioning at an upper region of the crusher relative to the first end.

⁶⁸ 4,034,922 to Coxhill Figure 1, annotated

⁶⁹ US 6,270,026 to Piepho 1:5-8

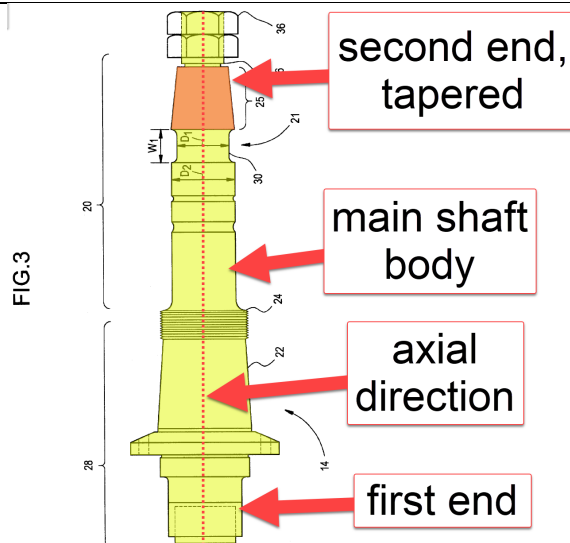
 70	 71
Coxhill main shaft	Piepho main shaft
Coxhill teaches: <i>While crushing, the crusher head shaft in a gyratory crusher will rotate in the opposite direction to that of the shaft drive eccentric.</i>⁷² Piepho teaches: <i>"The bottom ring 6 is driven by the yoke 12 which is attached to a vertical main shaft assembly 14 of the pulverizer."</i>⁷³	
11a2. a thickness of the shaft body being tapered in an axial direction of the main shaft at a <u>tapered</u> region of the second end so as to <u>taper and</u> decrease in cross-sectional area; and	YES: Coxhill in view of Piepho discloses a thickness of the shaft body being tapered in an axial direction of the main shaft at a tapered region of the second end so as to taper and decrease in cross-sectional area.

⁷⁰ US 4,034,922 to Coxhill Figure 1, annotated

⁷¹ US 6,270,026 to Piepho, Figure 1 annotated

⁷² US 6,270,026 to Piepho 1:30-32

⁷³ US 6,270,026 to Piepho 1:26-27



As shown above, the main shaft of Piepho is tapered on the second end of the shaft body. Further, the taper is in an axial direction. Due to this taper, the cross-sectional area of the shaft body decreases as shown by the orange highlighted area above.

*“The present invention provides an intervening material between the shaft end (25) and the mating bore in yoke bushing (18) fitted within the bore of yoke (12) to prevent fretting damage. For accurate alignment and for reliable Support of the yoke, this joint (21) must be capable of accepting radial, axial, and bending or overturning loads. **Preferably, the joint (21) is a tapered joint with the tapered end (25) of shaft (14).**”*⁷⁵

A POSITA would have been motivated to combine the tapered end on the main shaft of Piepho with the main shaft on Coxhill. This combination would have been nothing more than combining known elements according to known methods to yield predictable results. A POSITA would be further motivated, as Piepho describes, as the tapered shaft aids in accurate alignment which is notoriously more difficult with purely cylindrical shafting.

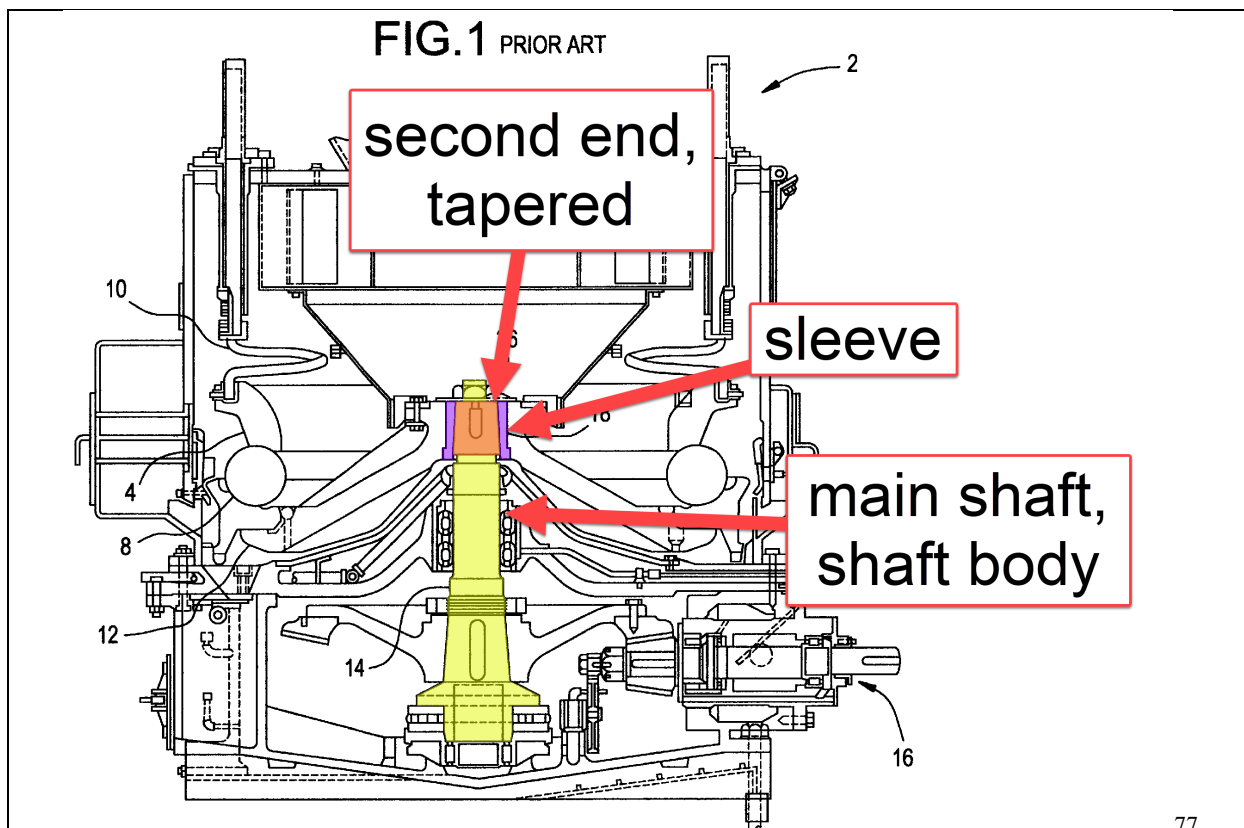
11b1. a sleeve fitted over the tapered region at the second end of the main shaft,

YES: Coxhill in view of Piepho discloses a sleeve fitted over the tapered region at the second end of the main shaft.

Coxhill teaches a sleeve fitted over the second end of the main shaft.

⁷⁴ US 6,270,026 to Piepho, Figure 3 annotated

⁷⁵ US 6,270,026 to Piepho 3:23-31, emphasis added.



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*“The present invention provides an intervening material between the shaft end (25) and the mating bore in yoke bushing (18) fitted within the bore of yoke (12) to prevent fretting damage. For accurate alignment and for reliable Support of the yoke, this joint (21) must be capable of accepting radial, axial, and bending or overturning loads. **Preferably, the joint (21) is a tapered joint with the tapered end (25) of shaft (14).**”*⁷⁸

A POSITA would be motivated to combine Coxhill’s shaft with a sleeve fitted onto the second end with Piepho’s teachings of a sleeve fitted over the tapered section of second end of the main shaft. A POSITA would have a reasonable expectation of success in making the combination as it is nothing more than combining prior art elements according to known methods to yield predictable results. A POSITA would be further motivated to use a tapered sleeve on a tapered shaft as it aids in alignment and makes it easier to install and detach as the distance the sleeve needs to travel while expanded is smaller compared to a sleeve with a cylindrical interference fit.

