

Filed September 4, 2024

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

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

v.

SANDVIK INTELLECTUAL PROPERTY AB,
Patent Owner.

Case No. IPR2024-01381
US Patent 11,014,090

**DECLARATION OF DAVID G. SMITH, IN SUPPORT OF PETITION FOR
INTER PARTES REVIEW OF U.S. PATENT 11,014,090**

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I. INTRODUCTION

1. I, David G. Smith, submit this 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. 11,014,090 ('090 patent or Pat '090).

2. The subject of my declaration is the invalidity of the '090 patent. This declaration is provided after my review and analysis of the '090 patent, the prior art, relevant background technology, and is also based on my education and experience, as well as additional materials identified herein.

II. BACKGROUND AND QUALIFICATIONS

3. Beusse Sanks PLLC and Gunster, Yoakley & Stewart have retained me as a technical expert in this action.

4. I have attached, as Exhibit 1, a copy of my Curriculum Vitae, which outlines my educational and employment history. I received a Bachelor's degree in Mechanical Engineering from Brigham Young University - Idaho. I received a Master's of Science degree in Mechanical Engineering from Brigham Young University (BYU), and a Masters of Business Administration from Brigham Young University (BYU) with an emphasis in Product Development. I am a licensed professional engineer (PE) and a certified safety professional in comprehensive practice (CSP).

5. I have experience in the fields of mechanical engineering, structural design, new product development, the design of equipment, machinery, safety and consumer products. In my role as a consultant, I have consulted on numerous products and custom testing devices. Among the products I have consulted on are drill rigs, pipe breakers, brick saws, auger conveyors, belt conveyors, dry bulk trailers, rock slingers, dump trailers and other hydraulic equipment.

6. I am a named inventor on seven U.S. Patents. I believe that my credentials as set forth above and, in my Curriculum Vitae, demonstrate that I am an expert in the fields of mechanical design, structural design, product design, design of equipment, and design safety.

7. I have attached as Exhibit 2 a list of all my deposition or trial testimony in the last four years.

8. In forming my opinions, I have considered the documents listed in Exhibit 3 in addition to any other documents cited in this declaration. To the best of my knowledge, these documents are true and accurate copies of what they purport to be. An expert in the field would reasonably rely on them to formulate opinions such as those set forth in this declaration.

III. LEGAL PRINCIPLES

9. I am not a lawyer. Therefore, in formulating my opinions and conclusions in this proceeding, I have been provided with an understanding of the

relevant aspects of U.S. patent law that govern the issues of patent validity. I am informed that the effective filing date for this analysis is May 23, 2014

A. Prior Art

10. I understand that, in this IPR proceeding, the prior art to the '090 patent includes patents and printed publications in the relevant field(s) that predate the patent's effective filing date.

B. Obviousness

11. I understand that a claim of a patent may be obvious to a person of ordinary skill in the art if the differences between the subject matter set forth in the patent claim and the prior art are such that the claimed subject matter as a whole would have been obvious at the time of the invention.

12. I understand that obviousness is a determination of law based on various underlying determinations of fact. In particular, these underlying factual determinations include (1) the scope and content of the prior art; (2) the level of ordinary skill in the art at the time the claimed invention was made; (3) the differences between the claimed invention and the prior art; and (4) the extent of any proffered objective "indicia" of non-obviousness. I understand that the objective indicia, also known as secondary considerations, which may be considered in such an analysis include, among other factors: the commercial success of the patented invention (including evidence of industry recognition or awards), the existence of a

long-felt but unmet need in the field satisfied by the invention, the failure of others to arrive at the invention, industry acquiescence and recognition of the invention, initial skepticism of the invention by others in the field, the extent to which the inventors proceeded in a direction contrary to the accepted wisdom of those of ordinary skill in the art, and licensing of the patent.

13. In determining the scope and content of the prior art, I understand a reference is considered prior art for the obviousness analysis if it falls within the inventors' field of endeavor. Additionally, a reference is prior art for the obviousness analysis, even if from a different field of endeavor, if it is reasonably pertinent to the particular problem for which the invention was made. A reference is reasonably pertinent if it is something a person of ordinary skill in the art would have looked to when attempting to solve the problem.

14. While multiple prior art references or elements may be combined to render a patent claim obvious, I understand that a patent claim composed of several elements is not proven obvious merely by demonstrating that each of its elements was, independently, known in the prior art. I understand that I should consider whether there is an "apparent reason" or motivation to combine the prior art references or elements in the way the patent claims. It is my further understanding that the law recognizes several rationales for combining references or modifying a reference to show obviousness of claimed subject matter. Some of these rationales

include: combining prior art elements according to known methods to yield predictable results; simple substitution of one known element for another to obtain predictable results; a predictable use of prior art elements according to their established functions; applying a known technique to a known method or product ready for improvement; and choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success.

IV. THE LEVEL OF ORDINARY SKILL IN THE ART

15. I have been advised by counsel that the Federal Circuit has noted a list of six factors that may be considered when determining the level of ordinary skill in the art. The factors are listed below. I have used the factors in combination with the available information in determining the level of ordinary skill in the art.

- A. The education level of the inventor.
- B. The type of problems encountered in the art.
- C. Prior art solutions to those problems.
- D. The rapidity with which innovations are made.
- E. The sophistication of the technology.
- F. The education level of active workers in the field.

A. **The education level of the inventor(s)**

16. The named inventors of the '090 patent are shown in the table below:

'090 Patent – Named Inventors
Axel Bergman – Malmo (SE)

Mikael M Larsson – Eslov (SE)
Patric Malmqvist – Svedala (SE)
Anders Hallberg – Sodra Sandby (SE)
Matts-Ake Nilsson – Gards Kopinge (SE)
Fredrik Eriksson – Malmo (SE)
Bengt-Arne Eriksson – Svedala (SE)
Anne Holmberg – Loddekopinge (SE)

17. I have located public information on the level of education for some of the above-named inventors. For example, Mr. Mikael M Larsson has a bachelor's degree in Engineering & Industrial Economics from HIG.¹ Similarly, Mr. Patric Malmqvist has a mechanical engineering degree from Malmö University.² Mr. Anders Hallberg also received a Bachelors of Science degree in Engineering from Malmö University.³

B. The type of problems encountered in the art.

18. The field of the '090 patent pertains to rock crushing machinery. Rock crushing equipment must repeatedly produce extremely large crushing forces in highly abrasive environments. Crushed rock is used for a wide variety of applications including feeding societies insatiable demand for aggregate, a key input for concrete which makes up a large part of the infrastructure for society and is the single most widely used construction material worldwide with billions of tons used each year.⁴ Crushed rock is also used to create aggregate input for

¹ Exhibit 1003, accessed 8-7-2024

² Exhibit 1004, accessed 8-7-2024

³ Exhibit 1005, accessed 8-8-2024

⁴ Exhibit 1006, accessed 8-5-2024

asphalt, another major construction material. Currently about 375 million tons of asphalt are produced every year⁵ which requires significant input for crushed rock. Other uses of crushed rock include structural base for foundations, railroads, drainage, and even just landscaping in general. In total 1.5 billion tons of crushed stone was produced in 2021 and the use of crushed stone has been consistently trading upward.⁶ Common types of rock that are crushed include limestone, dolomite, granite, marble, slate, quartzite, and more. Some rocks, like granite, marble, and quartzite are extremely hard and abrasive.

19. Cumulatively, the demand for crushed rock is enormous, which drives the need for production machinery as well as the need to run production machinery for as many hours as possible, eliminating down time. Considering the heavy nature of the task of crushing rock, this can lead to significant maintenance requirements and costs which includes the need to repeated assembly and disassembly to replace consumables.

20. Further still, other commonly encountered issues with rock crushing include feeding issues such as how to recover from a jam and how to handle uncrushables that inevitably get in the mix. Jamming may occur when a rock of the right size and orientation is fed into the crushing chamber and is unable to make it

⁵ Exhibit 1007, accessed 8-5-2024

⁶ Exhibit 1008, accessed 8-5-2024

to the crush zone such as shown below:



21. Another significant problem that can occur is when the rock feed is contaminated with uncrushables, which are foreign object that cannot be crushed such as large chunks of steel. Uncrushables present a significant hazard to rock crushing machinery as they can cause significant damage to components resulting in large maintenance costs and downtime.

C. **Prior art solutions to those problems.**

22. The prior art presents many solutions to the above-mentioned problems. For example, previously discussed jaw-style rock crushers use highly abrasion resistant materials on the jaws to handle long term use, wear, and tear. The jaw panels are commonly designed to have stout ribs that interleave thereby

⁷ Exhibit 1009, accessed 8-5-2024

creating a three-point bending load setup on the rock, thereby significantly reducing the amount of force required to break the rock. This rib structure also makes the crushing zone relieved so that broken rock has somewhere to go rather than being further compacted. Rock crushers use an incrementally progressive tapered crushing zone which spreads the crushing operation to fracture events. This spreads out the rock breaking action thereby further reducing the necessary force. Gyratory rock crushers similarly use highly abrasion resistant materials and a tapered crush zone that spreads out the crushing operation over time and space.

23. Rock crushers of all types commonly incorporate an eccentric over-center drive that is capable of generating significant amounts of periodic mechanical advantage and therefore force. Jaw-style crushers commonly incorporate large flywheels that build up momentum that can be put back into the jaws system as-needed. These features allow the drive systems to be reasonably sized while still reliably performing the crushing operations.

24. The prior art teaches having a protective abrasion and deformation resistant shell positioned over top of key areas inside the crushing zone. Not only do these protective shells protect the underlying components from the enormous contact pressures and stresses, they are also commonly separate pieces that are replaceable as-needed.

25. Beyond this rock crushers in the industry have been provided with

various adjustment means to control the degree of crushing implemented. The size of the aggregate needed will depend on the needs of the application. Consequently, it is not uncommon for rock crushers to be provided with an adjustment means to accomplish this. Further still, it is not uncommon for rock crushers to be provided with a relief mechanism that allows it to pass uncrushables. In gyratory cone crushers this is known to be accomplished by mounting the cone on a hydraulic ram that allows it to be retracted a sufficient distance to allow an uncrushable to pass before returning back to normal operating conditions. This allows a small amount of uncrushed rock to pass along with the uncrushable but crucially prevents the system from destroying itself against an uncrushable particle.

26. As mentioned previously, despite being designed to avoid jamming, inevitably, jamming can occur with a rock crushing machine. When this happens, various systems and tools have been devised to remove a jam so that the crushing operation may proceed. Some systems are as simple as having manual labor swing a sledge hammer at a jammed rock on a small enough machine. Other solutions involve placing wedges into the machine to help it grasp a rock particle in the right way so as to crush it. Still others systems involve crane elements or active jackhammering elements to either re-orient or partially break up the stubborn rock particle.

D. **The sophistication of the technology.**

27. Fundamentally, the function and motion of rock crushers is fairly simple. Whether it is a reciprocating jaw crusher, a gyrating cone crusher, or other design topology, rock crushing machinery generally has a crushing zone with a simple fixed member and a driven member. However, rock crushers are fairly complex machines. Crushers incorporate complicated physics, fracture mechanics, material science, and drive systems. Rock crushers commonly incorporate extensive interconnected mechanical systems, as well as electrical systems, and hydraulic systems. All of these systems must seamlessly cooperate in order for the rock crusher to do its job. Successful design of a rock crusher requires an understanding of tribology, fracture mechanics, and fluid mechanics to understand how to make a system that will guide widely varying particles of rock into the correct level of depth in the crushing zone, and then apply crushing forces without allowing the rock to slip back up and avoid being crushed. Crushed rock, especially granite and quartzite are notoriously abrasive and will test the durability of any system or material. Enhancing product life expectancy and reducing downtime for maintenance requires careful structural and fatigue analysis and intricate knowledge and extensive testing.

E. **The rapidity with which innovations are made.**

28. Rock crushing machinery has been designed, manufactured, and

operated for over 150 years. Innovations have been slow and incremental over time. Some of the rock crushing machinery (notably jaw crushers) use similar design topology to the original jaw style rock crusher by Eli Whitney. Gyrating cone crushers have been around for about 100 years and have been seeing slow and incremental improvements over time. Designing, building, and testing rock crushing machinery is no small task. It will typically require teams of people to accomplish the production of a single design. As such, innovations are going to be slow due to the time and cost involved.

F. **The education level of active workers in the field.**

29. Active workers in the field would typically be individuals with a bachelor's degree in mechanical engineering who may be fresh out of college and have no professional experience. Teams will also invariably require experienced engineers to help guide the process in the correct direction.

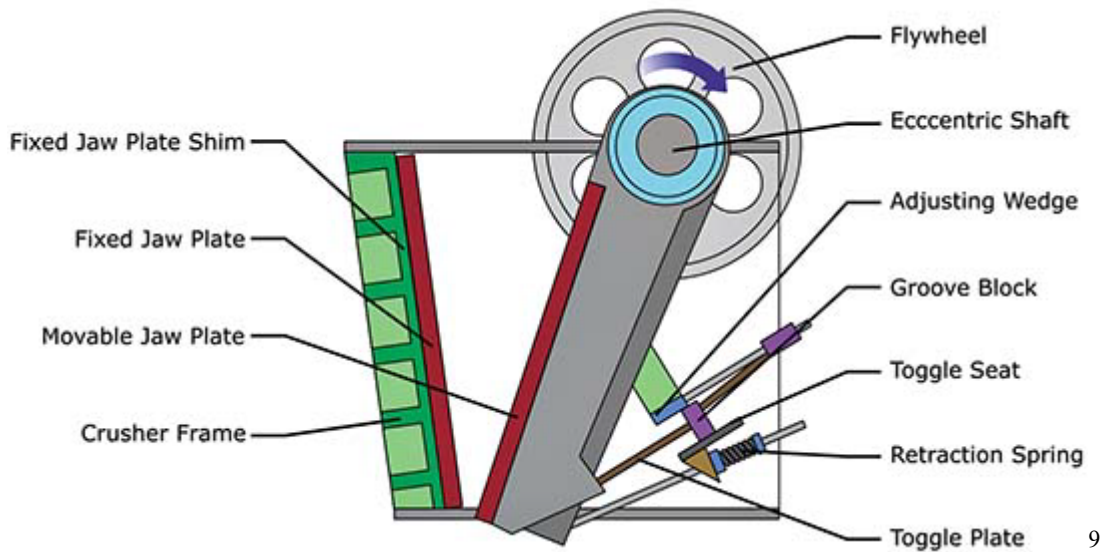
30. Considering the above, it is my opinion that at the time of the invention and the Challenged Claims of the '090 patent, a person having ordinary skill in the art would be a person who has a bachelor's degree in mechanical engineering or a related field, and at least 2 years of experience with industrial equipment design and development. A POSITA may also have a combination of more formal education and less work experience or a combination of less/different formal education and more work experience. I use that level of skill in making my observations and

reaching my conclusions herein, unless otherwise stated. As a result of my education and experience, I am qualified to testify as a person of ordinary skill in the art (POSITA) in this case.

V. BACKGROUND AND STATE OF THE ART

31. As discussed previously, the present matter relates to gyrating rock crushers. Before the advent of crushing machinery, aggregate was produced with manual labor such as by using hammers and pickaxes to break boulders and rocks into smaller pieces. The labor requirements where steep, which led to the development early mechanized rock crushing machinery. Eli Whitney Blake (the nephew of Eli Whitney who invented the cotton gin) is credited with inventing the first reciprocating jaw rock crusher in the 1850's.⁸ The basic reciprocating jaw crusher (a design still in use to this day) is shown below:

⁸ Exhibit 1010, accessed 7-30-2024

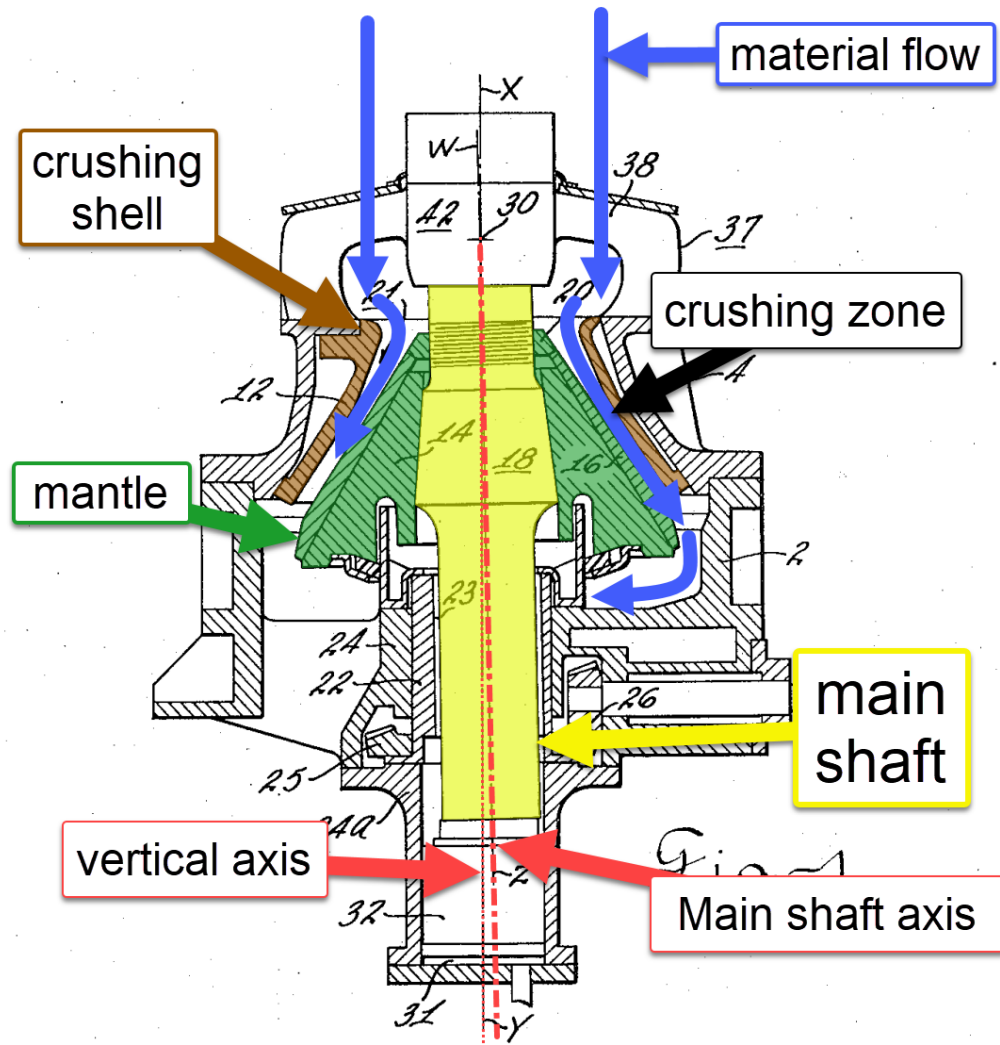


32. As shown above, the jaw crusher uses two jaws (one stationary and one reciprocating) arranged in a V-shape that successively crushes rock into smaller and smaller pieces.

33. The invention of the reciprocating jaw crusher was a quantum leap over manual labor in the rock crushing industry. As time went on, various improvements have been made to this design. Notably, modern jaw crushers have added the ability to pass uncrushable objects (such as large steel scrap) without damaging the equipment. Depending on the size, shape, orientation, and sequence of the rock entering the crusher, it is possible for a jam to occur. Various methods for eliminating jams have been devised, which typically require manual input or attention.