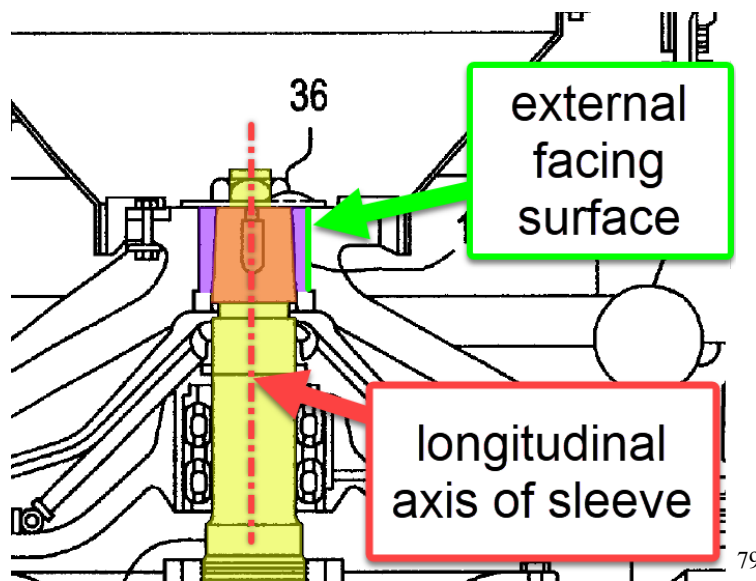
11b4. an external facing surface relative to the longitudinal axis,

YES: Both Coxhill and Piepho disclose a sleeve with an external

⁷⁷ US 6,270,026 to Piepho, Figure 1 annotated

⁷⁸ US 6,270,026 to Piepho 3:23-31, emphasis added.

facing surface relative to the longitudinal axis.



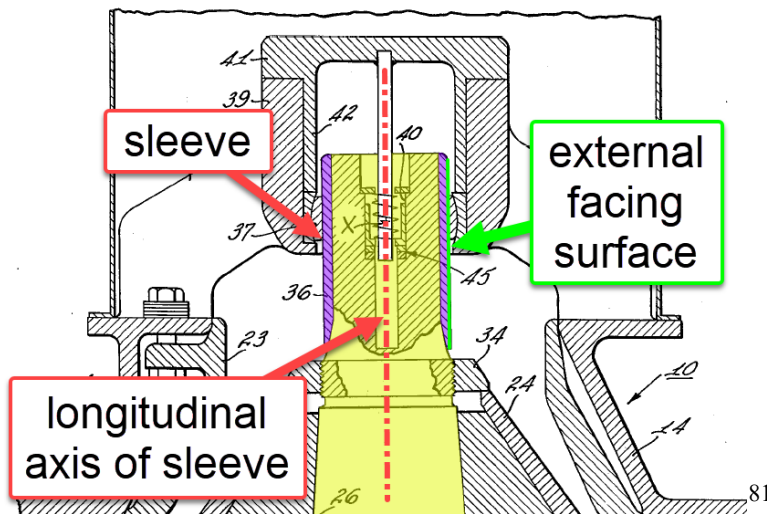
Piepho discloses a sleeve with an external facing surface relative to the longitudinal axis.

*“The present invention provides an intervening material between the shaft end (25) and the mating bore in yoke bushing (18) fitted within the bore of yoke (12) to prevent fretting damage.”*⁸⁰

As shown and described, the bushing (18) is fitted into a bore on the yoke (12). This fit-up involves contact between an external facing surface of the bushing (18) and the bore of yoke (12).

⁷⁹ US 6,270,026 to Piepho, Figure 1 annotated

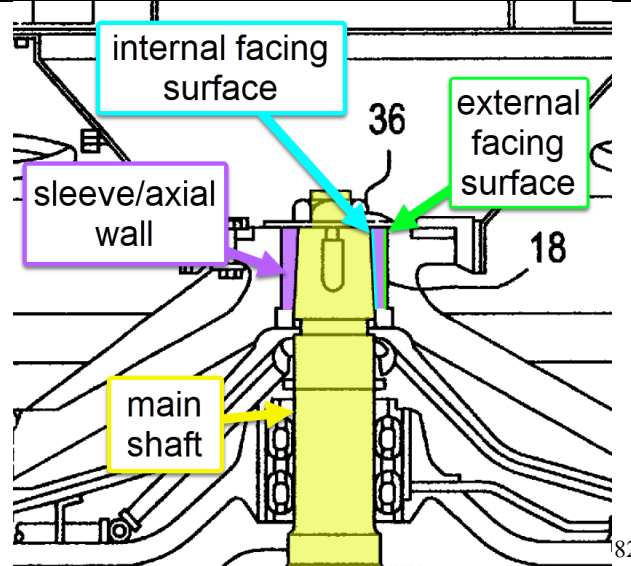
⁸⁰ US 6,270,026 to Piepho 3:24-27



Coxhill discloses the sleeve having an external facing surface facing away from the longitudinal axis of the sleeve.

11b5. the axial wall extending between the internal and external facing surfaces,

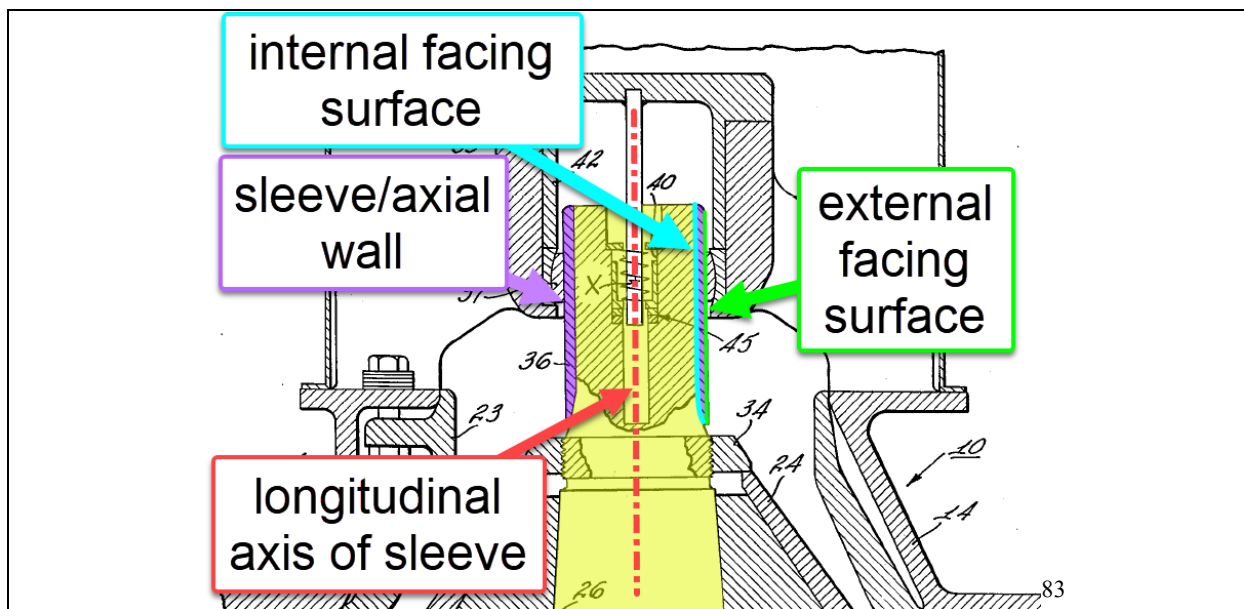
YES: Both Coxhill and Piepho disclose a sleeve with an axial wall that extends between the internal and external facing surfaces.