⁹ Exhibit 1011, accessed 7-30-2024

34. The gyrating cone crusher was first introduced to the market in the 1920's by the Symons brothers.¹⁰ The design topology for a typical gyrating cone crusher (as shown in US 3,813,047 to Torrence) is shown below:

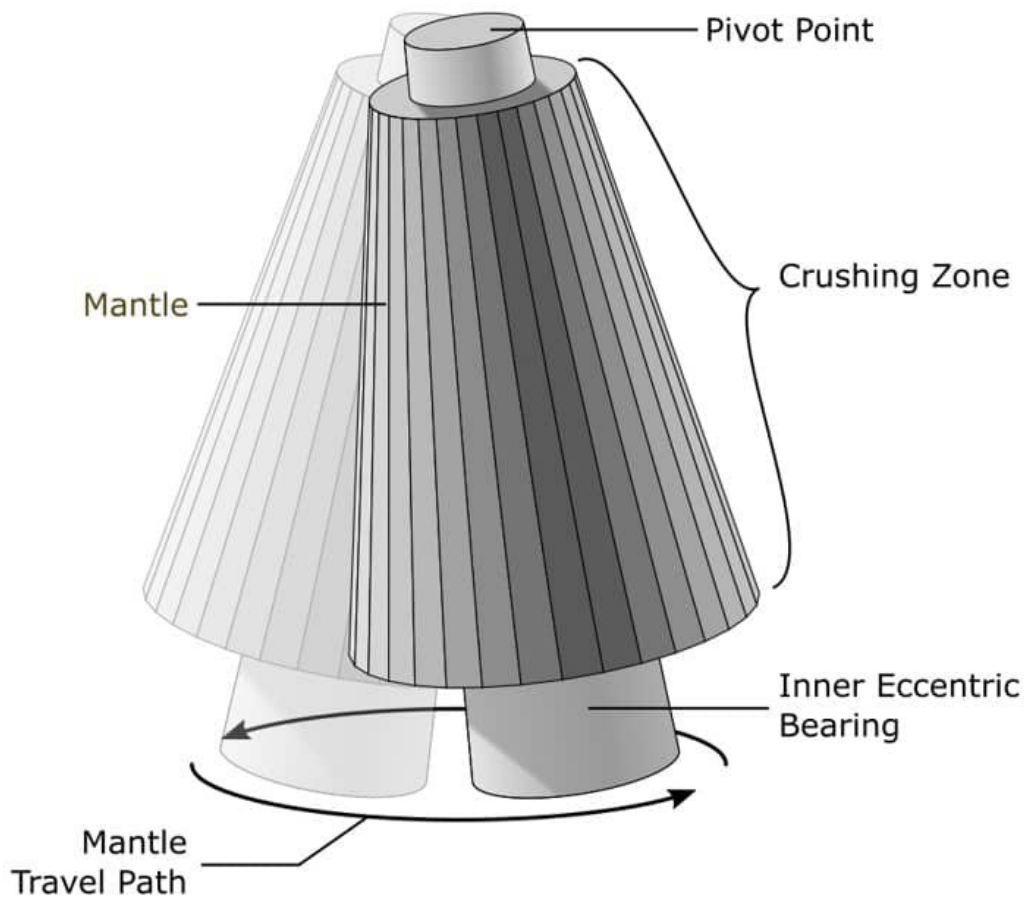


35. As shown above, the typical gyrating cone crusher has a central main shaft fitted with an internal crushing shell (mantle). The main shaft and mantle are

¹⁰ Exhibit 1013, accessed 7-30-2024

¹¹ Exhibit 1012, Figure 1, annotated

situated inside an external crushing shell with some clearance therebetween (the crushing zone). The main shaft is driven by an eccentric drive about an axis that makes it rotate and gyrate. The gyrating motion of the eccentric drive is shown below:

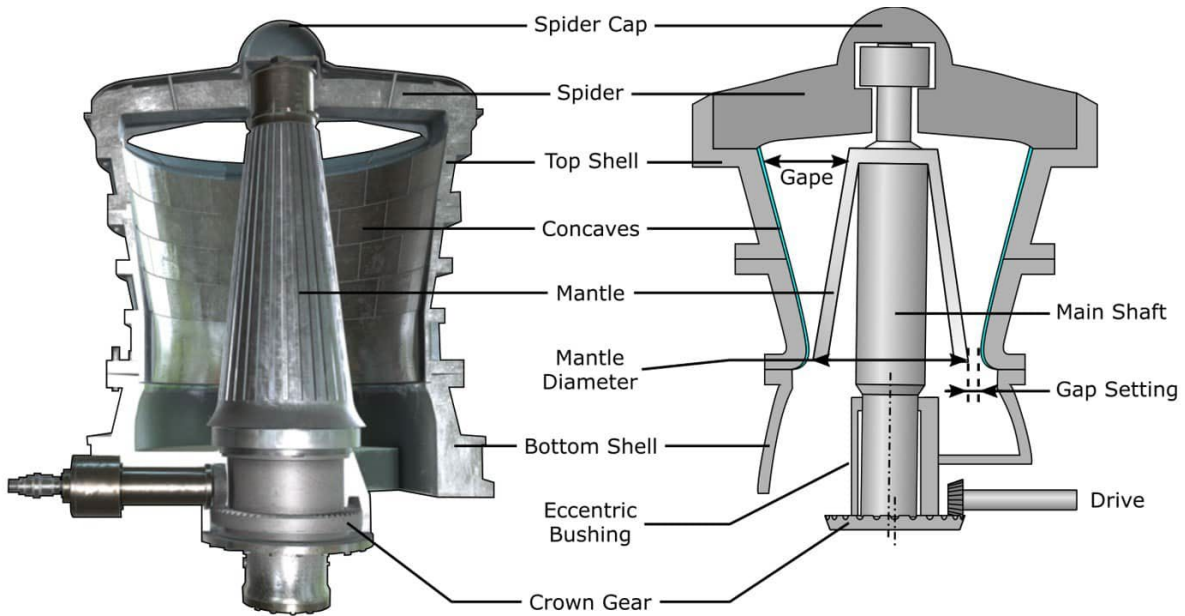


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36. The gyrating motion of the eccentric drive (shown above) allows rock to slide into the crushing zone and be sequentially crushed into smaller and smaller pieces until it is discharged out the base of the machine. For further clarity, the

¹² Exhibit 1014, accessed 7-30-2024

figure below shows how the diagram of a gyratory cone crusher relates to a physical build:



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37. As discussed previously, the present matter relates to a patent on a particular gyrating cone crusher. The main figure of the '090 patent is shown below:

¹³ Exhibit 1015, accessed 7-30-2024

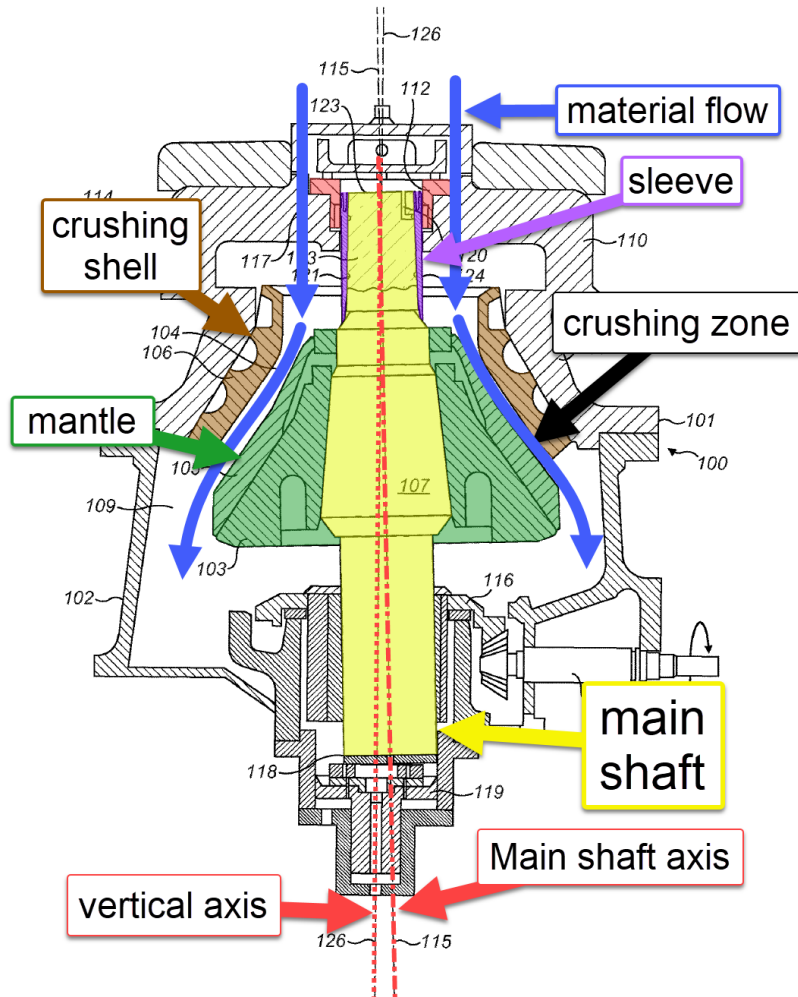
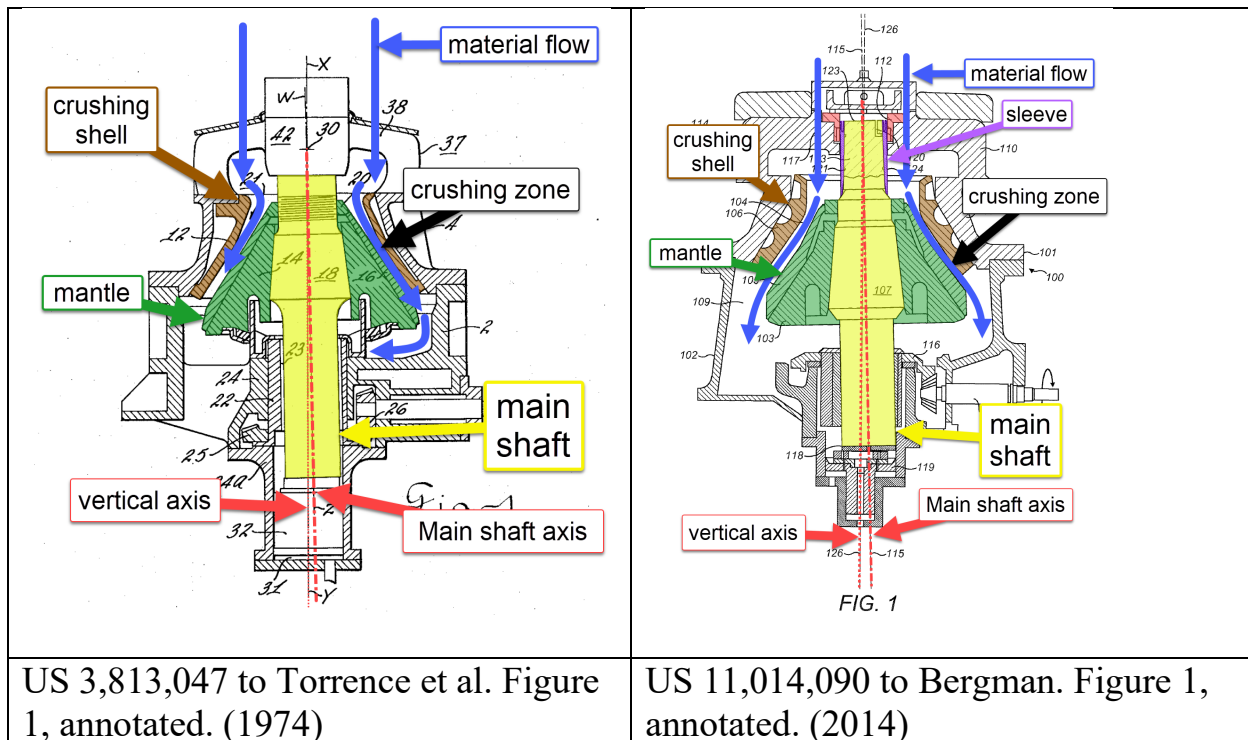


FIG. 1

38. As can be seen above, especially as compared with the Torrence cone crusher above, the '090 patent shows a cone crusher of typical design. It has a main shaft fitted with a mantle on an eccentric drive. The central cone shaft assembly is mounted internal to a crushing shell creating a crushing zone.



39. The '090 patent does not claim to disclose a new cone crusher design topology. Rather, the '090 patent claims to disclose an allegedly new and non-obvious arrangement for assembling, disassembling, and supporting the topmost portion of the main shaft. Specifically, the '090 patent states:

“It is an objective of the present invention to provide a gyratory crusher main shaft and a main shaft assembly (having a sleeve) that enables convenient mounting and dismounting of the protective sleeve at the upper end of the shaft that obviates a requirement for excessive heating of the main shaft and the use of grinding and cutting apparatus that otherwise carries a risk of damage to the main shaft and injury to the service personnel. It is a further specific objective of the present invention to provide a main shaft and sleeve assembly that facilitates mounting and dismounting of the sleeve at the shaft via control of a pressurised[sic] fluid delivered to the region of an axially upper end of the shaft radially between the shaft and the sleeve.”¹⁴

¹⁴ Exhibit 1001, 1:63-2:9

40. However, as will be demonstrated in this declaration, the '090 patent does not disclose anything new and non-obvious. To the contrary, the '090 patent merely uses ordinary design elements, well-known in the art, to produce predictable results. It is the result of nothing more than standard engineering design and does not present anything inventive. For example, the '090 patent describes including a sleeve fitted over the topmost portion of the main shaft of the gyratory crusher. The sleeve is provided with a tapered interference fit of ordinary design. Optionally, the sleeve may also comprise a fluid pathway where a fluid such as oil may be supplied under pressure to assist with mounting or dismounting the tapered sleeve. Several well-known arrangements of fluid pathways are described. Finally, an end retainer of ordinary design and construction is included. As will be demonstrated, each of these design elements are ordinary and well-known to a POSITA. Further, each of these design elements are well understood and the prior art teaches their use in rock crushing machinery already.

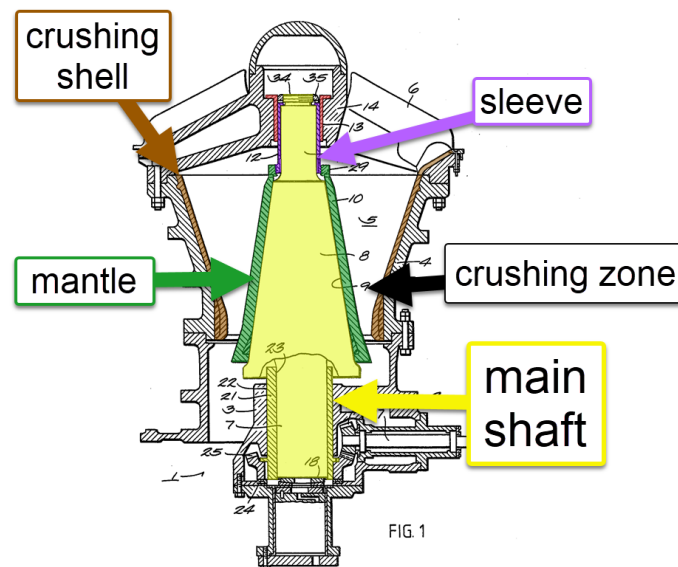
A. Gyratory Crusher with Wear Sleeve

1. U.S. Patent Publication No. 4,410,143 to Polinski

41. Gyratory crushers with wear sleeves were known in the art. For example, U.S. Patent Publication No. 4,410,143 ('143 patent or Pat '143) to Polinski describes a prior art system for a gyratory crusher with a bearing sleeve fitted over an upper region of a main shaft. The '143 patent is not listed as a cited

reference for the '090 patent. I understand Polinski is prior art to the '090 patent because it was filed September 26, 1980, which is well before the filing date for the '090 patent which is May 23, 2014. I am not aware of any information suggesting the '090 patent inventors made their alleged invention before May 23, 2014.

42. The Polinski gyratory crusher with wear sleeve in FIG. 1 of the '143 patent is shown below.



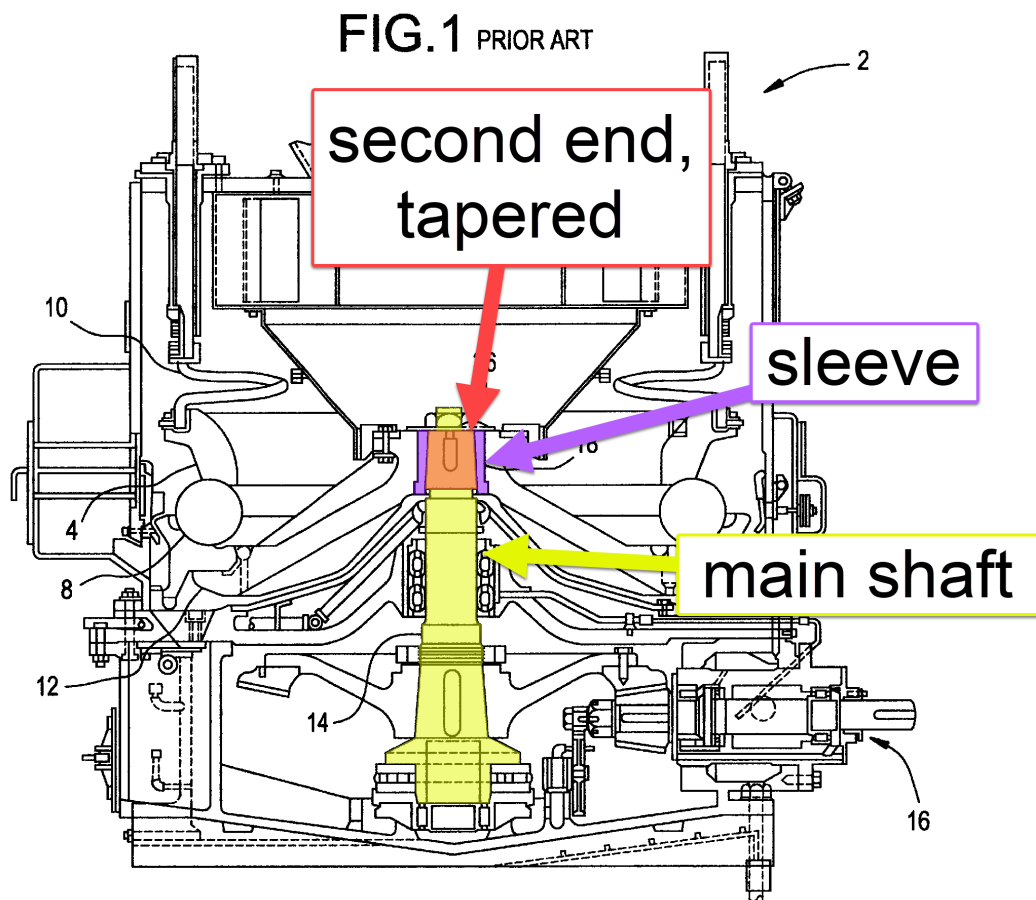
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2. U.S. Patent Publication No. 6,270,026 to Piepho et al

43. Another example of a rock crusher with a wear sleeve is disclosed in U.S. Patent Publication No. 6,270,026 ('026 patent or Pat '026) to Piepho et al. (Piepho). The '026 patent is not listed as a cited reference for the '090 patent. I

¹⁵ Exhibit 1017, Figure 1, annotated

understand Piepho is prior art to the '090 patent because it was filed June 5, 1997, which is before the earliest filing date for the '090 patent in 2014. The Piepho rock crusher with wear sleeve in FIG. 1 of Pat '026 is shown below.

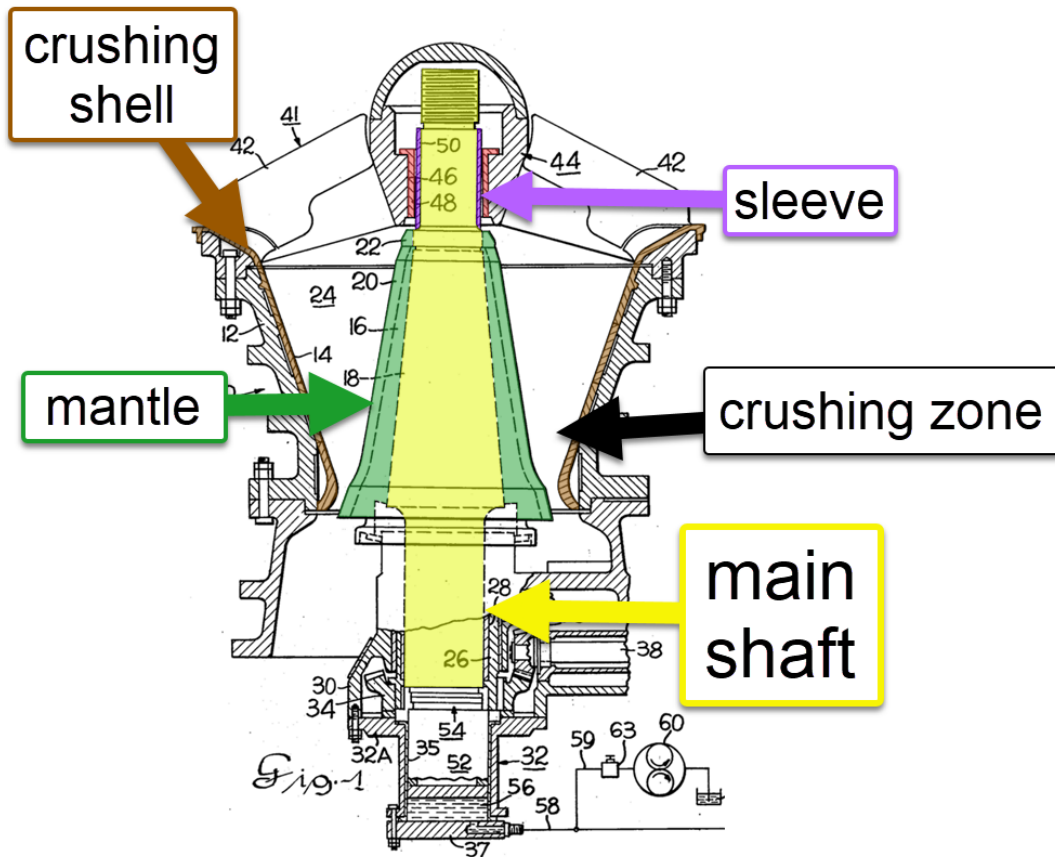


44. As shown in the figure above, I note that Figure 1 of Piepho is listed as representative of the prior art. As such, while Piepho was filed in 1997 as discussed above, Figure 1 of Piepho would have a priority date of at least as early as 1997 or earlier.