As shown above, Piepho discloses the axial wall of the sleeve extending between the internal and external facing surfaces.

⁸¹ US 6,270,026 to Piepho, Figure 1 annotated

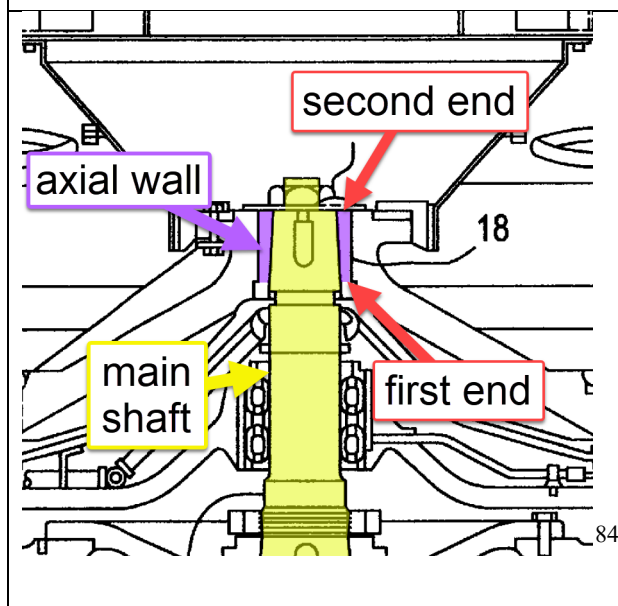
⁸² US 6,270,026 to Piepho, Figure 1 annotated



As shown above, Coxhill also discloses the axial wall of the sleeve extending between the internal and external facing surfaces.

11b6. the axial wall having a first sleeve end for positioning at a lower region of the main shaft and a second sleeve end for positioning at an upper region of the main shaft relative to the lower region,

YES: Both Coxhill and Piepho disclose an axial wall having a first sleeve end for positioning at a lower region of the main shaft and a second sleeve end for positioning at an upper region of the main shaft relative to the lower region.

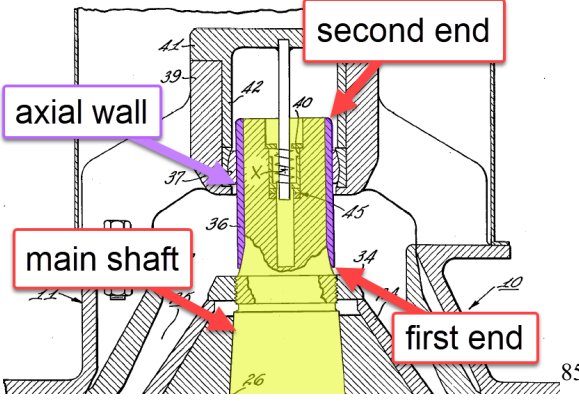
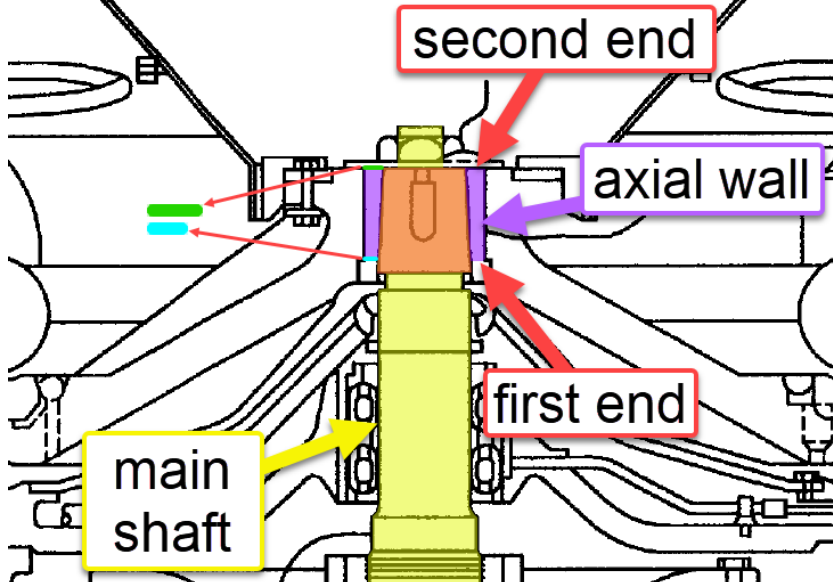


As shown Piepho disclose the axial wall has a first end positioned at a lower region of the main shaft and a second end positioned at an upper region of the main shaft relative to the lower region.

Note that the first end is on a lower region of the main shaft in exactly the same way as disclosed for the '568. That is, the first end of the sleeve is at the lower region of the tapered section. Thus, even though both the first and second ends of the axial wall are

⁸³ US 4,034,922 to Coxhill Figure 1, annotated

⁸⁴ US 6,270,026 to Piepho, Figure 1 annotated

	positioned at the second end of the main shaft, the first end of the sleeve is at a lower region of the main shaft <i>relative</i> to the second end. See '568 Figure 1.
	As shown, Coxhill also disclose the axial wall has a first end positioned at a lower region of the main shaft and a second end positioned at an upper region of the main shaft relative to the lower region. Like Piepho, Coxhill also discloses the first and second end positioned relative to the main shaft the same way as disclosed in the '568 patent.
11b7. wherein a thickness of the axial wall at a region between the first and second <u>sleeve</u> ends <u>tapers and</u> decreases in a direction from the second <u>sleeve</u> end to the first <u>sleeve</u> end,	YES: Piepho discloses that the thickness of the axial wall at a region between the first and second sleeve ends tapers and decreases in a direction from the second sleeve end to the first sleeve end.
	

⁸⁵ US 4,034,922 to Coxhill Figure 1, annotated

⁸⁶ US 6,270,026 to Piepho, Figure 1 annotated

In Piepho, as shown above the thickness of the axial wall decreases from the second end to the first end. This is demonstrated by the figure above which shows the **turquoise** line at the first end is shorter than the **green** line at the second end. This is because the sleeve bushing (18) is tapered to match the tapered portion of the main shaft.