¹⁶ Exhibit 1018, Figure 1, annotated

3. U.S. Patent Publication No. 4,060,205 to Pollak

45. Yet, another example of a gyratory crusher with a wear sleeve is disclosed in U.S. Patent Publication No. 4,060,205 ('205 patent or Pat '205) to Pollak. Pat '205 is not listed as a cited reference for the '090 patent. I understand Pollak is prior art to the '090 patent because it was filed November 29, 1977, which is before the earliest filing date for the '090 patent in 2014. Pollak discloses a gyratory crusher with wear sleeve in FIG. 1 of the '205 patent as shown below.



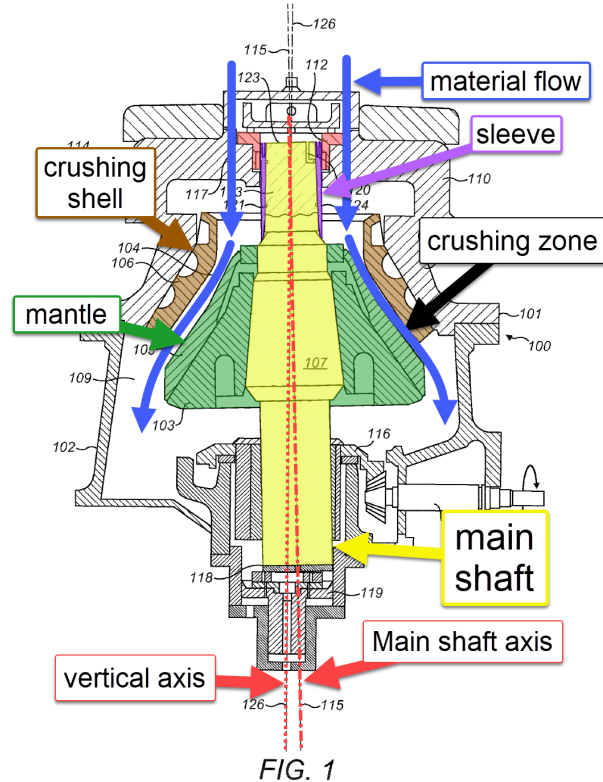
17

¹⁷ Exhibit 1019, Figure 1, annotated

4. International Patent Publication No. WO2014/019765 to Aberg

46. International patent publication WO2014/019765 to Aberg (hereafter the '765 patent or Aberg). Aberg discloses a rock crusher with a wear sleeve.

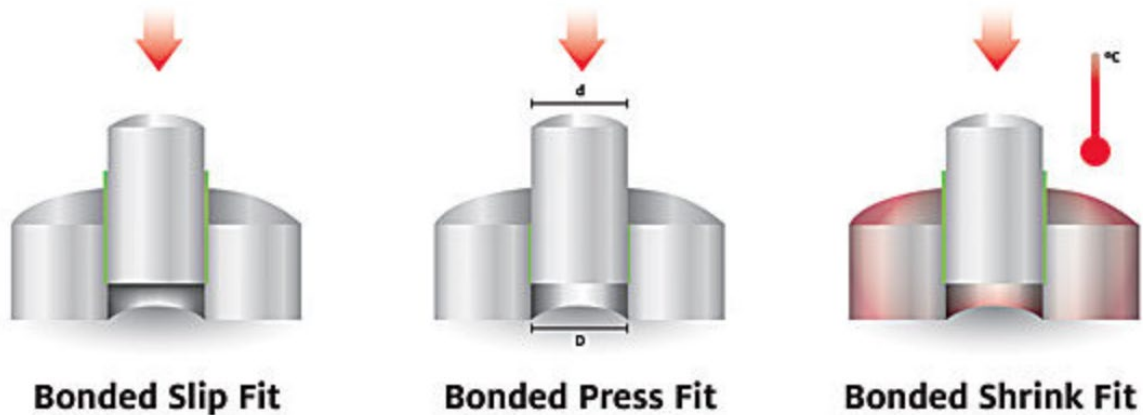
Aberg is not listed as a cited reference for the '090 patent. I understand that Aberg is prior art to the '090 patent because it was first published February 6, 2014, which is before the earliest filing date for the '090 which is May 23, 2014. The Aberg rock crusher with wear sleeve is shown below:



As shown in the figure above, Aberg shows a gyratory rock crusher of conventional design. The Aberg embodiment above, includes a wear sleeve as highlighted in purple.

B. Interference Fits and Making and Breaking Joints with Hydraulic Fluid

47. The '090 patent describes the use of a friction fit joint between the tapered sleeve and the main shaft.¹⁸ A friction joint is created when a pin or shaft is connected to a bore in a way that requires compression on the pin component and expansion of the bore. Also known as an interference fit joint, a friction fit is so called because the joint is held together by intense pressure developed between the shaft and the bore. The figure below is provided for further clarity:



48. As shown above, three options for bonding a pin or shaft inside of a bore. In the first scenario (bonded slip fit) the pin diameter is smaller than the hole diameter. The pin is capable of sliding freely in or out of the bore. A slip fit can be bonded or held stationary by use of adhesives.

49. In the middle scenario (the press fit) the diameter of the pin is *larger* than the diameter of the bore. This being the case, a pin cannot fit into the bore nor

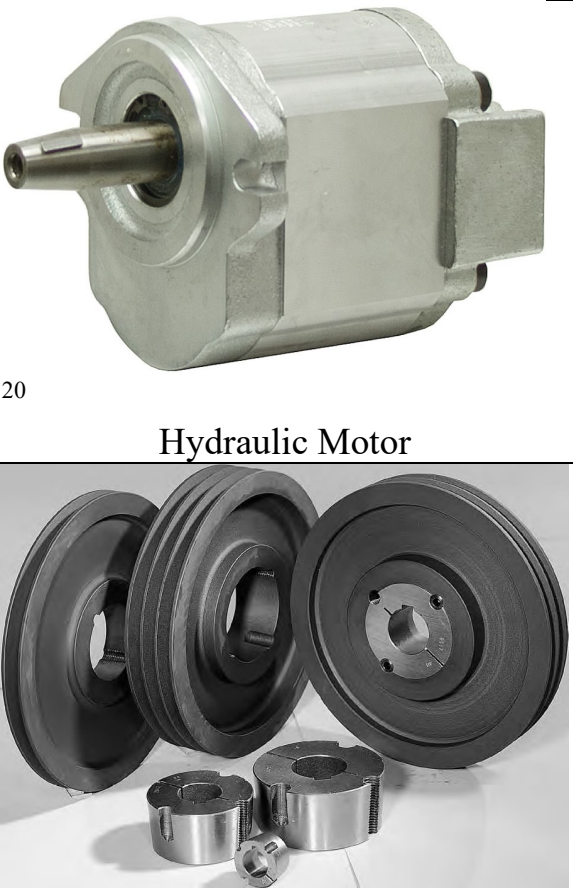
¹⁸ Exhibit 1001, 5:8-11

slide freely. This condition is why this type of joint is called an interference fit, specifically because the pin is bigger than the hole. As the name suggests, a “press fit” is one where the degree of interference is small enough that the joint can be pressed together with sufficient force. This pressing action applies radial compression to the pin (making it a smaller diameter) and radial force outward on the bore surface (making it a larger diameter). When sufficient force is applied the diameters are changed enough to move the pin into the hole. The forces that expanded the hole and contracted the pin generate a large amount of force/pressure and a large amount of friction, holding the pin in place inside of the hole.

50. In the third scenario above (a shrink fit) the degree of interference is larger than what it would be for a press-fit. Typically, the interference in a shrink fit is large enough that the pin and bore cannot be reasonably pressed together. Rather, the bore needs to be heated and/or the pin needs to be cooled. This change in temperature causes the material to expand or contract enabling the pin to be inserted into the bore or hole. As the material returns to an equilibrium temperature, the pin will expand (if it was cooled) and the bore will contract (if it was heated) and the mating joint surfaces will develop extremely high forces/pressures that will effectively bond the two components together by friction.

51. It is well-known in the art and would be well-known to a POSITA that interference fits can be accomplished using a straight cylindrical shape, or a

tapered conical shape. Not only are conical interference joints common in rock crushers, they are also common across many industries and applications such as boat propellers, hydraulic motors, pulley hubs, gearboxes, engine shafts, lathes, drill chucks, etc. They are a standard design element, are well-known, and well understood as demonstrated by the following table:

 19 Boat Propellers	 20 Hydraulic Motor 21 Tapered fit pulley hub
---	--

¹⁹ Exhibit 1020, accessed 7-31-2024. I note that this website was available at least as early as 2010: (https://web.archive.org/web/20101027092713/https://pbase.com/mainecruising/fitting_a_prop) Further, boat propellers have been fitted with tapered interference joints for a far longer time than that.

²⁰ Exhibit 1021, accessed 7-31-2024

²¹ Exhibit 1022, accessed 7-31-2024



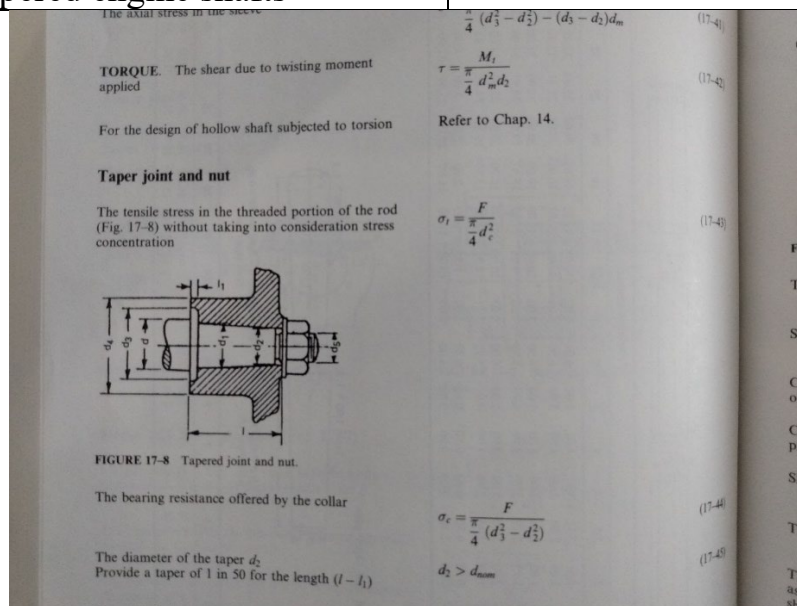
22

Tapered engine shafts

Drill chucks



23



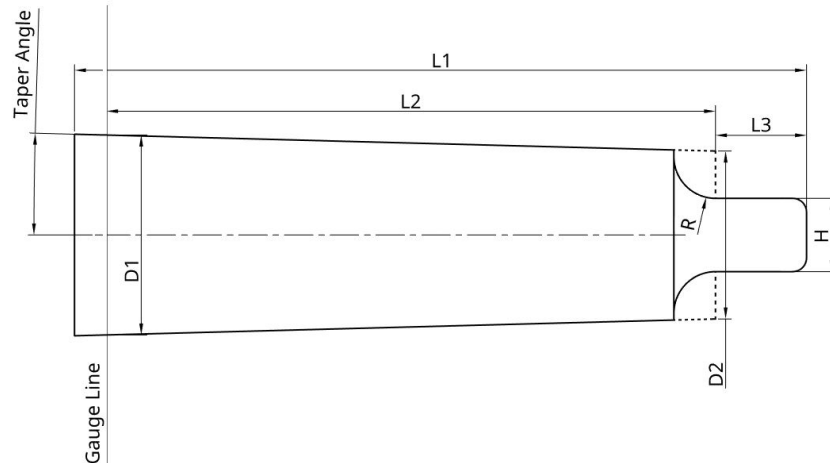
24

I note that tapered interference joints are literally a topic in a typical engineering course on machine design. For example, the above textbook excerpt shows a tapered press fit joint and several formulas of interest for stress calculation.

²² Exhibit 1023, accessed 7-31-2024

²³ Exhibit 1024, accessed 7-31-2024

²⁴ Exhibit 1025

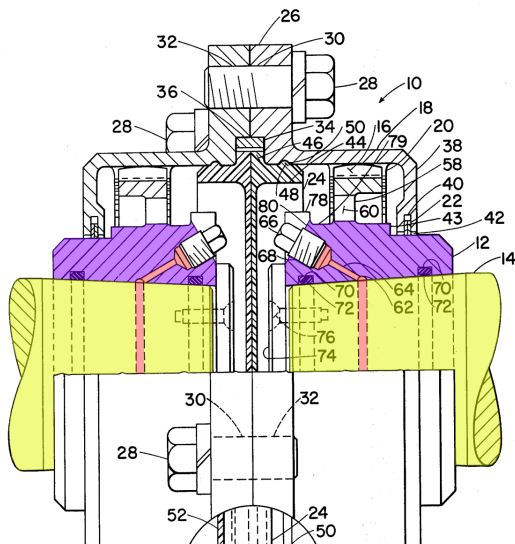


25

The famous Morse taper, also a topic covered in a typical engineering course on machine design, was invented in 1864 by Stephen A. Morse.²⁶ Morse tapers are used to create tapered interference joints commonly used on all manner of shafting for machinery. A Morse taper is a self-holding taper used to reliably hold two components together for transmission of torque.

Engineering standards such as SAE J755 (Exhibit 1028), SAE J1419 (Exhibit 1029), ASME B18.8.2 (Exhibit 1030) and more are written to specify tapered interference fits.

US 4,019,344 to Calistrat (1977)
Symmetrical sealed gear coupling

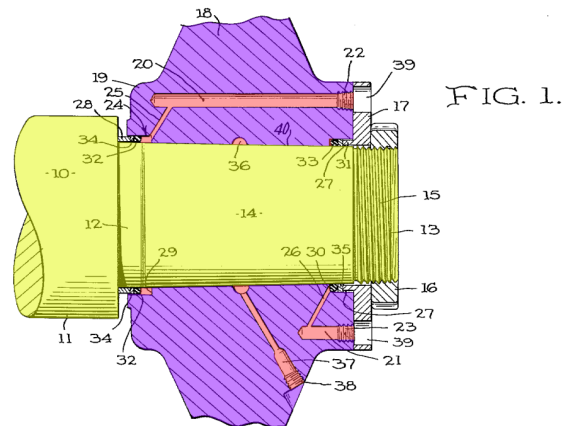
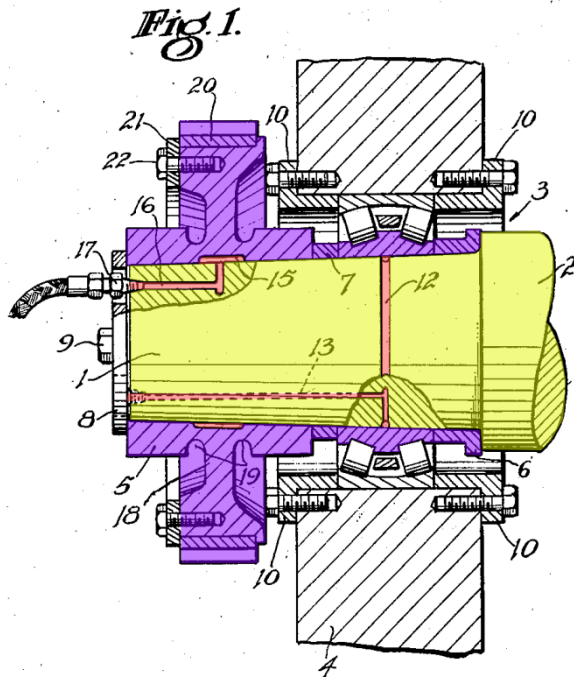


which is used to help break the tapered interference joints, as is well known.²⁷

preload. This is an extremely common way for tapered joints to be implemented.

US 2,840,399 to C.A. Harless Et Al (1958) Attachment of Gears to tapered shaft ends

US 3,228,102 to R.E. Sillett (1963) Hydraulic assembly and disassembly of parts having a heavy Interference fit

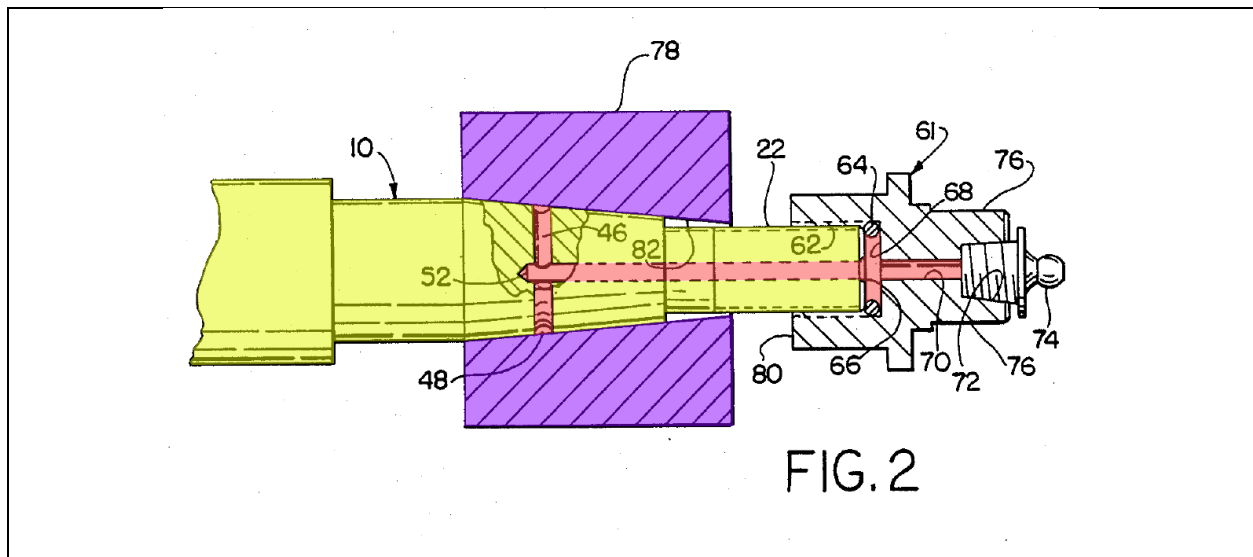


I note that not only does C.A. Harless disclose a tapered interference joint setup, it also features a fluid pathway which is used to help make or break the tapered interference joints, as is well known.

I note that not only does R.E. Sillett disclose a tapered interference joint setup, it also features a fluid pathway which is used to help make or break the tapered interference joints, as is well known.

US 4,829,718 to Behm (1989). Grinding Wheel Assembly and Method

²⁷ Exhibit 1031, 3:36-43

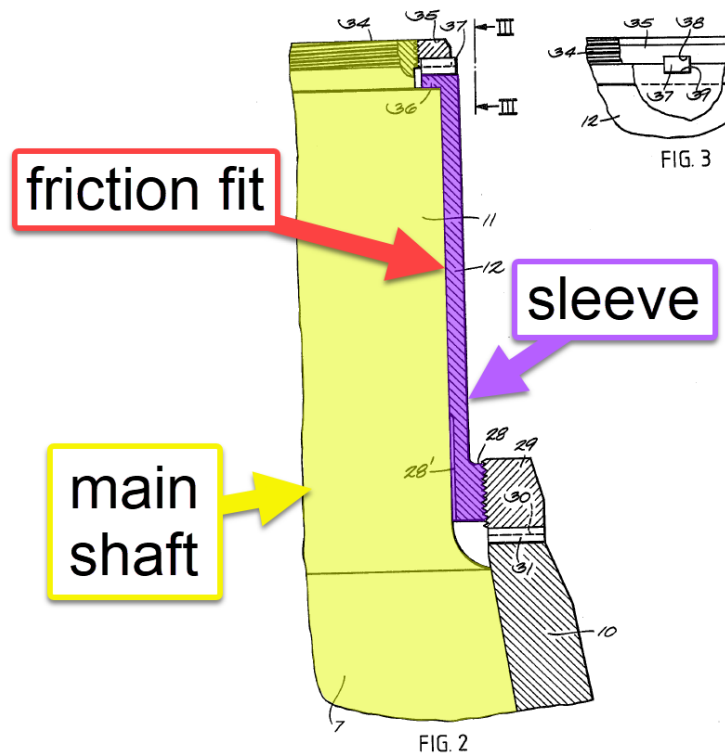


52. As shown above, tapered interference joints are extremely common and ordinary in mechanical machine design.

53. Additional examples of tapered interference joints as used with rock crushing apparatus specifically are shown below:

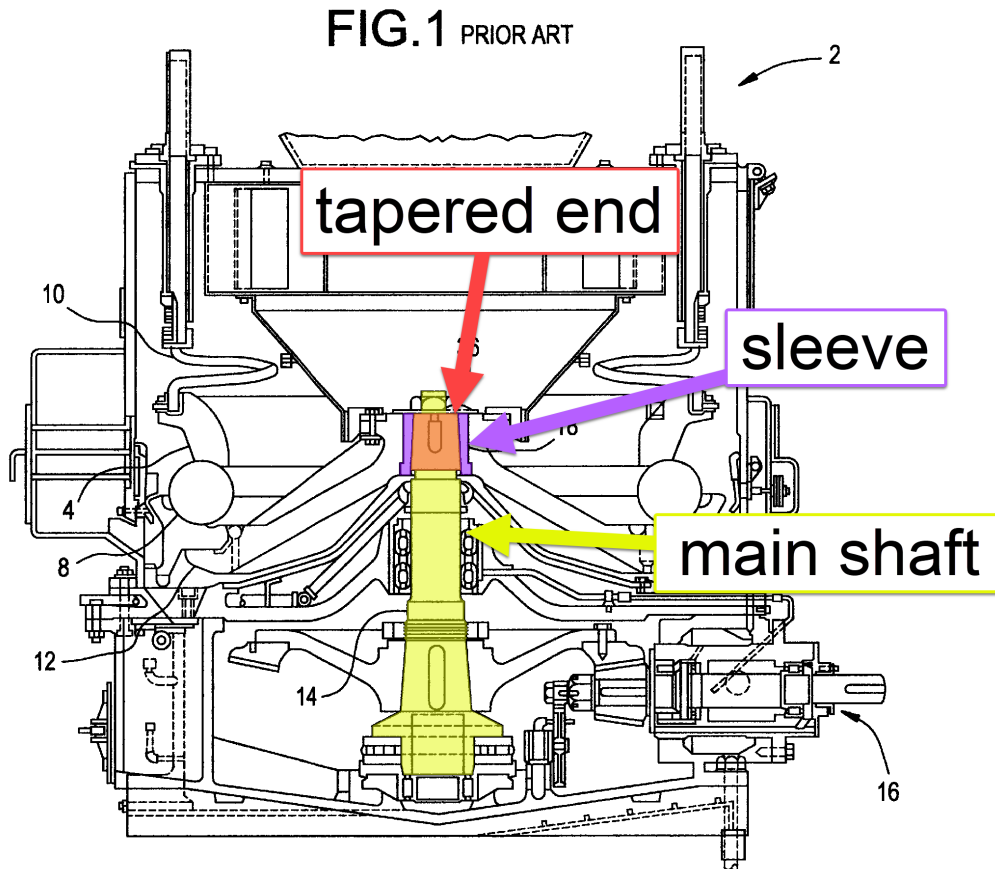
1. U.S. Patent Publication No. 4,410,143 to Polinski

54. Gyratory crusher having a friction fit shaft and sleeve arrangement were also known in the art. Polinski, discussed above, describes a prior art gyratory crusher with a sleeve that is friction fitted to the upper portion of the shaft, see Polinski 3:15-20. The Polinski gyratory crusher shaft and sleeve arrangement in FIG. 2 of Pat '143 is shown below.