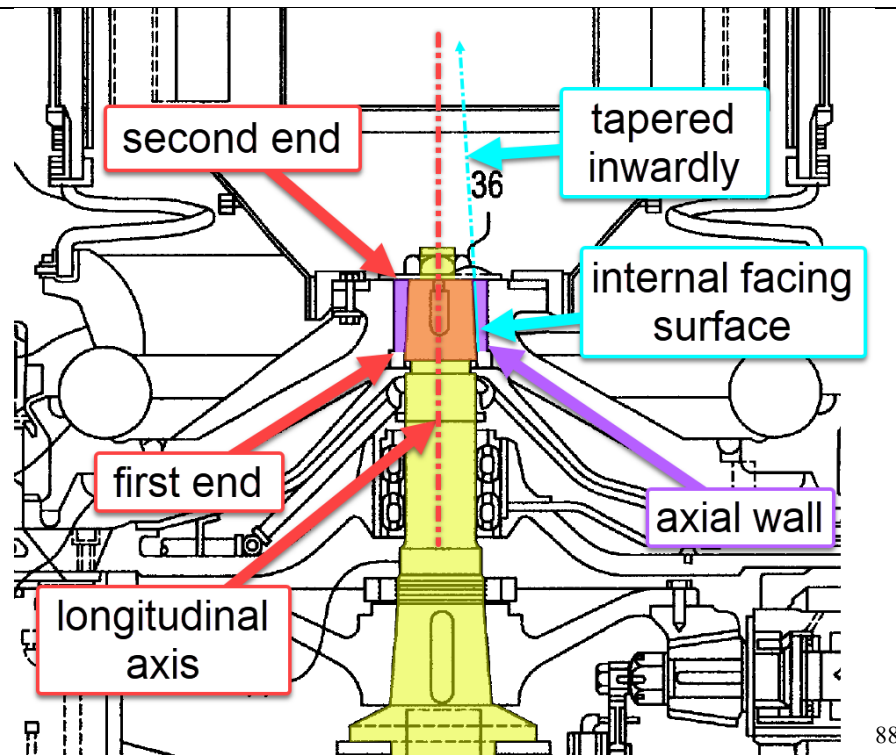
“Preferably, the joint (21) is a tapered joint with the tapered end (25) of shaft (14). The yoke bushing (18) has a mating bore similarly tapered.”⁸⁷

A POSITA would have been motivated to combine the sleeve (including the axial wall) and tapered shaft of Piepho with the main shaft of Coxhill resulting in the thickness of the axial wall at a region between the first and second sleeve ends tapering and decreasing in a direction from the second sleeve end to the first sleeve end. This combination would have been nothing more than combining known elements according to known methods to yield predictable results. A POSITA would be further motivated, as Piepho describes, as the tapered shaft aids in accurate alignment which is notoriously more difficult with purely cylindrical shafting. Piepho further teaches that a tapered joint is preferable to a cylindrical joint.

11b8. in the axial direction the internal facing surface at said region between the first and second sleeve ends extending transverse to the longitudinal axis so as to taper inwardly towards the longitudinal axis of the sleeve in the direction from the first sleeve end to the second sleeve end, and

YES: Piepho discloses that in the axial direction, the internal facing surface at said region between the first and second sleeve ends extends transverse to the longitudinal axis so as to taper inwardly towards the longitudinal axis of the sleeve in the direction from the first to sleeve end the second sleeve end.

⁸⁷ US 6,270,026 to Piepho 3:30-32



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As shown above the internal facing surface at the region between the first and second sleeve ends of the axial wall tapers inwardly towards the longitudinal axis in the direction from the first end of the sleeve to the second end of the sleeve. This is because the sleeve bushing (18) is tapered to match the tapered portion of the main shaft.

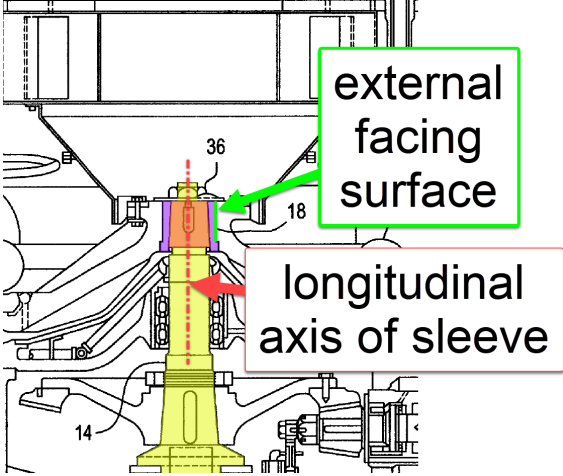
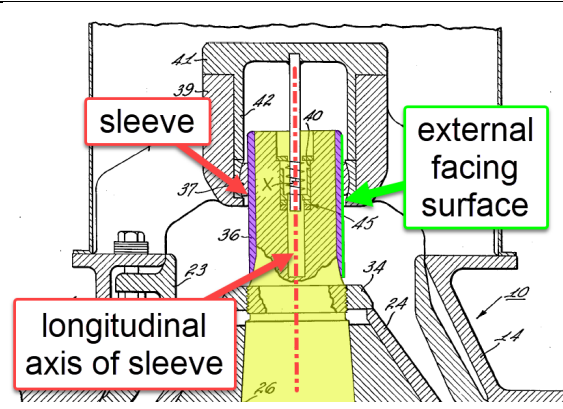
“Preferably, the joint (21) is a tapered joint with the tapered end (25) of shaft (14). The yoke bushing (18) has a mating bore similarly tapered.”⁸⁹

As the citation above describes, the bushing has a tapered bore that spans the entire axial length.

A POSITA would have been motivated to combine the sleeve (including the tapered internal surface) and tapered shaft of Piepho with the main shaft of Coxhill. This combination would have been nothing more than combining known elements according to known methods to yield predictable results. A POSITA would be further motivated, as Piepho describes, as the tapered shaft aids in accurate alignment which is notoriously more difficult with purely cylindrical shafting. Piepho further teaches that a tapered joint is preferable to a cylindrical joint.

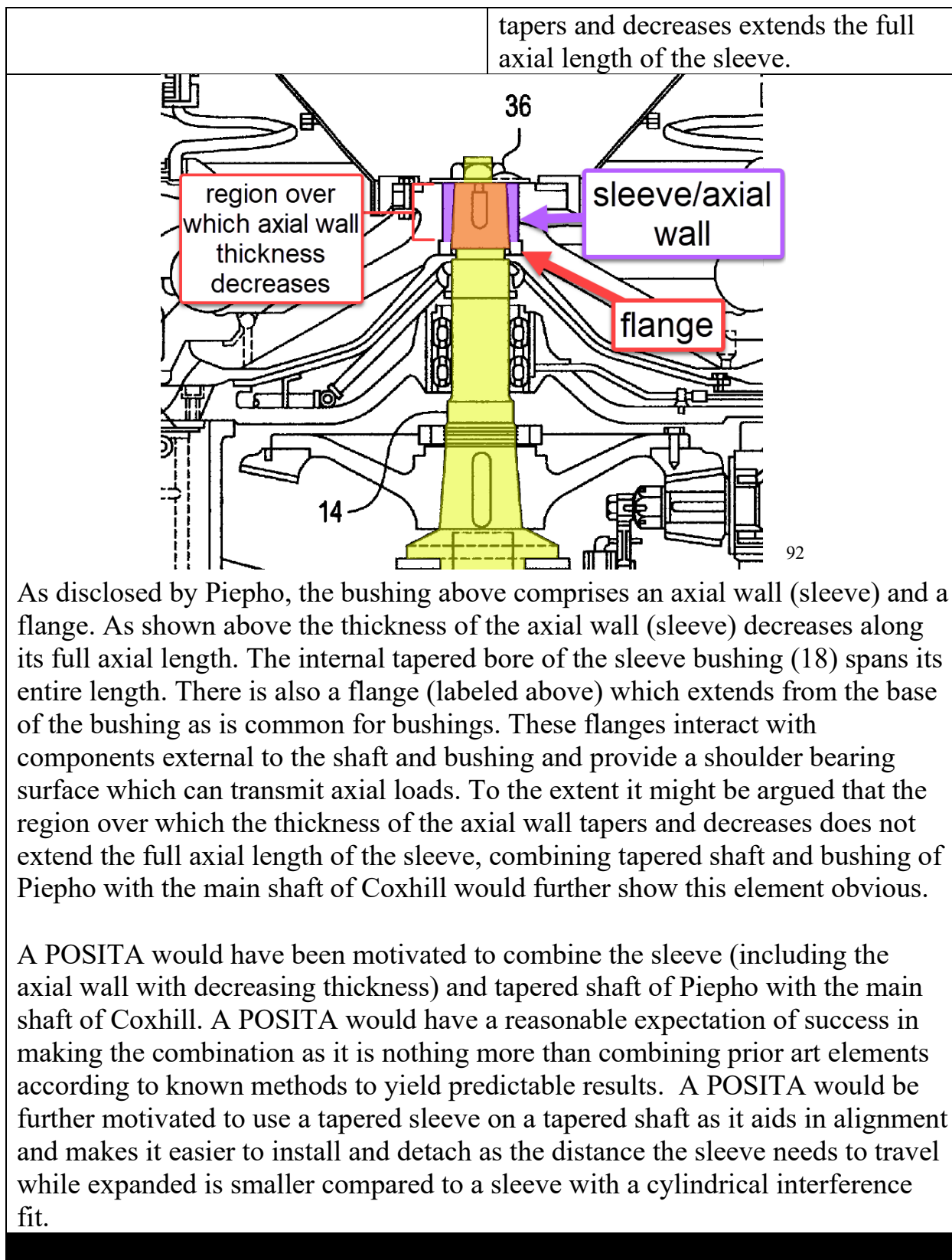
⁸⁸ US 6,270,026 to Piepho, Figure 1, annotated