2. U.S. Patent Publication No. 6,270,026 to Piepho et al

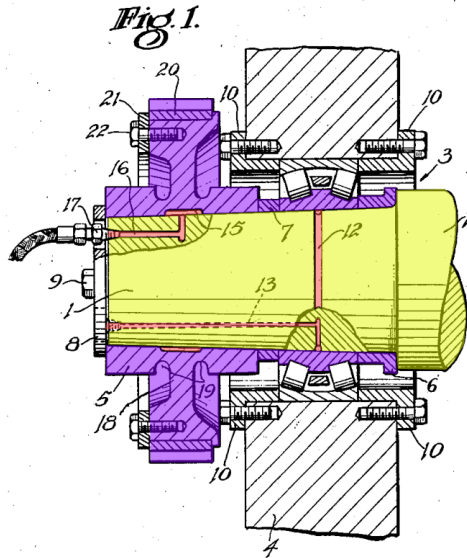
55. Piepho, discussed above, also describes a prior art rock crusher with a sleeve that is friction fitted to the upper portion of the shaft, see Piepho 3:23-32. The rock crusher shaft and sleeve arrangement in FIG. 1 of the '026 patent is shown below.



C. Pressurized Fluid Groove for Mounting and Dismounting Components

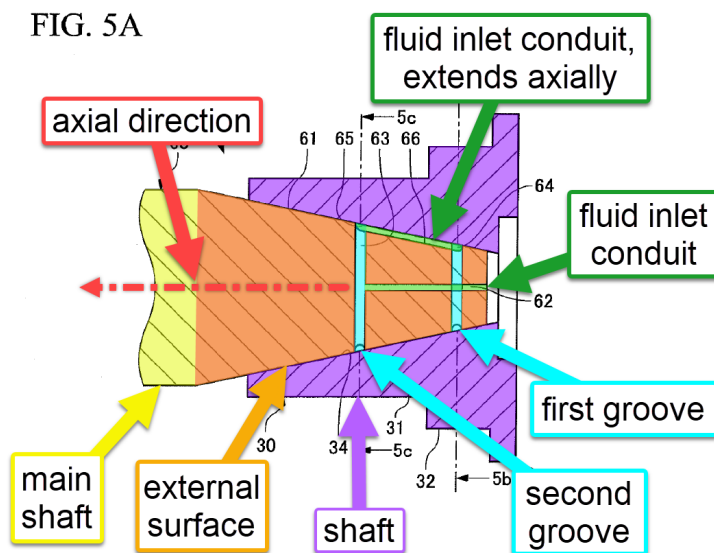
1. US 2,840,399 to C.A. Harless Et Al

56. Harless describes using pressurized oil for attachment of gears and bearings to tapered shaft ends. Harless discloses grooves being indented on both the shaft and the sleeve and also discloses multiple grooves for a sleeve on a tapered section. The oil is supplied through a conduit that extends axially within the shaft and then radially towards the surface of the shaft.



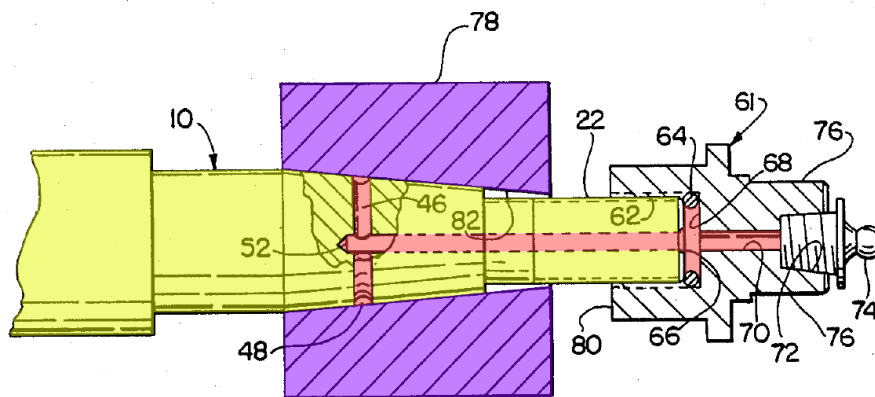
2. US 8,302,754 to Yagi

57. Yagi describes a tapered coupling structure for mounting a hub to a tapered shaft. Teaches a fluid conduit within the tapered shaft that extends axially and radially. Yagi further teaches a conduit on the external surface of the shaft to feed oil to the circular grooves that extend around the shaft.



3. US 4,829,718 to Behm

58. Behm describes a grinding wheel mounting apparatus and method of demounting characterized by a shaft with a tapered end portion and a wheel adaptor with a tapered axial bore for mounting on the shaft. Behm further teaches a fluid passage “for directing pressurized fluid to a point within the confines of the area of contact so that the pressure of such fluid may exert both radial and axial forces on the adaptor to effect its release from the shaft.”²⁸ Behm further teaches a removal fitting proportioned to permit only loosening of the object mounted to the shaft until the fitting itself is removed. This provides a “safety factor in that the pulley 26 cannot fall from the shaft 10 until the removal fitting 61 is removed from the shaft.”²⁹

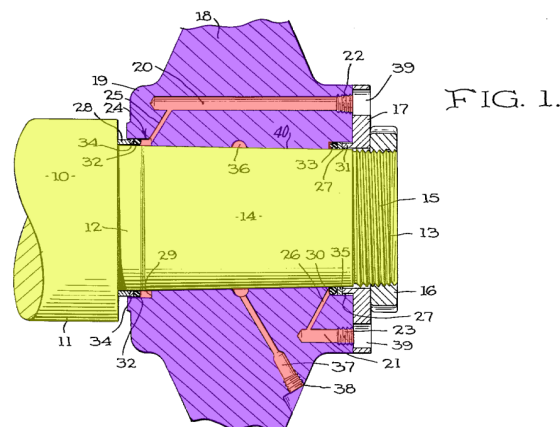


²⁸ Exhibit 1035, at Abstract

²⁹ ‘Exhibit 1035, 4:57-62

4. US 3,228,102 to R.E. Sillett

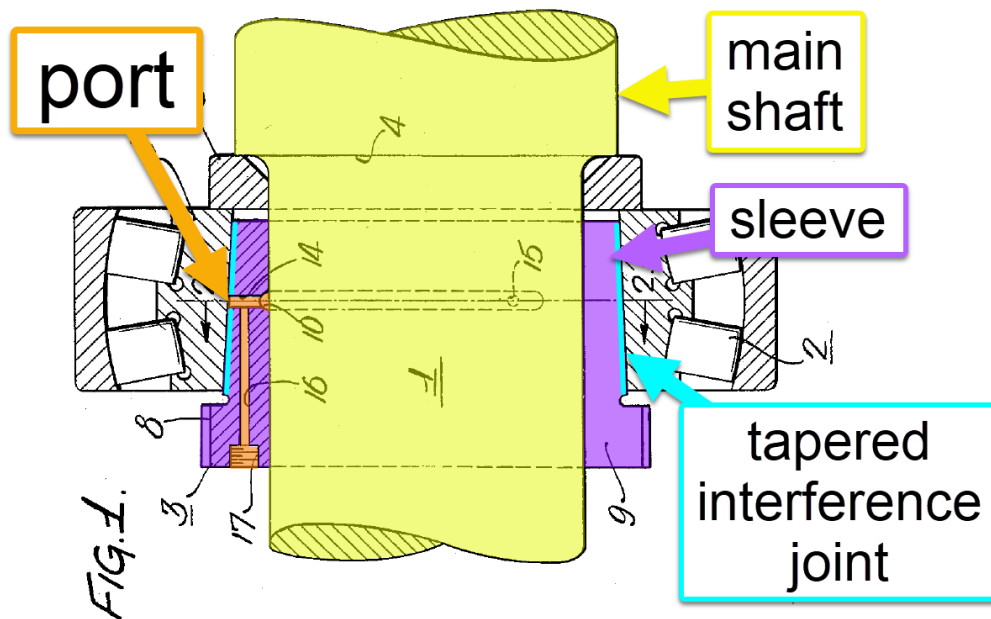
59. Sillett teaches (in 1966) a means for assembling and disassembling mating parts which may have a heavy interference fit on a tapered shaft. Sillett teaches that the bore can be through the sleeve or component mounted on the shaft, and can direct pressurized fluid to bores at different locations along the length of the shaft. Clearly, it was well known by the priority date of the '090 that pressurized fluid could be introduced to the mating surface on a tapered shaft through the shaft or through the sleeve/hub/object mounted on the shaft to make or break the interference fit.



5. U.S. Patent Publication No. 2,764,437 to A. E. Bratt

60. Grooves configured to receive pressurized fluid for the mounting and dismounting of components were known in the art. For example, U.S. Patent Publication No. 2,764,437 ('437 patent or Pat '437) to A. E. Bratt, (Bratt) describes a prior art system for producing an interference joint between two components and

a means of making and separating said components. Pat '437 is not listed as a cited reference for the '090 patent. I understand Bratt is prior art to the '090 patent because it was filed May 31, 1951, and issued in September 1956, which is before the earliest filing date for the '090 patent in 2014. The grooves configured to receive pressurized fluid for the mounting and dismounting of components is shown below in FIG. 1 of the '437 patent.



30

61. As shown above, A.E. Bratt discloses pressurizing oil into the tapered interference joint through the port.³¹ Specifically, pumping sufficiently pressurized oil into the port in this tapered interference joint facilitates the creates of the joint as it lubricates the mating components allowing them to be moved into their final

³⁰ Exhibit 1036, rotated and annotated

³¹ Exhibit 1036, 1:19-21, 29-34, 69-72, 2:6-29, emphasis added

positions more readily. Further, the pumping of sufficiently pressurized oil into the port will apply a force that will tend to push the joint apart due to the direction of the tapering of the joint.

6. International Patent Publication No. WO2014/019765 to Aberg

62. The '765 patent, discussed above, describes a friction fit that is used to attach the wear sleeve to the main crusher shaft. For example, Aberg describes how commonly a wear sleeve is attached to a rock crusher main shaft by a friction fit.

“Commonly, the protective sleeve comprises a cylindrical geometry and is held at the main shaft via an interference or friction fit.” 2:11-12

“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.” 3:3-5

63. Aberg further describes the use of fluid power elements to facilitate the assembly/disassembly of the main shaft and sleeve arrangement as well as for further lubrication. Consider, for example, the citation below:

*“Optionally, the sleeve comprises at least one groove indented in the internal facing surface. Additionally, the groove may extend in a circumferential direction around a region of the internal facing surface. Optionally, the groove extends in a direction axially along the 10 internal facing surface. Optionally, the sleeve may further comprise at least one bore provided through the wall to allow the passage of a fluid to the internal facing surface. **Accordingly, the bore is capable of allowing a lubricating fluid to be introduced through the body of the sleeve so as to flood the region between the internal facing surface of the sleeve and the external facing surface of the main shaft at the region of the sleeve.** Where 15 the sleeve comprises a groove at the internal facing*

surface, the lubricating fluid is capable of flowing within the groove both circumferentially and axially to fully lubricate the sleeve and main shaft interface.”³²

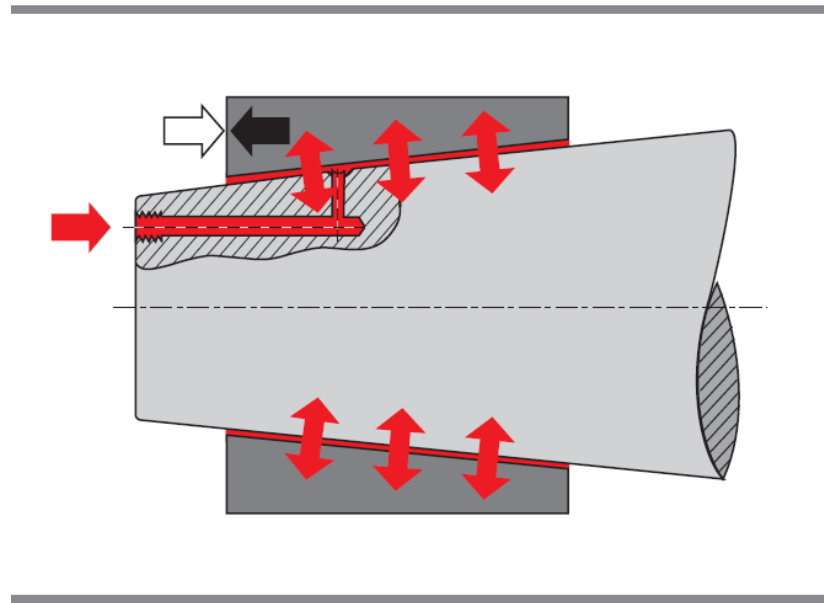
As shown above, the ’765 describes flooding the region between the sleeve and the main shaft with oil. A POSITA would understand that there is no purpose to this type of lubrication other than for the purposes of making or breaking the tapered interference fit. The tapered interference fit is used because it is desirable that the sleeve move and act with the main shaft as if it were a single body. Consequently, it would be undesirable to inject fluid into the interstitial region between the sleeve and the main shaft during operation. Rather, this would only be desirable during initial assembly or for maintenance purposes when the sleeve/shaft assembly is being put together or taken apart.

7. Public Literature “Accurate mounting of bearings, propellers and gears has never been quicker...”

64. Public literature titled “Accurate mounting of bearings, propellers and gears has never been quicker...” by SKF Maintenance Products is another example of grooves configured to receive pressurized fluid for the mounting and dismounting of components that was known in the art. I understand “Accurate mounting of bearings, propellers and gears has never been quicker...” is prior art to the ’090 patent because it has been available to the public since 2003, which is before the earliest filing date for the ’090 patent in 2014.

³² Exhibit 1016, 4:7-17, emphasis added

65. The grooves configured to receive pressurized fluid for the mounting and dismounting of components can be seen on page 2 of “Accurate mounting of bearings, propellers and gears has never been quicker...” as shown in the image below.



*Mounting and dismounting,
directly on a tapered shaft*

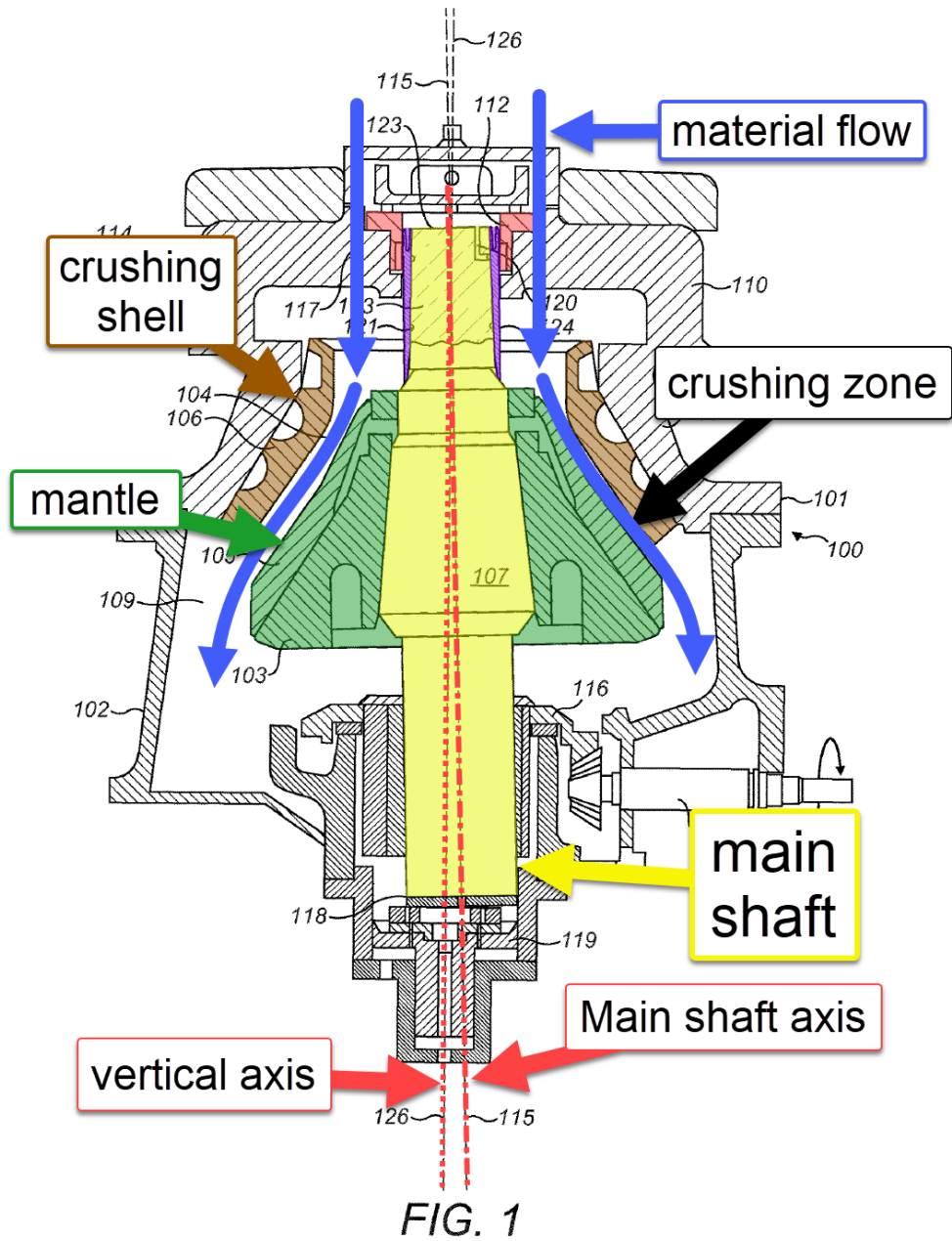
VI. THE '090 PATENT

A. Specification of the '090 Patent

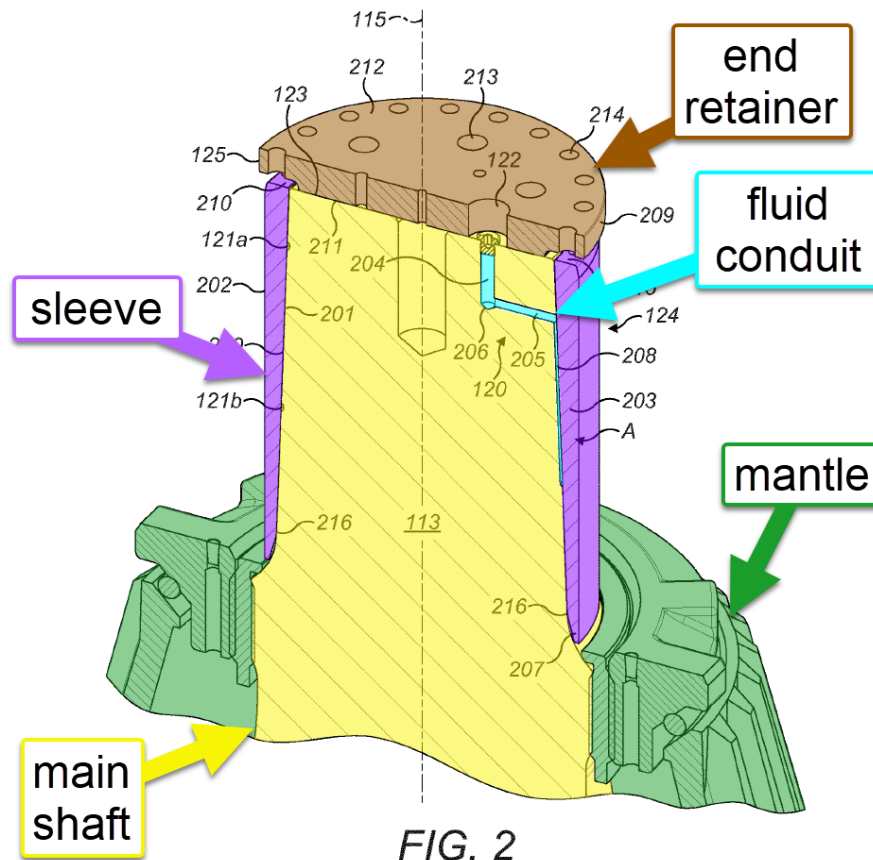
66. In the '090 patent, Bergman discloses “A gyratory crusher main shaft and a main shaft assembly for positioning within a gyratory crusher and in particular, although not exclusively, to a main shaft having an axial upper end region that tapers radially inward and comprises at least one groove to receive a pressurized fluid to facilitate mounting and demounting of a sleeve at the shaft.”