⁸⁹ US 6,270,026 to Piepho 3:30-32

11B9. wherein the external facing surface from the first sleeve end to the second sleeve end is parallel to the longitudinal axis of the sleeve such that the external facing surface of the sleeve when viewed externally has a cylindrical geometry.	YES: Both Coxhill and Piepho disclose that the external facing surface from the first sleeve end to the second sleeve end is parallel to the longitudinal axis of the sleeve such that the external facing surface of the sleeve when viewed externally has a cylindrical geometry.
	Piepho discloses as shown, the external facing surface revolved around the longitudinal axis of the sleeve forms a cylinder.
	Coxhill Piepho discloses as shown, the external facing surface revolved around the longitudinal axis of the sleeve forms a cylinder.
12P. The gyratory crusher as claimed in claim 11,	YES: As shown above, Coxhill in view of Piepho discloses the gyratory crusher as claimed in claim 11.
12a. wherein the region over which the thickness of the axial wall tapers and decreases extends substantially the full axial length of the sleeve.	YES: a combination of Piepho and Coxhill discloses that the region over which the thickness of the axial wall

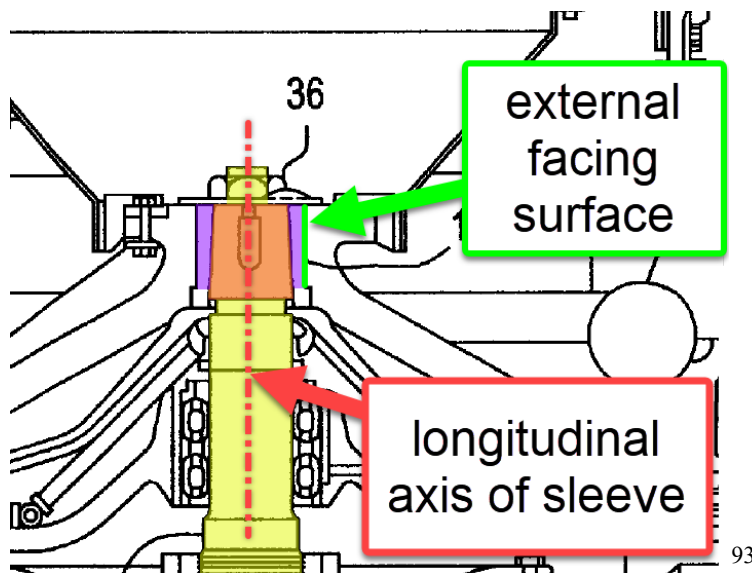
⁹⁰ US 6,270,026 to Piepho, Figure 1, annotated

⁹¹ US 4,034,922 to Coxhill, Figure 1, annotated



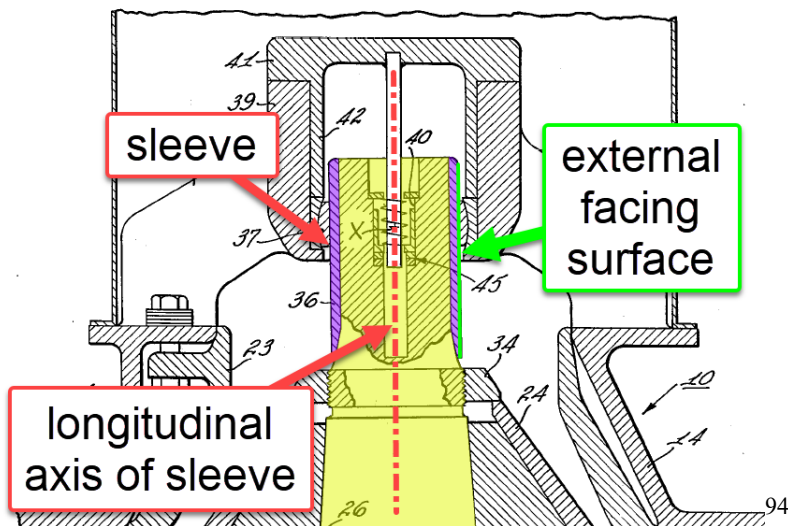
⁹² US 6,270,026 to Piepho, Figure 1, annotated

14P. The gyratory crusher as claimed in claim 11,	YES: As shown above, Coxhill in view of Piepho discloses the gyratory crusher as claimed in claim 11.
14a. wherein a cross-sectional shape profile of the external facing surface is substantially circular.	YES: Both Coxhill and Piepho disclose that the cross-sectional shape profile of the external facing surface is substantially circular.



Piepho discloses an external facing surface that, when revolved around the longitudinal axis of the sleeve, forms a cylinder which has a circular shaped cross-section.

⁹³ US 6,270,026 to Piepho, Figure 1, annotated



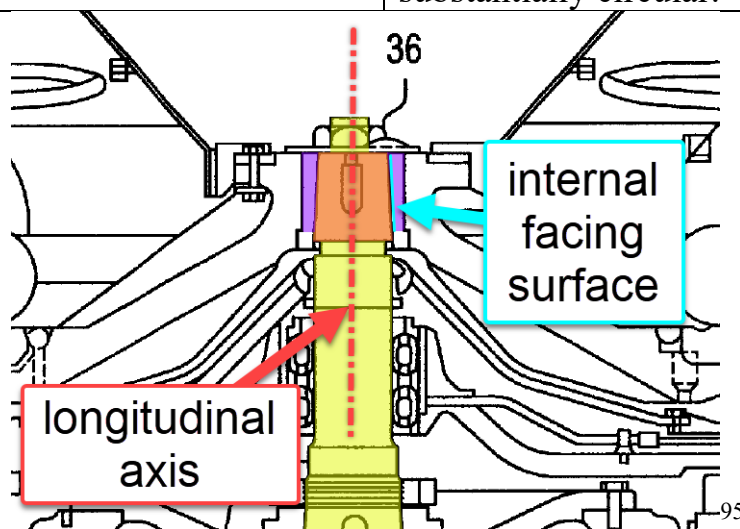
Coxhill also discloses an external facing surface that, when revolved around the longitudinal axis of the sleeve, forms a cylinder which has a circular shaped cross-section.

15P. The gyratory crusher as claimed in claim 11,

YES: As shown above, Coxhill in view of Piepho discloses the gyratory crusher as claimed in claim 11.