Pat `090, 1:14-19. The `090 patent includes an embodiment of a gyratory crusher and main shaft assembly in FIG. 1. The `090 patent includes an embodiment of a main shaft comprising of one groove to receive pressurized fluid for mounting and demounting of a sleeve at the shaft in FIG. 2.

67. FIG. 1 of the `090 patent is shown below. The gyratory crusher includes a crusher head 103 mounted upon an elongate shaft 107. Pat `090, 4:43-45. “An upper end region of a shaft 113 comprises an axial taper to define an upper conical section. The cone 113 tapers inwardly in the bottom to top direction away from head 103”.



68. FIG. 2 of the '090 patent is shown below.



B. Claims of the '090 patent

69. The '090 patent has 14 claims including 3 independent claims (claims 1, 9, and 14) as shown below:

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

- 1a.** a shaft body having a radially outward facing external surface, and a first end and a second end;
- 1b.** an axial region of the shaft body extending from the second end and being tapered relative to a longitudinal axis of the shaft body such that a cross sectional area of the shaft body at the tapered axial region decreases in a direction from the first end to the second end;
- 1c.** a shaft sleeve mounted on the tapered axial region; and

- 1d1.** at least one groove indented at the external surface and positioned at the tapered axial region,
- 1d2.** the at least one groove being arranged to receive a pressurised[sic] fluid to facilitate mounting and dismounting of the shaft sleeve at the shaft body.
- 2P.** The main shaft as claimed in claim 1,
- 2a.** further comprising a fluid inlet conduit extending axially from the second end and provided in fluid communication with the at least one groove to allow a fluid to be supplied to the at least one groove from the second end.
- 3P.** The main shaft as claimed in claim 2,
- 3a.** wherein the fluid inlet conduit extends internally within the shaft body such that a part of the fluid inlet conduit extends radially outward to the at least one groove.
- 4P.** The main shaft as claimed in claim 3,
- 4a.** wherein the at least one groove extends in a circumferential direction around the shaft body.
- 5P.** The main shaft as claimed in claim 4,
- 5a.** wherein the at least one groove extends substantially or completely circumferentially around the shaft body.
- 6P.** The main shaft as claimed in claim 5,
- 6a.** further comprising a plurality of grooves at the external surface.
- 7P.** The apparatus as claimed in claim 6,
- 7a.** further comprising a first groove extending in a circumferential direction around the shaft body and a second groove extending in a circumferential direction around the shaft body, the first groove being separated axially from the second groove and coupled in fluid communication.
- 8P.** The main shaft as claimed in claim 7,

8a. wherein at least a part of the fluid inlet conduit is indented and extends axially at the external surface as a channel to couple the first and second grooves in fluid communication.

9P. A gyratory crusher main shaft assembly for a crusher comprising:

9a1. a shaft body having a radially outward facing external surface, and

9a2. a first end and a second end,

9a3. an axial region of the shaft body extending from the second end and being tapered relative to a longitudinal axis of the shaft body such that a cross sectional area of the shaft body at the tapered axial region decreases in a direction from the first end to the second end,

9a4. a shaft sleeve mounted on the tapered axial region,

9a5. and at least one groove indented at the external surface and positioned at the tapered axial region,

9a6. the at least one groove being arranged to receive a pressurised[sic] fluid to facilitate mounting and dismounting of the sleeve at the shaft body; and

9b. a sleeve fitted over the tapered axial region, the sleeve having a tapered wall thickness, such that the wall thickness at a second end of the sleeve is greater than the wall thickness at a first end of the sleeve.

10P. The assembly as claimed in claim 9,

10a1. further comprising an end retainer releasably mounted at the second end of the shaft body and having a perimeter region extending radially outward beyond the external surface at the tapered region,

10a2. the perimeter region positioned to radially overlap the sleeve at the second end of the sleeve to inhibit axial separation of the sleeve from the shaft body.

11P. The assembly as claimed in claim 10,

11a. wherein the end retainer includes a recess extending circumferentially at the perimeter region to allow axial movement of the sleeve into the recess.

12P. The assembly as claimed in claim 9,

12a. further comprising a fluid inlet conduit extending axially from the second end of the shaft body in fluid communication with the at least one groove to allow a fluid to be supplied to the at least one groove from the second end of the shaft body.

13P. The assembly as claimed in claim 9,

13a. further comprising a fluid inlet conduit extending radially through the wall thickness of the sleeve in fluid communication with the at least one groove to allow a fluid to be supplied to the at least one groove through the sleeve.

14P. A gyratory crusher comprising;

14a1. a main shaft including a shaft body having a radially outward facing external surface,

14a2. 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,

14a3. an axial region of the shaft body extending from the second end and being tapered relative to a longitudinal axis of the shaft body such that a cross sectional area of the shaft body at the tapered axial region decreases in a direction from the first end to the second end,

14a4. the tapered axial region being configured to mount a shaft sleeve;

14b. a sleeve fitted over the tapered axial region, the sleeve having a tapered wall thickness such that a wall thickness at a second upper end of the sleeve is greater than a wall thickness at a first lower end of the sleeve; and

14c. at least one groove indented at the external surface and positioned at the tapered axial region, the at least one groove being arranged to receive a

pressurized fluid to facilitate mounting and dismounting of the sleeve at the shaft body.

C. Prosecution History of the '090 Patent

70. I have reviewed the prosecution history of the application that led to the '090 patent. Changes were made to the application by the applicant prior to PTO examination. During prosecution of the '090 patent, one notable Office Action was issued by the PTO. Changes to the application by the applicant were made in response to the PTO Office Action before granting the '090 patent.

71. Changes made to the patent application by the applicant prior to PTO examination can be found on Application No.: New, filed May 11, 2016 (Exhibit 1002, at 102-108).

72. Claim 1 of Application No.: New added “of a crusher” to the description of a gyratory crusher main shaft (Exhibit 1002, at 108).

73. Claim 9 of Application No.: New removed “as claimed in any preceding claim” (Exhibit 1002, at 108)

74. Claim 9 of Application No.: New added “having a radially outward facing external surface and a first end and a second end, an axial region of the shaft body extending from the second end and being tapered relative to a longitudinal axis of the shaft body such that a cross sectional area of the shaft body at the tapered axial region decreases in a direction from the first end to the second end, a

shaft sleeve mounted on the tapered axial region and at least one groove indented at the external surface and positioned at the tapered axial region, the at least one groove being arranged to receive a pressurized fluid to facilitate mounting and dismounting of the sleeve at the shaft body;” (Exhibit 1002, at 106).

75. Claim 13 of Application No.: New removed “any one of claims” (Exhibit 1002, at 105).

76. Claim 14 of Application No.: New removed “as claimed in any preceding claim” (Exhibit 1002, at 105).

77. Claim 14 of Application No.: New added “having a radially outward facing external surface a first end for position 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 and axial region of the shaft body extending from the second end and being tapered relative to a longitudinal axis of the shaft body such that a cross sectional area of the shaft body at the tapered axial region decreases in a direction from the first end to the second end the tapered axial region being configured to mount a shaft sleeve; and a sleeve fitted over the tapered axial region, the sleeve having a tapered wall thickness such that a wall thickness at a second upper end of the sleeve is greater than a wall thickness at a first lower end of the sleeve” (Exhibit 1002, at 105).

78. Office Action dated September 25, 2018, rejection to claims 1-14

under 35 U.S.C. 112 (b) states “The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention” (Exhibit 1002, at 283 section 2)

79. Office Action dated September 25, 2018, rejection to claims 1-14 under states “Claims 1-14 are rejected as best understood under 35 U.S.C 102(a)(1) as being anticipated by Johnson et al” (Exhibit 1002, at 281 section 6)

80. The applicant responded to Office Action dated September 25, 2018, with Application No.: 15/035,774 on January 25, 2019 (Exhibit 1002, at 287-295).

81. Application No.: 15/035,774 removed “positioning at a lower region of the crusher” and “for positioning at an upper region of the crusher relative to the first end” to claims 1 and 9 (Exhibit 1002, at 293-294).

82. Application No.: 15/035,774 added “at least one” to the description of the groove through the sleeve in claims 2-4, 12 and 13 (Exhibit 1002, at 292-294).

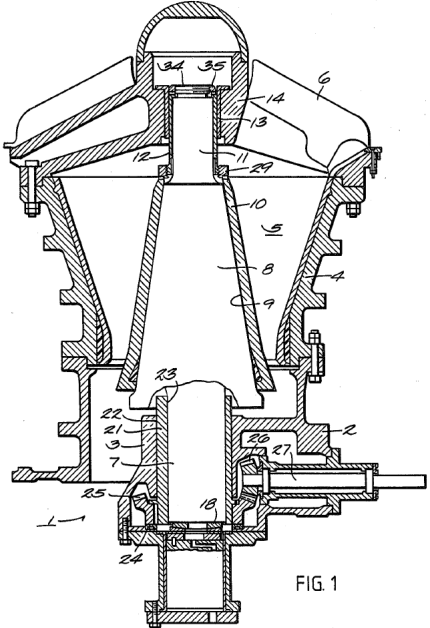
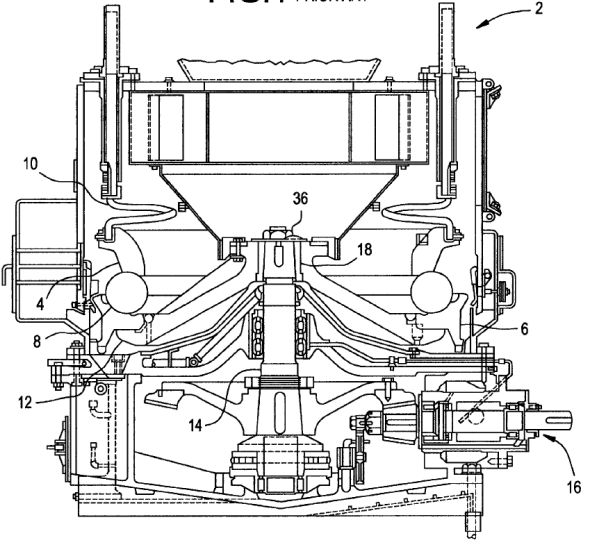
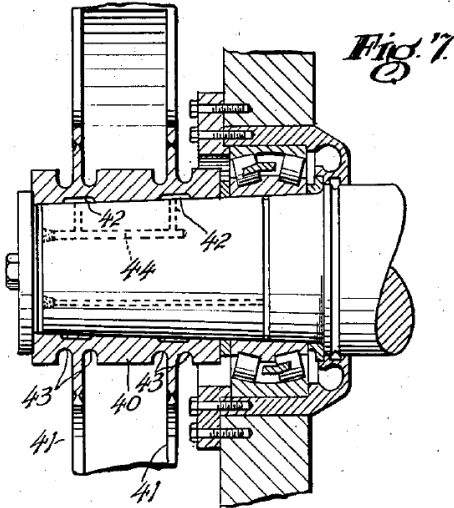
VII. CLAIM CONSTRUCTION

83. It is my understanding that claim construction has not been completed in the present matter. As such, I understand that the claim terms are to be given their meaning as they would be understood by a POSITA in view of the intrinsic evidence. I understand that unless the intrinsic record indicates otherwise, claim terms are to be given their plain and ordinary meaning as they would be understood by a POSITA. Consequently, I have used the plain and ordinary

meaning in my analysis.

VIII. INVALIDITY ANALYSIS OF THE '090

A. Polinski in view of Piepho, and in further view of C. A. Harless Render Claims 1-14 Obvious

 FIG. 1	FIG.1 PRIOR ART 
US 4,410,143 to Polinski i.e. "Polinski"	US 6,270,026 to Piepho i.e. "Piepho"
 Fig. 7	
US 2,840,399 to C.A. Harless (1958) i.e. "Harless"	

84. 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”*³³

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

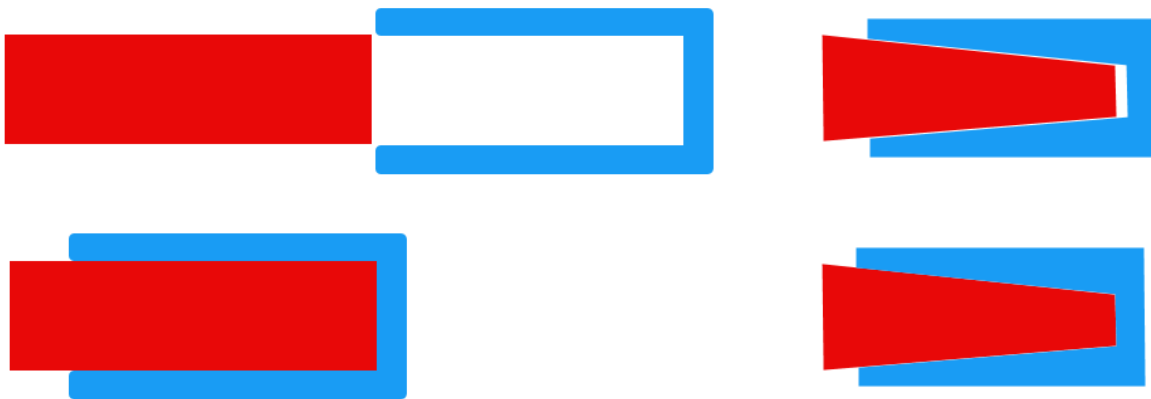
*“The present invention provides an intervening material between the shaft end (25) and the mating bore in yoke bushing (18) fitted within the bore of yoke (12) to prevent fretting damage. For accurate alignment and for reliable Support of the yoke, this joint (21) must be capable of accepting radial, 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.**”*³⁴

86. As shown above, a POSITA would be motivated to combine the tapered joint of Piepho with the teachings of Polinski based on the explicit teachings of the prior art. In addition to this, a POSITA would understand the advantages afforded by the use of a tapered joint as compared with a cylindrical joint. For example, tapered interference joints provide advantages in assembly, alignment, and fit-up.

³³ Exhibit 1018, 1:5-8

³⁴ Exhibit 1018, 3:24-35, emphasis added

87. As shown above, tapered interference joints are extremely common and ordinary in mechanical machine design. Tapered interference fits have significant and important benefits over straight fits, that would motivate a POSITA to incorporate them into the design of equipment, including in the design of rock crushing apparatuses. One important benefit is that with a tapered interference fit, the distance that the sleeve must slide over the shaft while expanded to make the fit is significantly smaller. As illustrated below (left), with a straight interference fit, the sleeve must traverse the entire length of the sleeve while expanded to make the fit. With a tapered joint, (right below) the sleeve can slide freely onto the shaft for the majority of the length and only needs to travel a short distance when expanded to make the joint.



88. Other benefits that would motivate a POSITA to implement the well-known tapered interference fits taught in the prior art include the ease of removal

and ability to prevent damage,³⁵ they are able to be used in more locations as they do not require presses and gear pullers,³⁶ and make removing components on a tapered shaft particularly easy,³⁷ particularly when combined with known hydraulic systems for making and breaking the interference fit. US 2,840,399 to C.A. Harless issued June 24, 1958. This is well in advance of the filing date of the '090 patent. As such, the C.A. Harless reference is also prior art to the '090 patent.

89. A POSITA would be motivated to combine Polinski in view of Piepho, and further in view of Harless to gain multiple advantages as taught in the prior art. Harless teaches the advantages of using hydraulic means for making and breaking tapered interference joints.

*“... the invention is concerned with the shrink fitting of gears and similar members on shafts. This has been accomplished heretofore by heating or refrigerating one of the members, this being a procedure of limited applicability, and even where applicable having a tendency to involve over stressing the web of a gear or similar member. **Elements such as bearings and coupling sleeves have been fitted to shafting by expanding the elements hydraulically,** but it has not been possible to shrink fit a member such as a gear in this way, due to the excessive pressure required to expand the portion of the gear hub in radial alignment with the web. **It is an object of the invention to provide for the attachment of a gear or other drive member to a tapered shaft,** by expanding certain portions of the hub of the gear, while avoiding the excess pressure necessary to expand the web or any other radially extending part of the gear. A further object of the invention is to provide for attaching a bearing and a gear or other drive member to a shaft as concentrically as possible, and without creating unbalanced strain conditions in the gear. **A still further object of the invention is to provide an attachment permitting removal of a gear or other drive member** without the use of a gear puller or similar equipment.”³⁸*

³⁵ Exhibit 1035, 1:13-15, 1:35-42

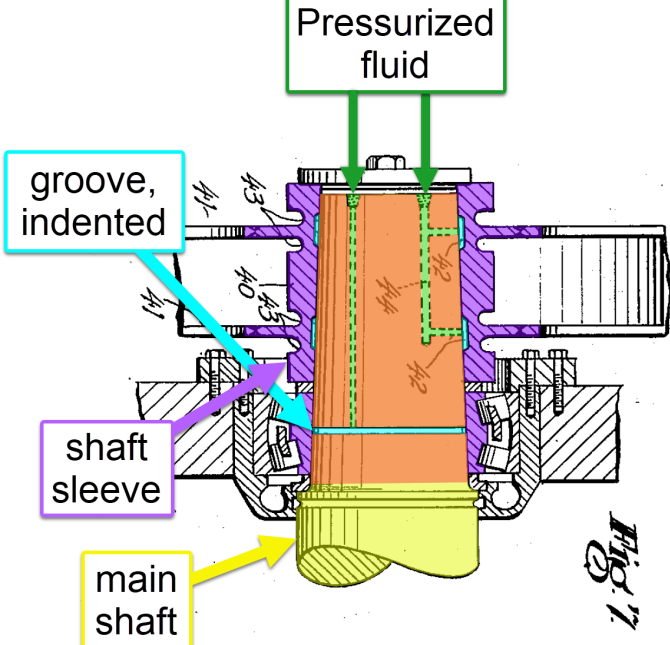
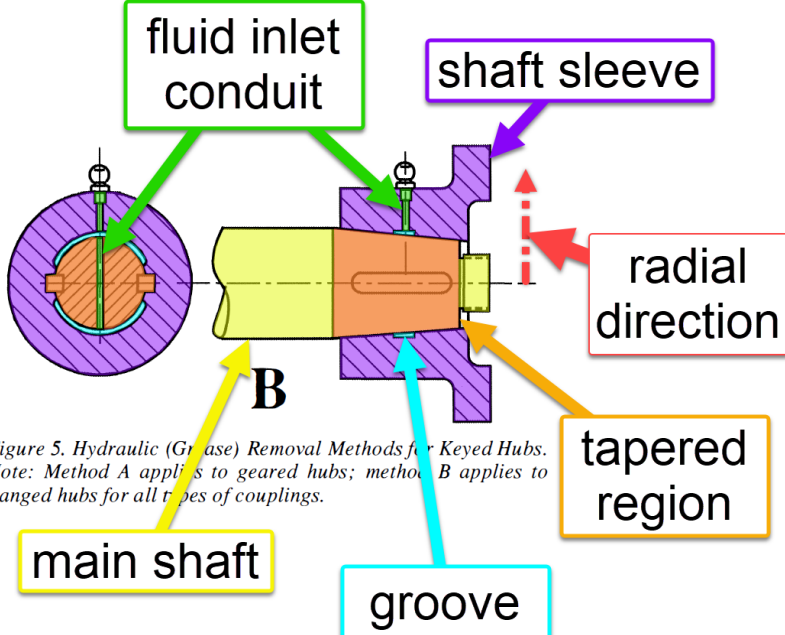
³⁶ Exhibit 1034, 1:15-24

³⁷ Exhibit 1033, 3:15-22

³⁸ Exhibit 1033, 1:18-42, emphasis added

90. As shown above, Harless is aimed at fixedly attaching and detaching components such as sleeves to tapered shaft ends, as facilitated by the use of fluid power elements, just the same as the '090 patent. Thus, Harless would be considered analogous art and would be within the purview of a POSITA. Further, Harless highlights that even in 1958, the technology of using hydraulic means to aid in making and breaking tapered interference joints was already well-known.