15a. wherein a cross-sectional shape profile of the internal facing surface is substantially circular.

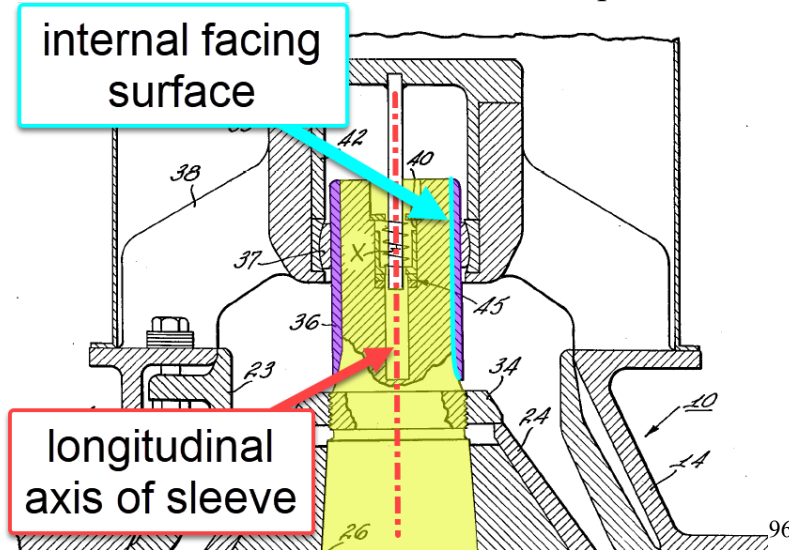
YES: Both Coxhill and Piepho disclose that the cross-sectional shape profile of the internal facing surface is substantially circular.



⁹⁴ US 4,034,922 to Coxhill, Figure 1, annotated

⁹⁵ US 6,270,026 to Piepho, Figure 1, annotated

Piepho discloses an internal facing surface that, when revolved around the longitudinal axis of the sleeve, will have a circular shaped cross-section.



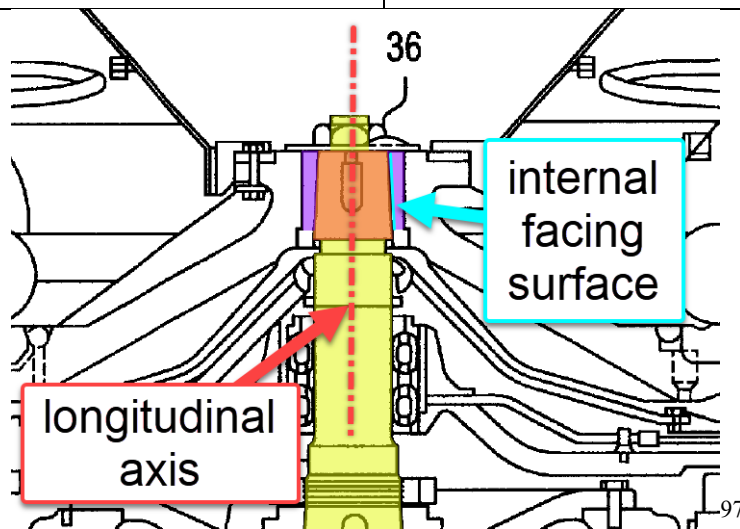
Coxhill also discloses an internal facing surface that, when revolved around the longitudinal axis of the sleeve, will have a circular shaped cross-section.

16P. The gyratory crusher as claimed in claim 11,

YES: As shown above, Coxhill in view of Piepho discloses the gyratory crusher as claimed in claim 11.

16a. wherein a shape profile of the internal facing surface defines a section of a cone in the axial direction.

YES: Piepho discloses that the shape profile of the internal facing surface defines a section of a cone in the axial direction.



⁹⁶ US 4,034,922 to Coxhill, Figure 1, annotated

⁹⁷ US 6,270,026 to Piepho, Figure 1, annotated

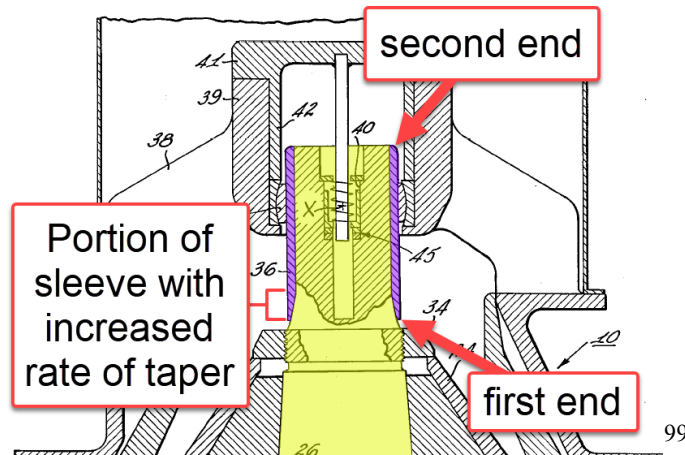
As shown above the shape of the internal facing surface of the sleeve bushing (18) is tapered to fit up with the tapered portion of the main shaft. A tapered internal facing surface is a section of a cone and it is oriented in the axial direction. This is consistent with the description in the specification of Piepho.

“Preferably, the joint (21) is a tapered joint with the tapered end (25) of shaft (14). The yoke bushing (18) has a mating bore similarly tapered.”⁹⁸

A POSITA would be motivated to combine Coxhill’s shaft and sleeve with Piepho’s teachings of a tapered shaft end and tapered sleeve (with an internal facing surface that defines a section of a cone) fitted over the tapered section of second end of the main shaft. A POSITA would have a reasonable expectation of success in making the combination as it is nothing more than combining prior art elements according to known methods to yield predictable results. A POSITA would be further motivated to use a tapered sleeve on a tapered shaft as it aids in alignment and makes it easier to install and detach as the distance the sleeve needs to travel while expanded is smaller compared to a sleeve with a cylindrical interference fit.

18P. The gyratory crusher as claimed in claim 11,	YES: As shown above, Coxhill in view of Piepho discloses the gyratory crusher as claimed in claim 11.
18a. wherein at a ~~curved~~ region ~~[[of]]~~ <u>proximal to the first sleeve end, the thickness of the axial wall reduces at an increased rate relative to a region of the axial wall proximal to the second sleeve end</u> ~~the internal facing surface is curved radially outward relative to the longitudinal axis in a direction towards the external facing surface such that the axial wall thickness decreases to zero at the curved region.~~	YES: Coxhill in view of Piepho discloses wherein at a region proximal to the first sleeve end, the thickness of the axial wall reduces at an increased rate relative to a region of the axial wall proximal to the second sleeve end.

⁹⁸ US 6,270,026 to Piepho 3:30-32



Coxhill discloses a portion of the sleeve where the thickness of the sleeve decreases and an increased rate relative to the portion of the sleeve proximal the second end of the sleeve. In Coxhill alone, the portion of the sleeve proximal the second end does not decrease, so any decrease in the thickness would be at an increased rate.

In Coxhill in view of Piepho, the thickness of the sleeve would decrease slowly in the portion near the second end, as necessary to fit on the tapered shaft of Piepho and faster in the portion proximal the first end as shown in Coxhill.