91. The prior art teaches many different arrangements for implementing tapered interference joints. A POSITA will understand that the various tapered joint designs represent design choices that are available for them to make. For example, the prior art teaches at least two different ways in which pressurized fluid such as oil or grease can be delivered to circumferential grooves to hydraulically expand a hub or sleeve for installation or removal. The Harless reference teaches the delivery of the fluid through conduits inside the main shaft. Meanwhile, other prior art teaches delivering the pressurized fluid through a radial port through the sleeve itself. Examples of these options are shown below for clarity:

 C.A. Harless	As shown, Harless discloses a well-known method of delivering pressurized fluid to grooves which are used to hydraulically expand a hub and a bearing so as to make or break a tapered interference fit.
 <i>Figure 5. Hydraulic (Grease) Removal Methods for Keyed Hubs. Note: Method A applies to geared hubs; method B applies to flanged hubs for all types of couplings.</i>	As shown, a technical paper dating back to 1993, titled “Hydraulic Removal of Coupling Hubs – Keyed and Keyless” shows both the option of feeding fluid through the sleeve.

92. As shown above, a POSITA would recognize that it is a design choice

³⁹ Exhibit 1033, Figure 7, annotated

⁴⁰ Exhibit 1039, pg. 6, annotated

as to whether the fluid is routed through the shaft or through the sleeve. Further, making this design choice would amount to nothing more than combining known elements using known methods to produce predictable results. The manner in which fluid is delivered to the grooves is commonly implemented through either the shafting itself or through the sleeve mounted on the shafting.

93. It was well known in the art that the circumferential groove and the bore could be formed in either the sleeve or the shaft.⁴¹ As it is well known that the sleeves wear out and are replaceable, a POSITA would be motivated to form the groove and conduit in the shaft, as the shaft can be used with multiple sleeves and would only have to be manufactured once, where the groove and conduit would have to be manufactured in each replaceable sleeve.

94. A POSITA would further be motivated to implement the well-known hydraulic processes for making and breaking interference fits as they are well known to protect the shaft from damage,⁴² they are able to be used in more locations as they do not require presses and gear pullers,⁴³ does not require the maintenance that presses and gear pullers do,⁴⁴ and make removing components on a tapered shaft particularly easy.⁴⁵

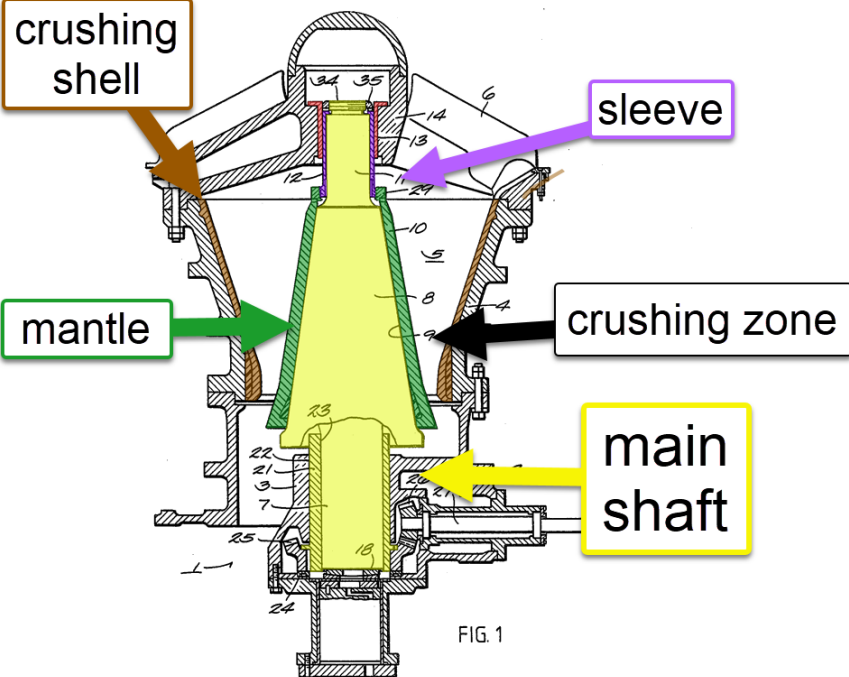
⁴¹ See Exhibit 1033 or Exhibit 1038 (Figure 7)

⁴² Exhibit 1035, 1:13-15, 1:35-42

⁴³ Exhibit 1034, 1:15-24

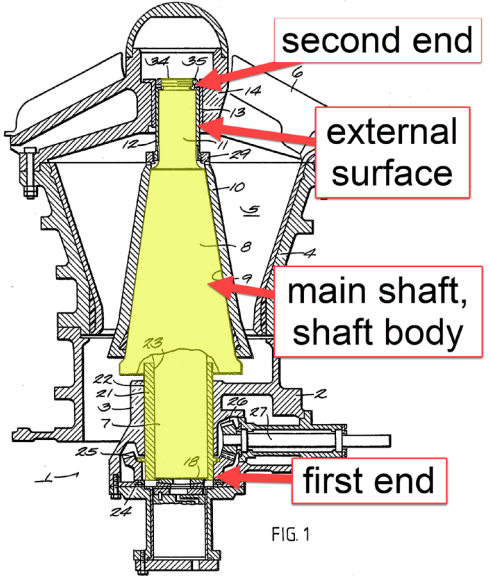
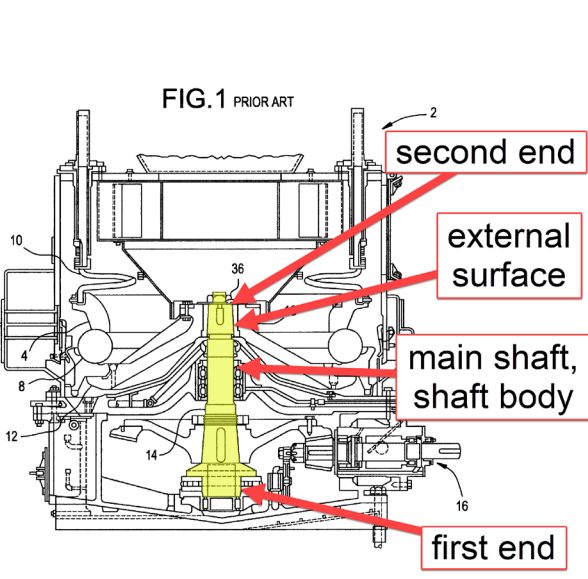
⁴⁴ Exhibit 1034, 1:35-40

⁴⁵ Exhibit 1033, 3:15-22

Challenged Claim	Obvious by Prior Art?
1P. A gyratory crusher main shaft of a crusher comprising:	YES: Although the preamble is generally not considered limiting, Polinski discloses a gyratory crusher main shaft of a crusher.
As shown above, and consistent with the specification, Polinski discloses a gyratory crusher main shaft. For example, the main shaft carries a mantle and is gyrated on an off-vertical axis creating a crushing zone between the mantle and the crushing shell. <i>“The present invention relates to gyratory crushers and, in particular, to the main shaft supporting the crusher head or mantle within the crusher.”⁴⁶</i>  47	
1a. a shaft body having a radially outward facing external surface, and a first end and a second end;	YES: Polinski and Piepho each disclose a shaft body having a radially outward facing external surface, and a first end and a second end.

⁴⁶ Exhibit 1017 1:6-8, emphasis added

⁴⁷ Exhibit 1017, Figure 1, annotated

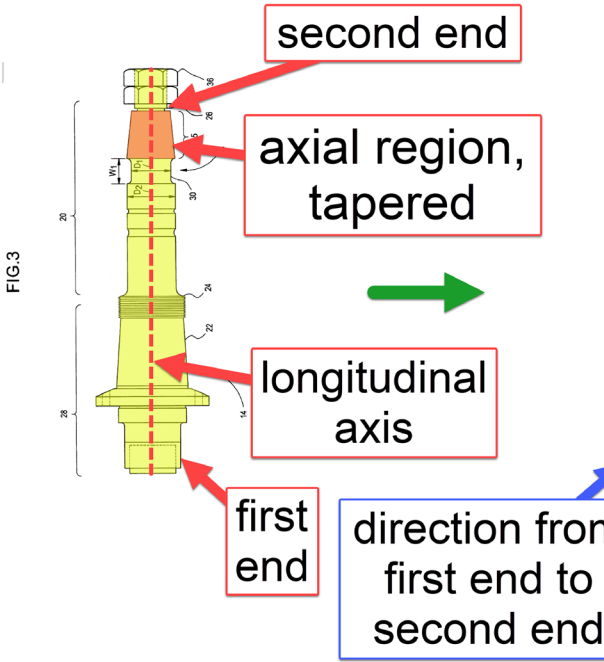
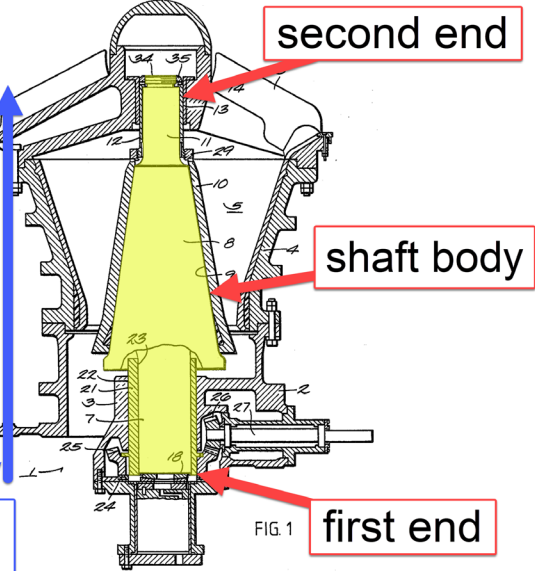
 FIG. 1 48	 FIG. 1 PRIOR ART 49
Polinski shaft body	Piepho shaft body
As shown above, both Polinski and Piepho disclose a shaft body including a shaft body. The shaft body has a radially outward facing external surface. Further, the main shaft has a first end and a second end. <i>“Referring to FIG. 1, 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 <u>a centrally located gyratable main shaft 7.</u>”⁵⁰</i> <i>“The bottom ring 6 is driven by the yoke 12 which is attached to a <u>vertical main shaft</u> assembly 14 of the pulverizer.”⁵¹</i>	
1b. an axial region of the shaft body extending from the second end and being tapered relative to a longitudinal axis of the shaft body such that a cross sectional area of the shaft body at the tapered axial region decreases in a direction from the first end to the second end;	YES: Polinski in view of Piepho discloses an axial region of the shaft body extending from the second end and being tapered relative to a longitudinal axis of the shaft body such that a cross section area of the shaft body at the tapered axial region

⁴⁸ Exhibit 1017, Figure 1, annotated

⁴⁹ Exhibit 1018, Figure 1 annotated

⁵⁰ Exhibit 1017, 2:32-37, emphasis added

⁵¹ Exhibit 1018, 1:26-27, emphasis added

	decreases in a direction from the first end to the second end.
	

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As shown above, the shaft body of Piepho has a tapered region that extends from the second end. The taper of this portion is relative to the longitudinal axis of the shaft body. Due to this taper, the cross-sectional area of the shaft body decreases as shown by the orange highlighted area above. This decrease in cross-sectional area occurs in the direction from the first (bottom) end of the main shaft to the second (top) end of the main shaft.

*“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).**”⁵³*

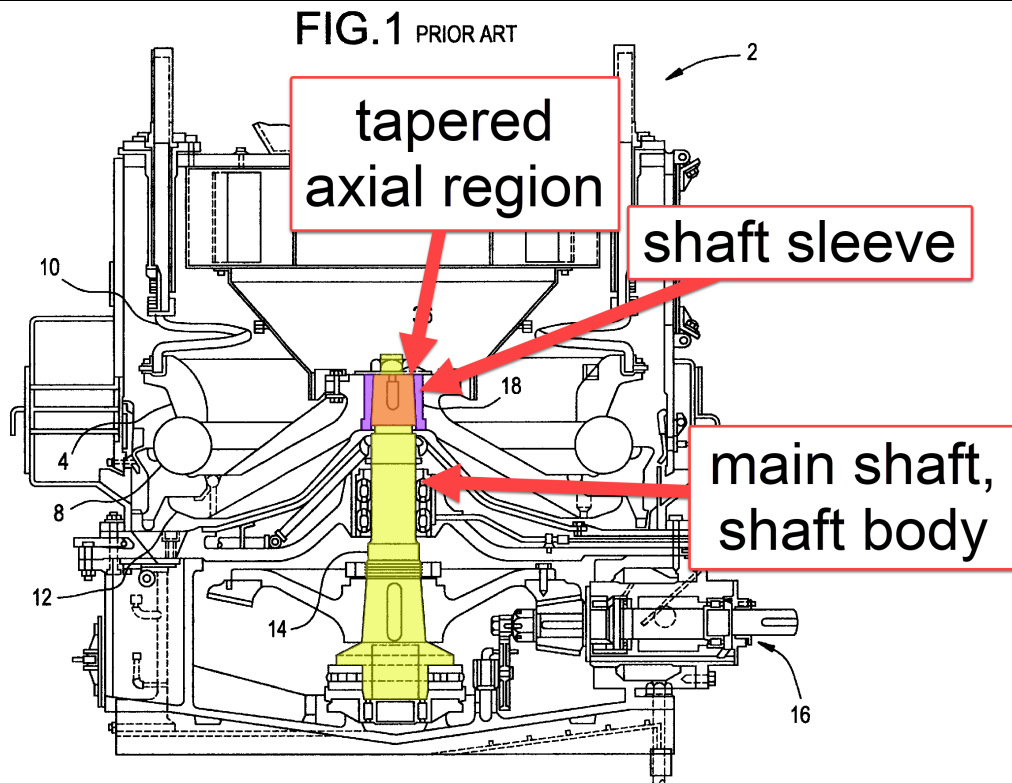
A POSITA would have been motivated to incorporate the tapered end on the main shaft of Piepho with the main shaft on Polinski. As Piepho describes, the tapered shaft aids in accurate alignment which is notoriously more difficult with purely cylindrical shafting. Incorporating the tapered portion of the Piepho shaft with Polinski would be a combination of known elements, in known ways, producing predictable results.

⁵² Exhibit 1018, Figure 3 annotated; Exhibit 1017, Figure 1, annotated

⁵³ Exhibit 1018, 3:23-31, emphasis added.

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

YES: Polinski in view of Piepho discloses a shaft sleeve mounted on the tapered axial region.



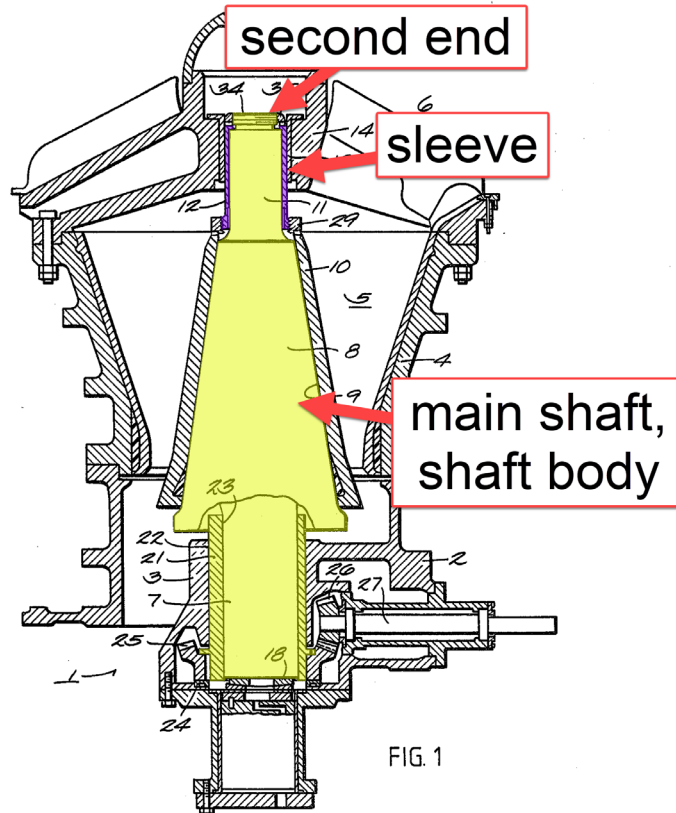
As shown above, Piepho teaches a sleeve mounted on the tapered axial region at the second end of the main shaft. This sleeve is the bushing 18 (highlighted in purple above).

*“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).**”*⁵⁵

Further, the main shaft of Polinski also has a sleeve. The sleeve of Polinski is fitted over a cylindrical portion of the main shaft body of Polinski, however, a POSITA would be motivated to use the tapered sleeve of Piepho as it aids in alignment and fit-up.

⁵⁴ Exhibit 1018, Figure 1, annotated

⁵⁵ Exhibit 1018, 3:23-31, emphasis added.



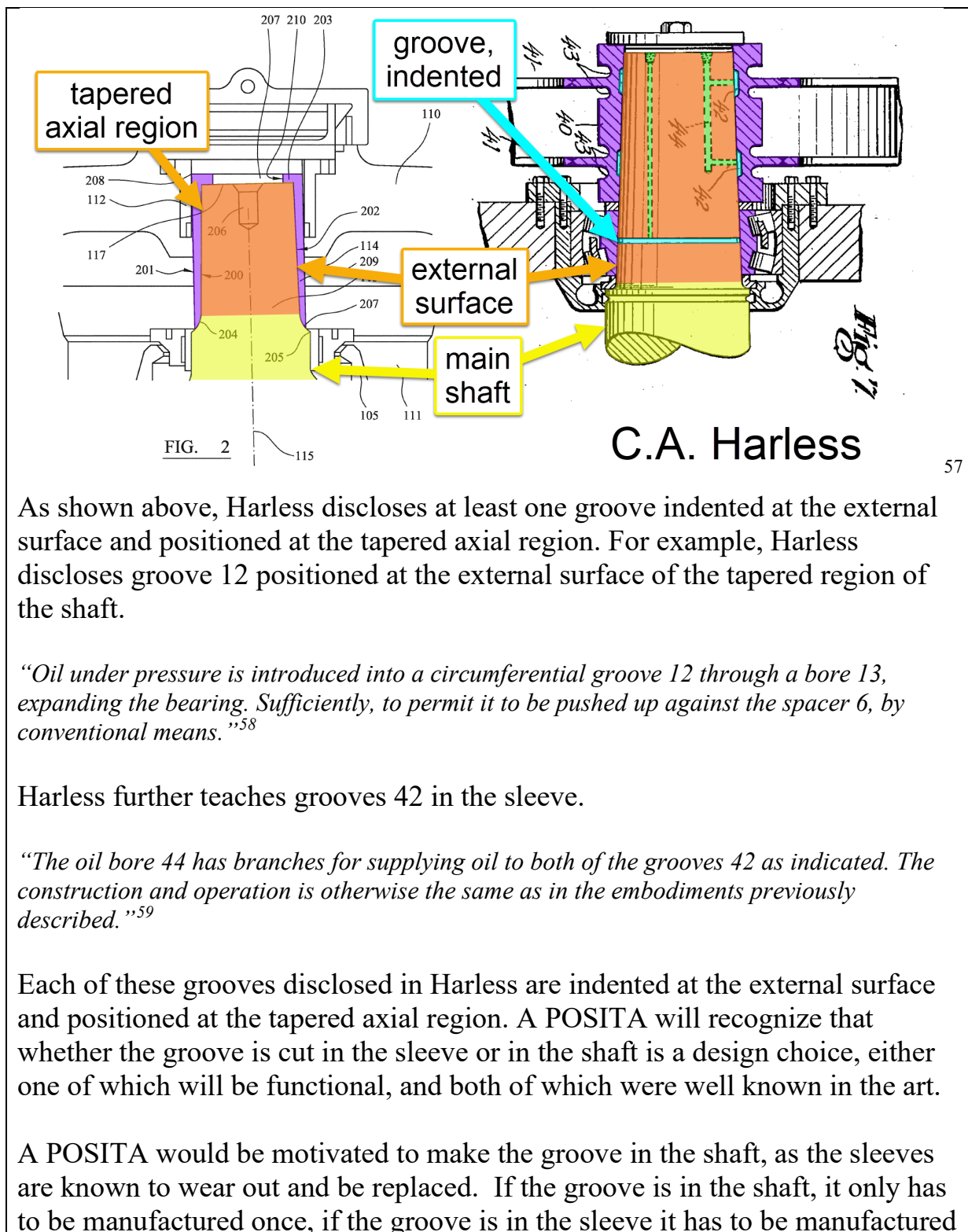
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A POSITA would be motivated to combine Polinski's shaft with a sleeve fitted onto the second end with Piepho's teachings of a sleeve fitted over the tapered section of second end of the main shaft. A POSITA would have a reasonable expectation of success 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.

1d1. at least one groove indented at the external surface and positioned at the tapered axial region,

YES: Polinski in view of Piepho, and in further view Harless discloses at least one groove indented at the external surface and positioned at the tapered axial region.

⁵⁶ Exhibit 1017, Figure 1, annotated



⁵⁷ Exhibit 1018, Figure 1, annotated; US 2,840,399 to C.A. Harless, Figure 7, annotated

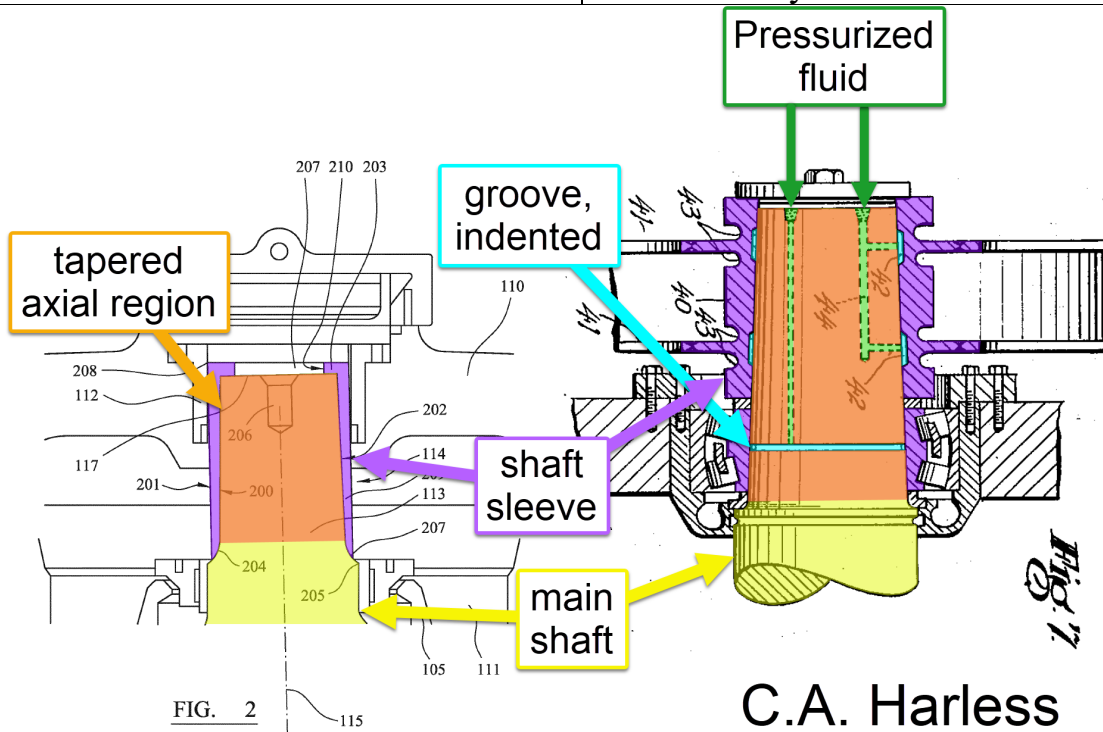
⁵⁸ Exhibit 1033, 2:19-22

⁵⁹ Exhibit 1033, 4:20-23

for each sleeve used with the shaft. A groove on the shaft would save time and money as compared to a groove on the sleeve. This combination of Polinski in view of Piepho and Harless is the result of combining known elements using known methods to produce predictable results.

1d2. the at least one groove being arranged to receive a pressurised[sic] fluid to facilitate mounting and dismounting of the shaft sleeve at the shaft body.

YES: Polinski in view of Piepho and Harless discloses that at least one groove is arranged to receive a pressurized fluid to facilitate mounting and dismounting of the shaft sleeve at the shaft body.



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As shown above, Harless discloses that each of the three grooves are arranged to received pressurized fluid which is used to facilitate both mounting and dismounting of components such as shaft sleeves at the shaft body.

"Oil under pressure is introduced into a circumferential groove 12 through a bore 13, expanding the bearing sufficiently, to permit it to be pushed up against the spacer 6, by conventional means.

Thereafter, the oil pressure is released, permitting the bearing inner race to contract and fixing it to the shaft with a shrink fit, the extent of shrink or interference being, as indicated, about .003 inch."⁶¹

⁶⁰ Exhibit 1018, Figure 1, annotated; Exhibit 1033, Figure 7, annotated

⁶¹ Exhibit 1033, 2:19-26, emphasis added

*"The oil bore 44 has branches for supplying oil to both of the grooves 42 as indicated. The construction and operation is otherwise the same as in the embodiments previously described."*⁶²

"It is an object of the invention to provide for the attachment of a gear or other drive member to a tapered shaft, by expanding certain portions of the hub of the gear, while avoiding the excess pressure necessary to expand the web or any other radially extending part of the gear.

...

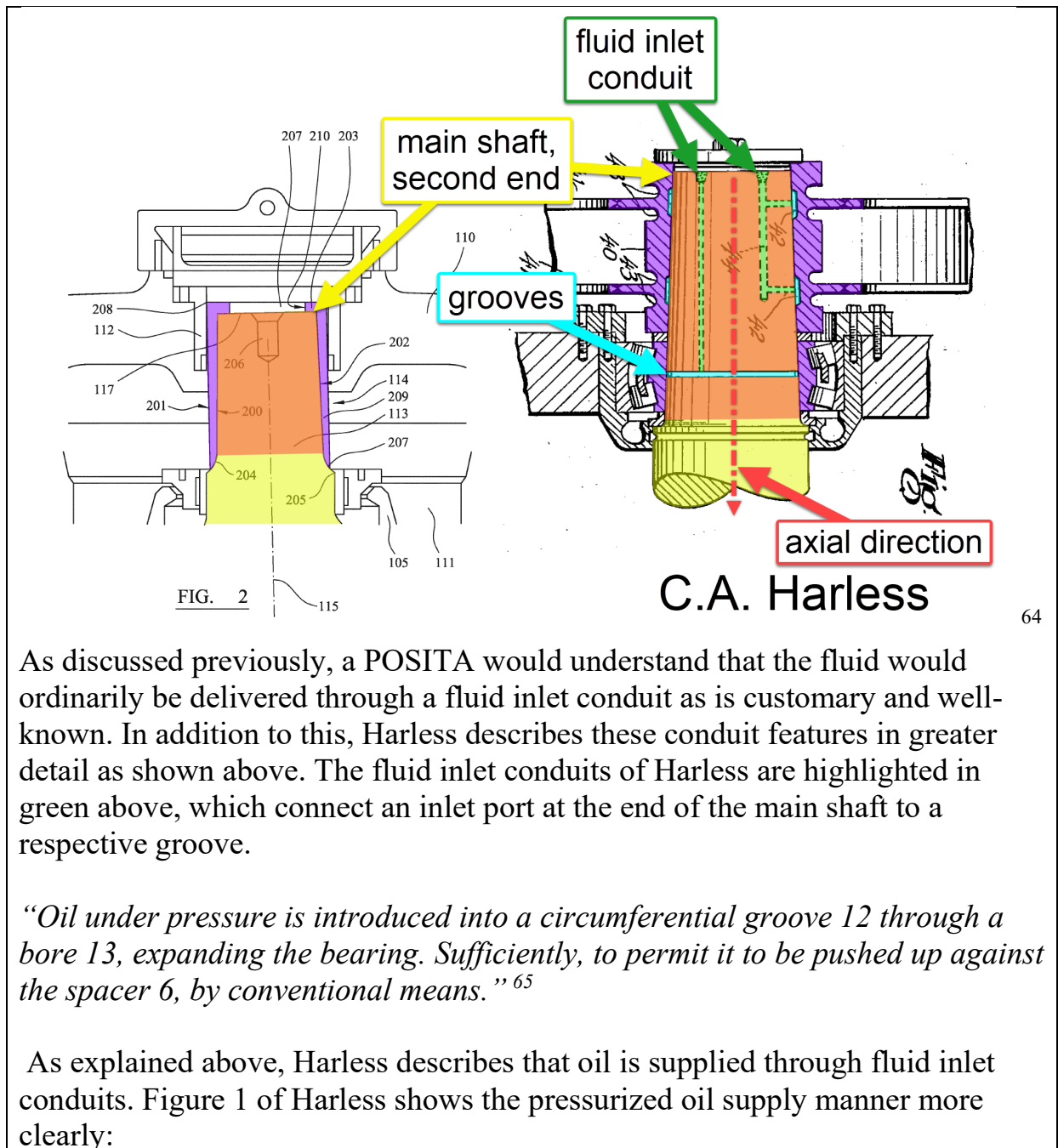
A still further object of the invention is to provide an attachment permitting removal of a gear or other drive member without the use of a gear puller or similar equipment."⁶³

As shown in the figure above and described in the citations above, Harless discloses at least one groove (three grooves in Figure 7) which are arranged to receive pressurized fluid (oil) to facilitate mounting or dismounting a shaft sleeve element at the shaft body. This combination of Polinski in view of Piepho and Harless is the result of combining known elements using known methods to produce predictable results. A POSITA would be further motivated to combine these elements to simplify the equipment and process for making and breaking interference fits as discussed above, and would have every expectation of success as the technology was already well developed and documented.

2P. The main shaft as claimed in claim 1,	YES: As shown above, Polinski in view of Piepho and Harless discloses the main shaft as claimed in claim 1.
2a. further comprising a fluid inlet conduit extending axially from the second end and provided in fluid communication with the at least one groove to allow a fluid to be supplied to the at least one groove from the second end.	YES: Polinski in view of Piepho and Harless discloses that the main shaft further comprises a fluid inlet conduit extending axially from the second end and provided in fluid communication with the at least one groove to allow a fluid to be supplied to the at least one groove from the second end.

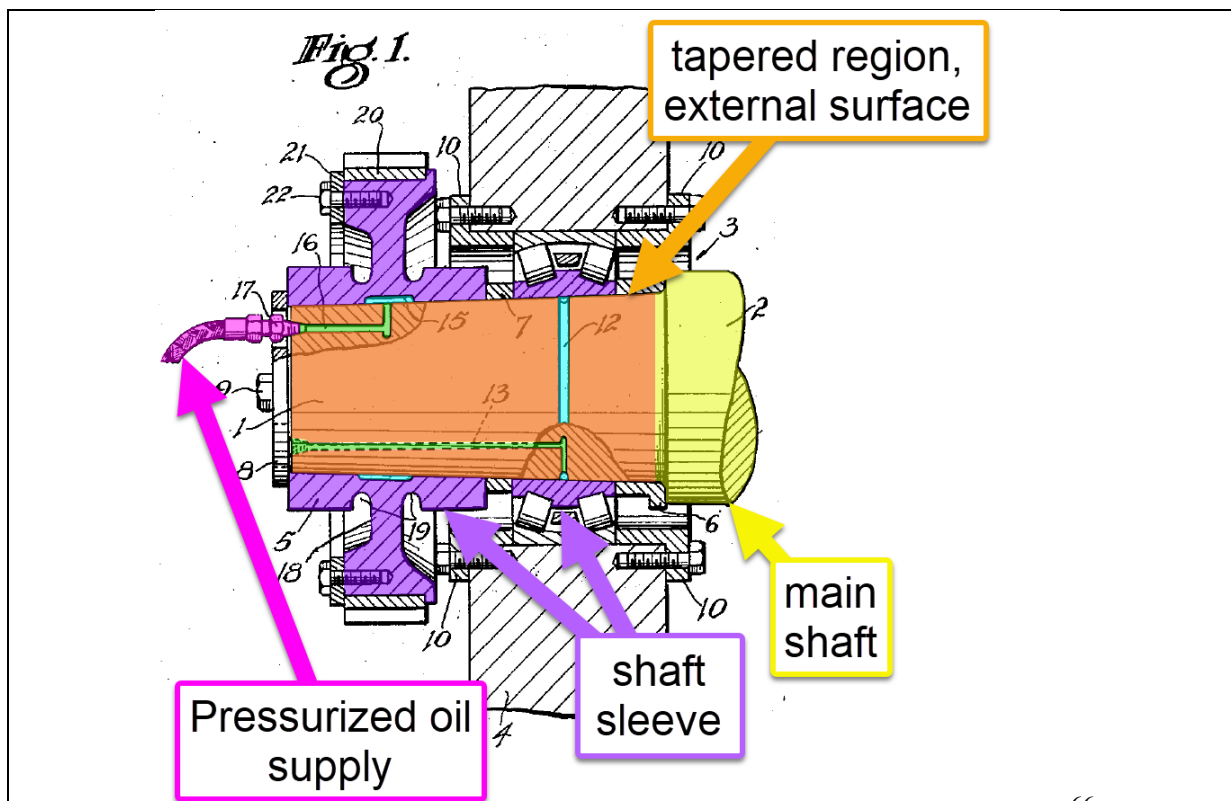
⁶² Exhibit 1033, 4:20-23

⁶³ Exhibit 1033, 1:30-34, 39-42



⁶⁴ Exhibit 1018, Figure 1, annotated; Exhibit 1033, Figure 7, annotated

⁶⁵ Exhibit 1033, 2:19-22



66

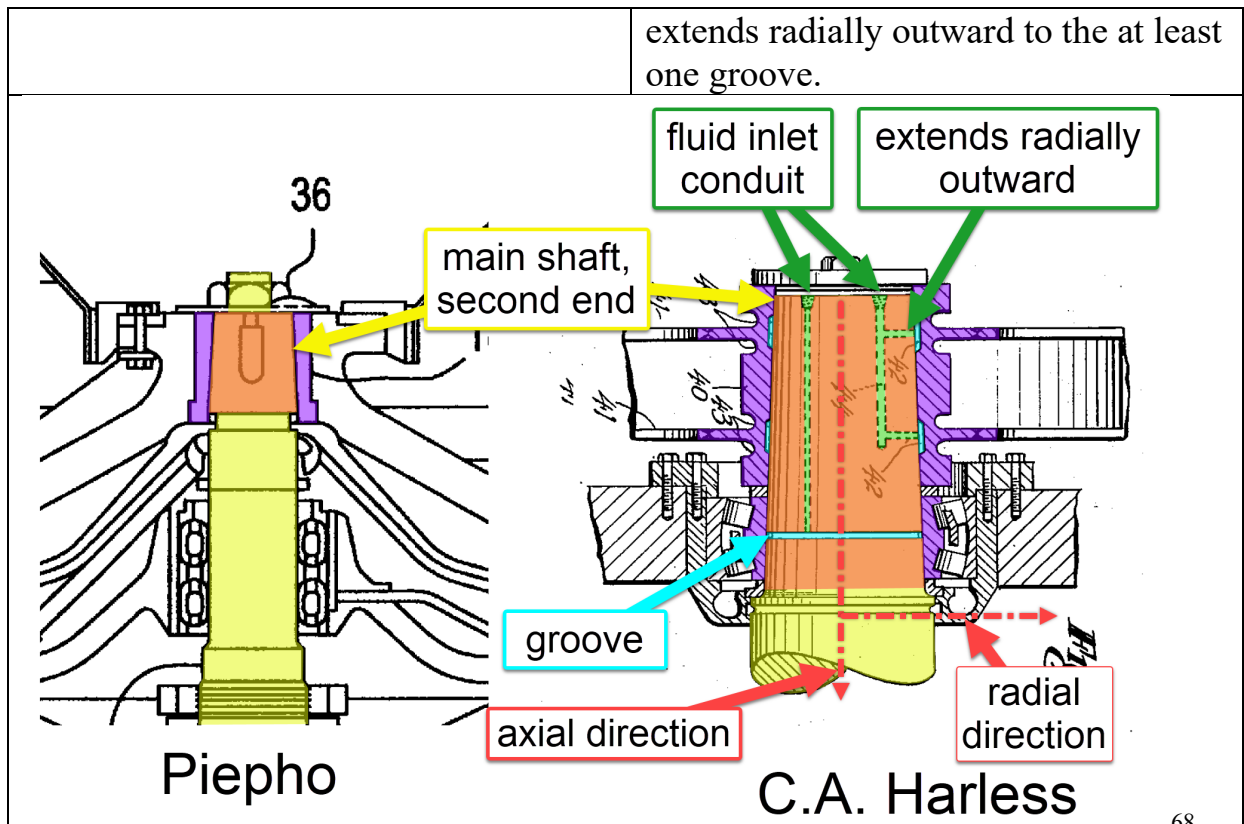
“The shaft is provided with a bore 16 for supplying oil from a removable fitting 17.”⁶⁷

This combination of Polinski in view of Piepho and Harless is the result of combining known elements using known methods to produce predictable results. A POSITA would be further motivated to combine these elements to simplify the equipment and process for making and breaking interference fits as discussed above, and would have every expectation of success as the technology was already well developed and documented.

3P. The main shaft as claimed in claim 2,	YES: As shown above, Polinski in view of Piepho and Harless discloses the main shaft as claimed in claim 2.
3a. wherein the fluid inlet conduit extends internally within the shaft body such that a part of the fluid inlet conduit extends radially outward to the at least one groove.	YES: As shown above, Polinski in view of Piepho and Harless discloses that the fluid inlet conduit extends internally within the shaft body such that a part of the fluid inlet conduit

⁶⁶ Exhibit 1033, Figure 1, annotated

⁶⁷ Exhibit 1033, 2:44-45



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As show above, Harless shows the fluid inlet conduits extending internally within the main shaft body. Because the axial component of the fluid inlet conduit is internal to the shaft body, and because it must still connect to the grooves (some of which are cut in the sleeve elements and some of which are cut in the periphery of the shaft body itself), the fluid inlet conduits must have a radial component. This radial component connects the axial component with the respective groove located at the surface. A POSITA would understand that Harless discloses a typical and ordinary way in which fluid conduits are created.

*“The invention may also be applied to double webbed gears where both webs extend radially, and such an ap plication is shown in Figure 7. In this case, the hub 40 has a pair of radial webs. 41 and the hub is relieved by grooves 43 at each side of these webs. **The oil bore 44 has branches for supplying oil to both of the grooves 42 as indicated.** The construction and operation is otherwise the same as in the embodiments previously described.”⁶⁹*

⁶⁸ Exhibit 1018, Figure 1, annotated; Exhibit 1033, Figure 7, annotated

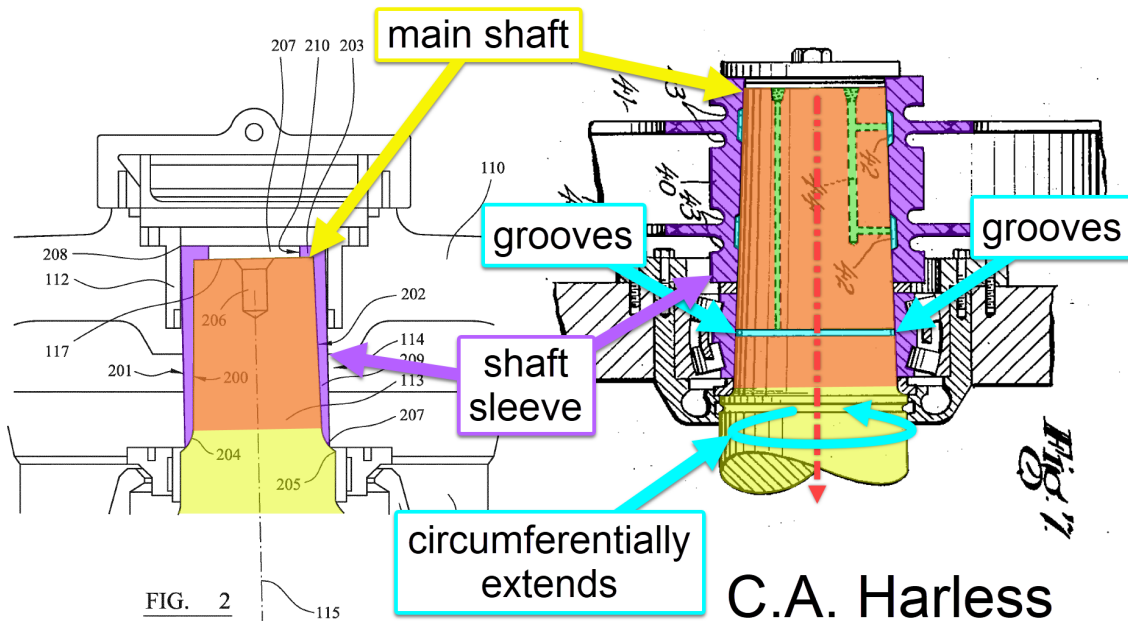
⁶⁹ Exhibit 1033, 4:16-23

“Oil under pressure is introduced into a circumferential groove 12 through a bore 13, expanding the bearing. Sufficiently, to permit it to be pushed up against the spacer 6, by conventional means.”⁷⁰

As described above, the oil bore of Harless has branches that connect the oil bore to the respective grooves. As shown in the figures of Harless, these branches extend in the radial direction and are part of the fluid inlet conduit.

This combination of Polinski in view of Piepho and Harless is the result of combining known elements using known methods to produce predictable results. A POSITA would be further motivated to combine these elements to simplify the equipment and process for making and breaking interference fits as discussed above, and would have every expectation of success as the technology was already well developed and documented.

4P. The main shaft as claimed in claim 3,	YES: As shown above, Polinski in view of Piepho and Harless discloses the main shaft as claimed in claim 3.
4a. wherein the at least one groove extends in a circumferential direction around the shaft body.	YES: Polinski in view of Piepho and Harless discloses that the at least one groove extends in a circumferential direction around the shaft body.