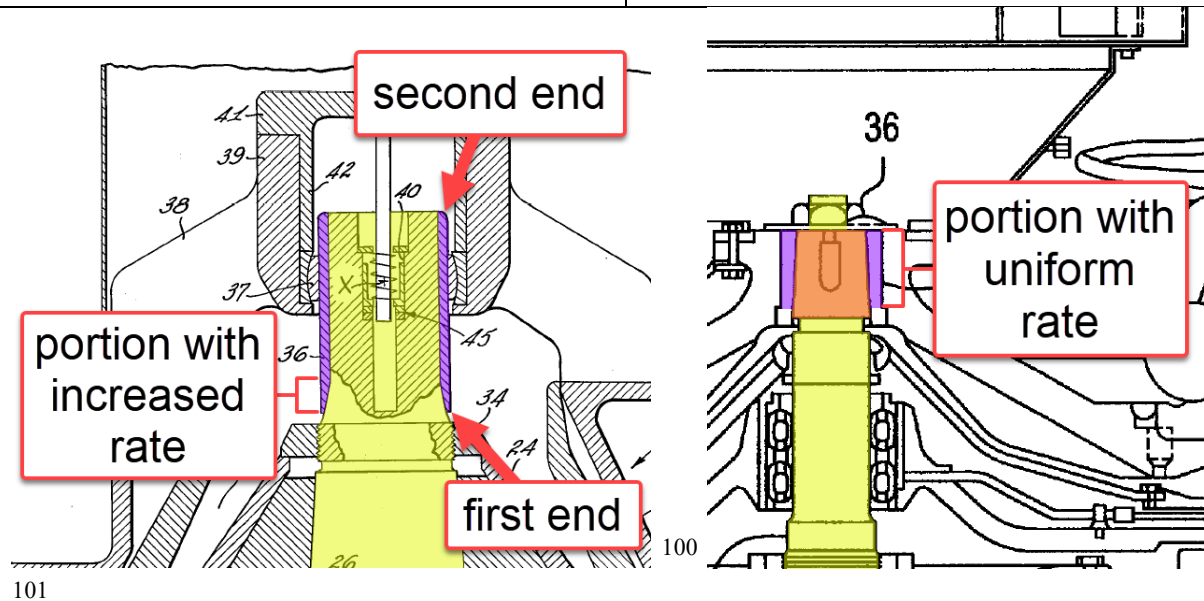
A POSITA would be motivated to combine Coxhill's shaft and sleeve with Piepho's teachings of a tapered shaft end and tapered sleeve (with an internal facing surface that defines a section of a cone) fitted over the tapered section of second end of the main shaft. A POSITA would have a reasonable expectation of success in making the combination as it is nothing more than combining prior art elements according to known methods to yield predictable results. A POSITA would be further motivated to use a tapered sleeve on a tapered shaft as it aids in alignment and makes it easier to install and detach as the distance the sleeve needs to travel while expanded is smaller compared to a sleeve with a cylindrical interference fit.

19P. The gyratory crusher as claimed in claim 18,	YES: As shown above, Coxhill in view of Piepho discloses the gyratory crusher as claimed in claim 18.
19a. wherein the thickness of the axial wall reduces at a uniform rate along an entire axial length of the sleeve other	YES: Coxhill in view of Piepho discloses wherein the thickness of the axial wall reduces at a uniform rate

⁹⁹ US 4,034,922 to Coxhill, Figure 1, annotated

than the region proximal to the first sleeve end.

along an entire axial length of the sleeve other than the region proximal to the first sleeve end.



As seen above, Coxhill in view of Piepho discloses a portion of the axial wall (the entire portion other than the portion near the first end) that reduces in thickness at a uniform rate as shown by the cone-shaped internal facing surface and cylinder-shaped external facing surface.

A POSITA would be motivated to combine Coxhill's shaft and sleeve with Piepho's teachings of a tapered shaft end and tapered sleeve (with an internal facing surface that defines a section of a cone) fitted over the tapered section of second end of the main shaft. A POSITA would have a reasonable expectation of success in making the combination as it is nothing more than combining prior art elements according to known methods to yield predictable results. A POSITA would be further motivated to use a tapered sleeve on a tapered shaft as it aids in alignment and makes it easier to install and detach as the distance the sleeve needs to travel while expanded is smaller compared to a sleeve with a cylindrical interference fit.

E. Coxhill in View of Piepho and Polinski Render Claim 13 Obvious

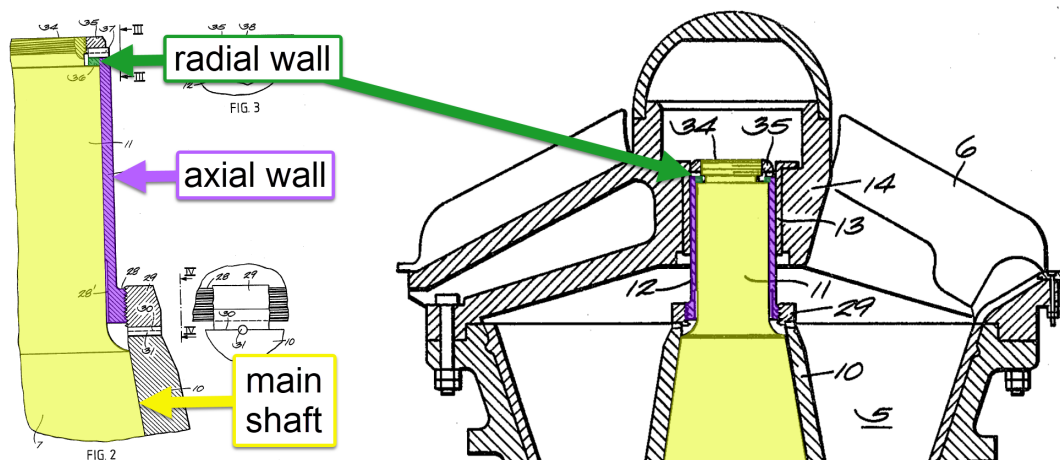
Challenged Claim

Does the Prior Art disclose this?

¹⁰⁰ US 4,034,922 to Coxhill, Figure 1, annotated

¹⁰¹ US 6,270,026 to Piepho, Figure 1, annotated

13P. The gyratory crusher as claimed in claim 11,	YES: As shown above, Coxhill in view of Piepho discloses the gyratory crusher as claimed in claim 11.
13a1. further comprising a radial wall extending perpendicular or transverse to the axial wall,	YES: Polinski discloses a radial wall extending perpendicular or transverse to the axial wall.



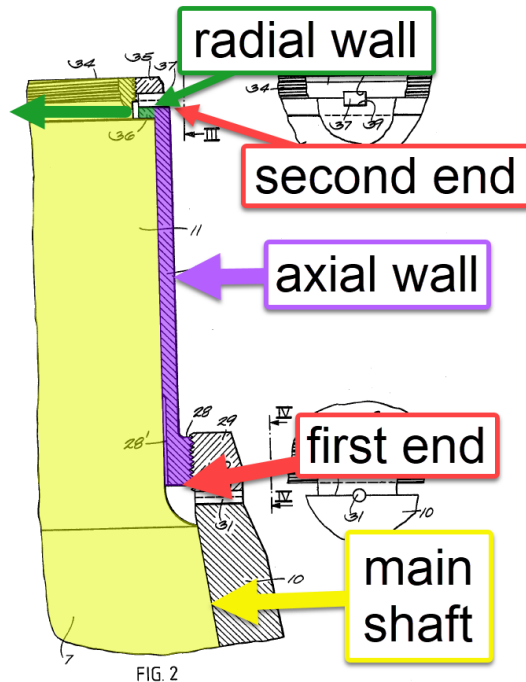
As shown above Polinski discloses a radial wall that extends transversely to the axial wall. This feature serves as a shoulder that sets the depth of the sleeve during fit-up and provides a shoulder for potentially bearing axial loads.

“As best shown in FIGS. 2 and 3, a threaded lug 34 is provided on the end of the journal which is adapted to receive a sleeve nut 35 which axially overlies an inwardly projecting annular lip 36 on the upper end of the sleeve 12.”¹⁰²

A POSITA would be motivated to include this radial wall in the combination of Polinski in view of Piepho as it makes for a more predictable assembly process and provides additional bearing surface for the top sleeve securing nut.

13a2. the radial wall being positioned at or towards the second end and extending inwardly towards the longitudinal axis.	YES: Polinski discloses that the radial wall is positioned at or towards the second end and extends inwardly towards the longitudinal axis.
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¹⁰² US 4,410,143 to Polinski 3:25-29, emphasis added.



As shown above the radial wall of Polinski is positioned at the second end of the sleeve. Further it extends inwardly towards the longitudinal axis.

*“As best shown in FIGS. 2 and 3, a threaded lug 34 is provided on the end of the journal which is adapted to receive a sleeve nut 35 which axially overlies an inwardly projecting annular lip 36 on the upper end of the sleeve 12.”*¹⁰³

A POSITA would be motivated to include this radial wall in the combination of Polinski in view of Piepho as it makes for a more predictable assembly process and provides additional bearing surface for the top sleeve securing nut.

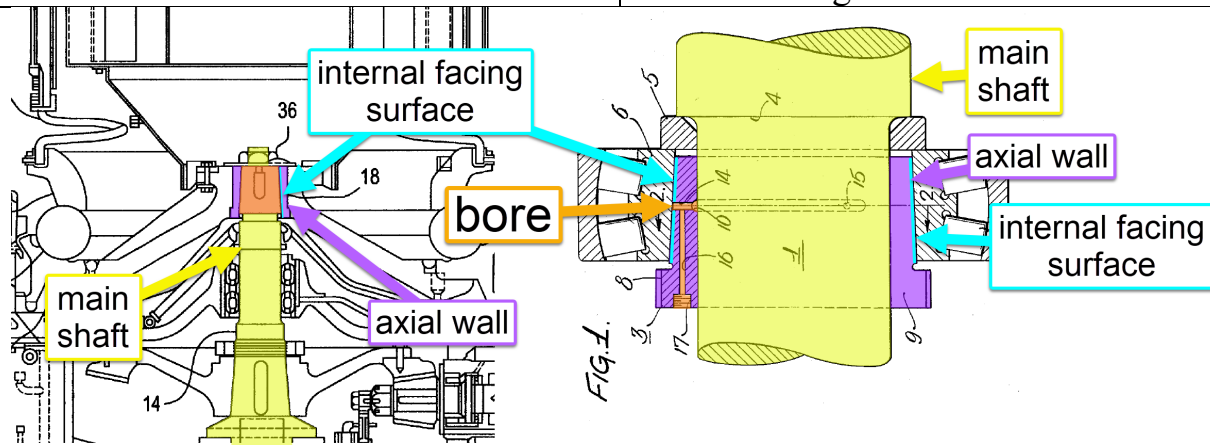
F. Coxhill in View of Piepho and Bratt Render Claim 17 Obvious

Challenged Claim	Does the Prior Art disclose this?
17P. The gyratory crusher as claimed in claim 11,	YES: As shown above, Coxhill in view of Piepho discloses the gyratory crusher as claimed in claim 11.
17a. further comprising at least one bore provided through the axial wall to	YES: Polinski in view of Piepho and further in view of A.E. Bratt discloses further comprising at least one bore

¹⁰³ US 4,410,143 to Polinski 3:25-29, emphasis added.

allow the passage of a fluid to the internal facing surface.

provided through the axial wall to allow the passage of a fluid to the internal facing surface.



Piepho

A.E. Bratt

As shown above, A.E. Bratt discloses a tapered sleeve on a shaft, and a bore provided through the axial wall allow the passage of a fluid to the internal facing surface between the sleeve and the shaft.

“The present invention relates to a press fitted or shrunk joint and has for its purpose to facilitate the making of the joint or the separation thereof.

...

*According to the present invention arrangements are made for introducing under pressure a fluid, either liquid or gaseous, between the engaging surfaces so that the metallic contact is relieved over at least the greater part of the surfaces whereby **these may be more easily displaced relative each other.***

...

A passage 16, extending from the flanged end of the sleeve axially to the hole 14, establishes a channel of communication between the groove 10, and holes 13, 14 and 15, and an exposed surface of the assembly.

...

The outer end of the passage 16 is then connected to a source of a suitable pressure fluid, for example oil, such connection being facilitated by the threads 17 at the outer end of the passage. The pressure of the oil must be as great at least as the specific pressure between the engaging surfaces of the sleeve and shaft and of the sleeve and bearing so that the oil may force its way between the said surfaces. The oil thus introduced and distributed by way of the groove 10 and holes 13, 14 and 15, forms films between the inner and outer surfaces of the sleeve and the confronting surfaces of the shaft and bearing respectively and make it possible to displace the sleeve axially with respect both to the shaft and bearing by application of forces of relatively low order and without damage to the said surfaces. The oil film may be so thin that it relieves the metallic contact between the surfaces but does not materially expand or contract the engaging parts.

The same procedure may be used in obvious manner to aid in effecting the force fit between [sic] the sleeve and the shaft and bearing. The oil introduced in this operation quickly disappears from between the surfaces and does not affect the strength of the joint and its ability to transmit power.”¹⁰⁴

As described above, A.E. Bratt discloses an apparatus for delivering lubricating oil through a bore in the axial wall of a tapered sleeve to assist in the making or braking of a tapered interference-fit joint. A POSITA would understand that this is the only reasonable function of adding lubricating oil to the mating surfaces of a tapered interference-fit joint.

A POSITA would be motivated to implement the well-known hydraulic processes for making and breaking interference fits, for example between the sleeve and the shaft, as they are well known to protect the shaft from damage,¹⁰⁵ they are able to be used in more locations as they do not require presses and gear pullers,¹⁰⁶ does not require the maintenance that presses and gear pullers do,¹⁰⁷ and make removing components on a tapered shaft particularly easy.¹⁰⁸

VI. CONCLUSION

37. It is my opinion that Claims 11-16 are obvious over Polinski in view of Piepho and Pollak.

38. It is my opinion that Claim 17 is obvious over Polinski in view of Piepho, Pollak and Bratt.

39. It is my opinion that Claims 18-19 are obvious over Polinski in view of Piepho and Pollak.

40. It is my opinion that Claims 11-12, 14-16 and 18-19 are obvious over

¹⁰⁴ US 2,764,437 to A.E. Bratt 1:19-21, 29-34, 69-72, 2:6-29, emphasis added

¹⁰⁵ Behm 1:13-15, 1:35-42

¹⁰⁶ Sillett 1:15-24

¹⁰⁷ Sillett 1:35-40

¹⁰⁸ Harless 3:15-22

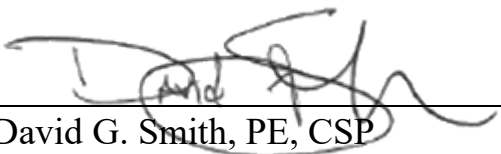
Coxhill in view of Piepho.

41. It is my opinion that Claim 13 is obvious over Coxhill in view of Piepho and Polinski.

42. It is my opinion that Claim 17 is obvious over Coxhill in view of Piepho and Bratt.

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

Executed on September 16, 2025 in Meridian, ID.



David G. Smith, PE, CSP