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⁷⁰ Exhibit 1033, 2:19-22

⁷¹ Exhibit 1018, Figure 1, annotated; Exhibit 1033, Figure 7, annotated

As shown above, Harless shows these circumferential groove very clearly as highlighted in turquoise above. The sleeve elements in Figure 7 of Harless are sectioned revealing the un-sectioned main shaft element. Thus, it is easy to see the topmost two grooves of Harless figure 7 are visible in the section. Simultaneously, the un-sectioned main shaft groove (lowermost in the figure above) clearly extends around the periphery of the tapered portion of the main shaft (highlighted in orange).

“Oil under pressure is introduced into a circumferential groove 12 through a bore 13, expanding the bearing. Sufficiently, to permit it to be pushed up against the spacer 6, by conventional means.”⁷²

“The oil bore 44 has branches for supplying oil to both of the grooves 42 as indicated. The construction and operation is otherwise the same as in the embodiments previously described.”⁷³

As explained above, Harless describes the grooves that extend circumferentially around the shaft body. Not only is the lowermost groove circumferential, a POSITA would understand that grooves 42 extend circumferentially as is ordinary and customary in machine design. This allows the fit-up of components to be made reliably without having to align a small cavity in the sleeve with a small bore in the shaft. That the section of the sleeve shows the groove elements on both sides further demonstrates that the groove elements extend circumferentially.

This combination of Polinski in view of Piepho and Harless is the result of combining known elements using known methods to produce predictable results. A POSITA would be further motivated to combine these elements to simplify the equipment and process for making and breaking interference fits as discussed above, and would have every expectation of success as the technology was already well developed and documented.

5P. The main shaft as claimed in claim 4,

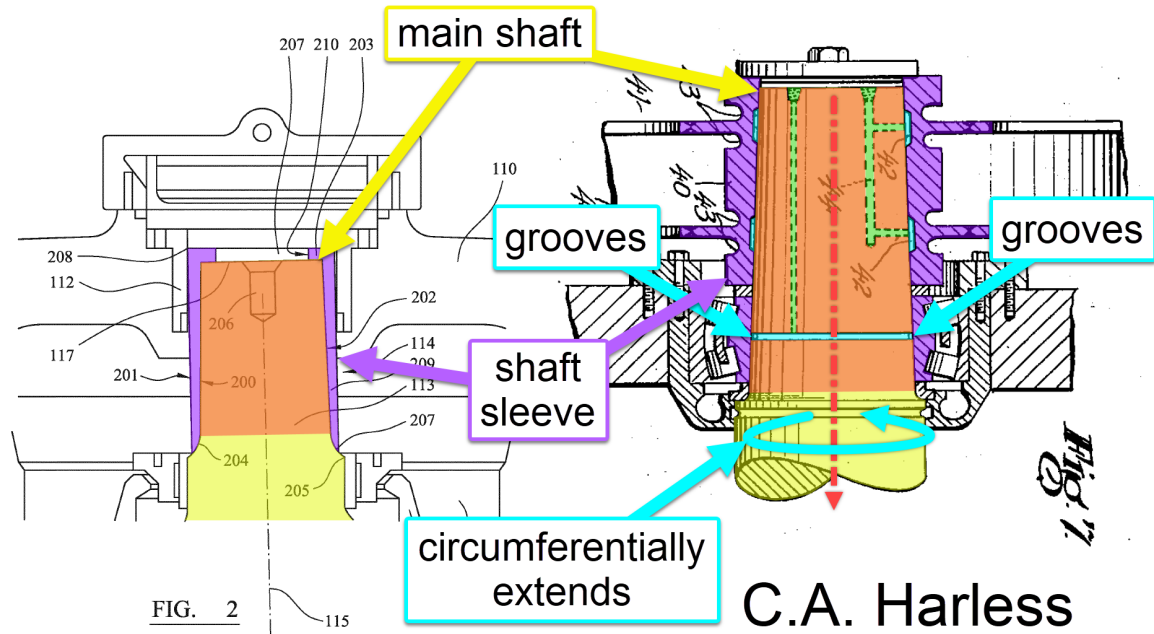
YES: As shown above, Polinski in view of Piepho and Harless discloses the main shaft as claimed in claim 4.

⁷² Exhibit 1033, 2:19-22

⁷³ Exhibit 1033, 4:20-23

5a. wherein the at least one groove extends substantially or completely circumferentially around the shaft body.

YES: Polinski in view of Piepho and Harless discloses that the at least one groove extends substantially or completely circumferentially around the shaft body.



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Harless describes the grooves that extend circumferentially around the shaft body. Not only is the lowermost groove circumferential, a POSITA would understand that groove 42 extend circumferentially as is ordinary and customary in machine design. This allows the fit-up of components to be made reliably without having to align a small cavity in the sleeve with a small bore in the shaft. That the section of the sleeve shows the groove elements on both sides further demonstrates that the groove elements extend completely or substantially circumferentially. A POSITA will further understand that manufacturing methods to cut such grooves will commonly be made using a lathe or similar rotating machinery. As such, a POSITA would expect that these grooves would extend completely circumferentially.

This combination of Polinski in view of Piepho and Harless is the result of combining known elements using known methods to produce predictable results. A POSITA would be further motivated to combine these elements to simplify the equipment and process for making and breaking interference fits as

⁷⁴ Exhibit 1018, Figure 1, annotated; Exhibit 1033, Figure 7, annotated

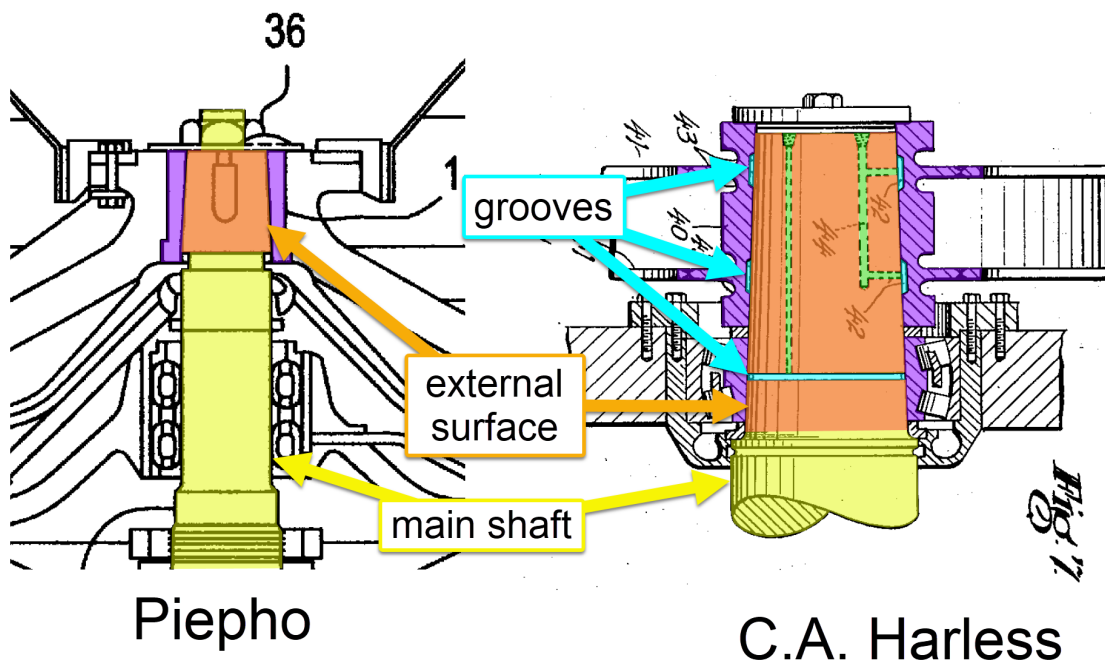
discussed above, and would have every expectation of success as the technology was already well developed and documented.

6P. The main shaft as claimed in claim 5,

YES: Polinski in view of Piepho and Harless discloses the main shaft as claimed in claim 5.

6a. further comprising a plurality of grooves at the external surface.

YES: Polinski in view of Piepho and Harless discloses further comprising a plurality of grooves at the external surface.



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As shown above, Harless discloses a plurality of grooves at the external surface. Specifically, Harless figure 7 shows three such grooves.

*"The invention may also be applied to double webbed gears where both webs extend radially, and such an application is shown in Figure 7. In this case, the hub 40 has a pair of radial webs. 41 and the hub is relieved by grooves 43 at each side of these webs. **The oil bore 44 has branches for supplying oil to both of the grooves 42 as indicated.** The construction and operation is other wise the same as in the embodiments previously described."*⁷⁶

⁷⁵ Exhibit 1018, Figure 1, annotated; Exhibit 1033, Figure 7, annotated

⁷⁶ Exhibit 1033, 4:16-23, emphasis added

“Oil under pressure is introduced into a circumferential groove 12 through a bore 13, expanding the bearing. Sufficiently, to permit it to be pushed up against the spacer 6, by conventional means.”⁷⁷

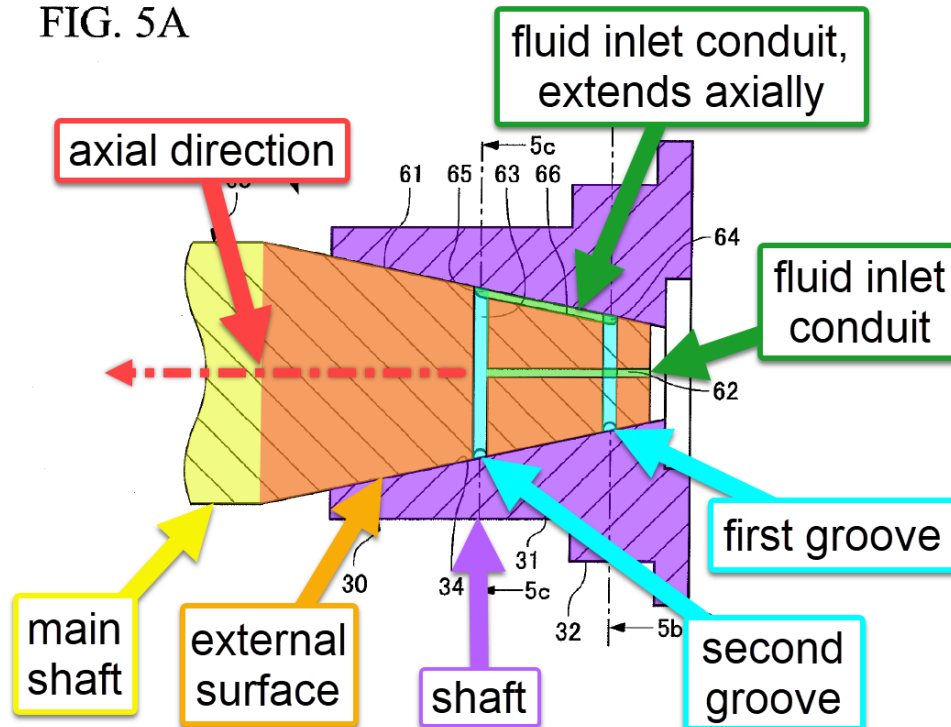
As described above, Harless discloses three grooves in the embodiment of Figure 7, each of which are located at the tapered external surface.

This combination of Polinski in view of Piepho and Harless is the result of combining known elements using known methods to produce predictable results. A POSITA would understand that it is desirable to more evenly distribute the oil pressure over the surface of the sleeve. This way, the oil pressure causes a more even expansion of the joint, which makes the fit-up easier to accomplish. Particularly over longer sleeves, a singular groove can cause the sleeve to expand in one locale, but not in others. Consequently, a POSITA would be motivated to include a plurality of groove on a length sleeve such as would be typical on a gyratory crusher main shaft.

The US 8,302,754 to Yagi, further teaches a shaft with a plurality of grooves indented into the surface of the shaft.

⁷⁷ Exhibit 1033, 2:19-22, emphasis added

FIG. 5A



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As shown above, Yagi discloses a tapered interference joint just the same as Piepho and Harless. For example, Yagi describes a tapered shaft and a correspondingly tapered hub which may be coupled together and separated through the use of pressurized oil.⁷⁹ Further, as shown above, Yagi shows a fluid inlet conduit between two axially spaced circumferential grooves.⁸⁰ This portion of the fluid inlet conduit extends axially along the outer surface of the tapered portion of the main shaft.

A POSITA would be further motivated to combine these elements to simplify the equipment and process for making and breaking interference fits as discussed above, and would have every expectation of success as the technology was already well developed and documented.

7P. The apparatus as claimed in claim 6,	YES: As shown above, Polinski in view of Piepho and Harless discloses the apparatus as claimed in claim 6.
7a. further comprising a first groove extending in a circumferential direction	YES: Polinski in view of Piepho and Harless discloses further comprising a

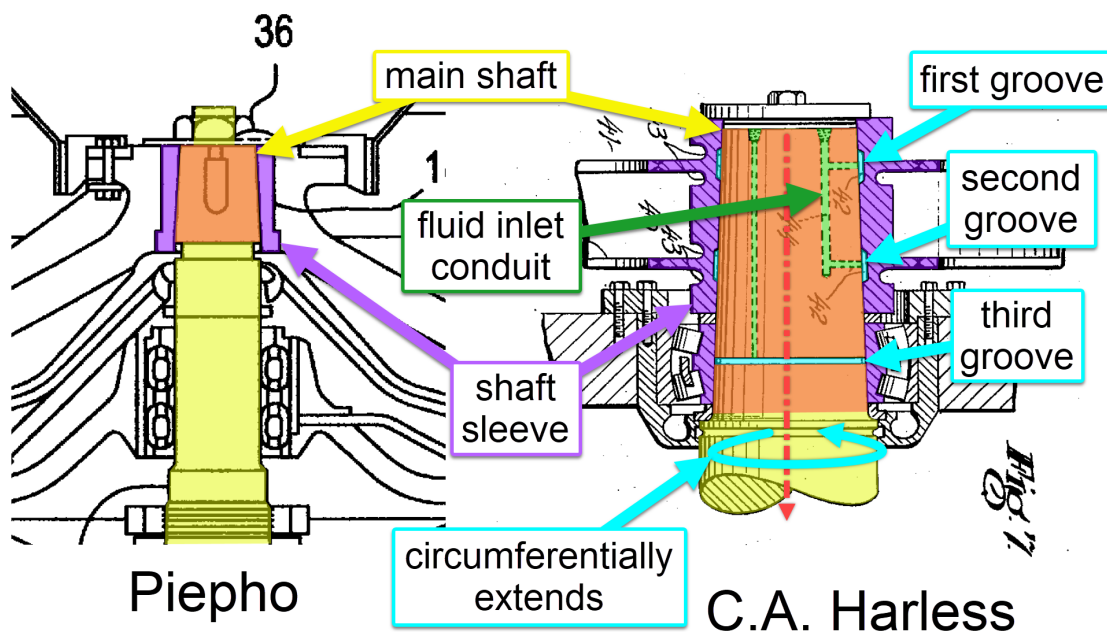
⁷⁸ Exhibit 1040, Figure 5A, annotated

⁷⁹ Exhibit 1040, 1:6-10, 2:24-28

⁸⁰ That the grooves of Yagi extend circumferentially is clearly shown in Figures 5B and 5C of Yagi, which depict cross sections taken that the respective grooves.

around the shaft body and a second groove extending in a circumferential direction around the shaft body, the first groove being separated axially from the second groove and coupled in fluid communication.

first groove extending in a circumferential direction around the shaft body and a second groove extending in a circumferential direction around the shaft body. Further the first groove is separated axially from the second groove and coupled in fluid communication.



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As shown above, Harless Figure 7 shows that the first and second groove. As discussed previously (see element 4a) each of these grooves extend circumferentially. Further, each of these grooves are axially displaced from one another. The first groove is closer to the topmost portion of the main shaft while the second groove is spaced away below the first groove as shown in the figure above. A POSITA will recognize that these grooves are spaced from one another to more evenly distribute the oil pressure of the length of the sleeve element so as to facilitate making or breaking the tapered interference joint. A POSITA would be similarly motivated to distribute the oil pressure evenly over the long sleeve element of Polinski in view of Piepho using a plurality of axially distributed grooves.

⁸¹ Exhibit 1018, Figure 1, annotated; Exhibit 1033, Figure 7, annotated

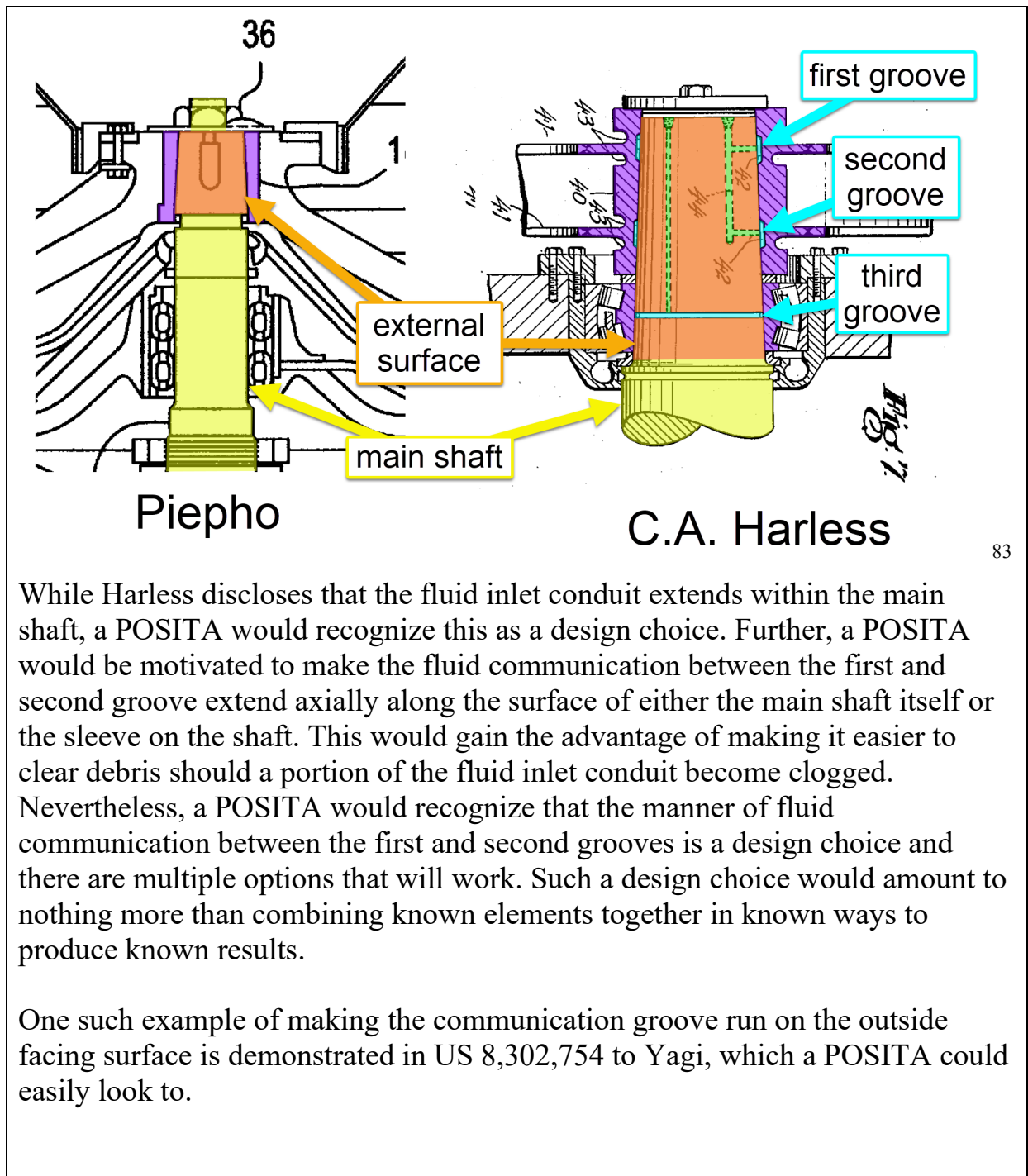
Further, the first and second groove are in fluid communication with one another as shown by the fluid inlet conduit (highlighted in green) which branches to both the first groove and the second groove from a single inlet point.

*“The invention may also be applied to double webbed gears where both webs extend radially, and such an application is shown in Figure 7. In this case, the hub 40 has a pair of radial webs. 41 and **the hub is relieved by grooves 43 at each side of these webs. The oil bore 44 has branches for supplying oil to both of the grooves 42 as indicated.** The construction and operation is otherwise the same as in the embodiments previously described.”⁸²*

This combination of Polinski in view of Piepho and Harless is the result of combining known elements using known methods to produce predictable results. Oil pathways are commonly cut into machine components in a manner consistent with the disclosure of Harless. A POSITA would be further motivated to combine these elements to simplify the equipment and process for making and breaking interference fits as discussed above, and would have every expectation of success as the technology was already well developed and documented.

8P. The main shaft as claimed in claim 7,	YES: As shown above, Polinski in view of Piepho and Harless discloses the main shaft as claimed in claim 7.
8a. wherein at least a part of the fluid inlet conduit is indented and extends axially at the external surface as a channel to couple the first and second grooves in fluid communication.	YES: Polinski in view of Piepho and Harless discloses that at least part of the fluid inlet conduit is indented and extends axially at the external surface as a channel to couple the first and second grooves in fluid communication.

⁸² Exhibit 1033, 4:16-23, emphasis added



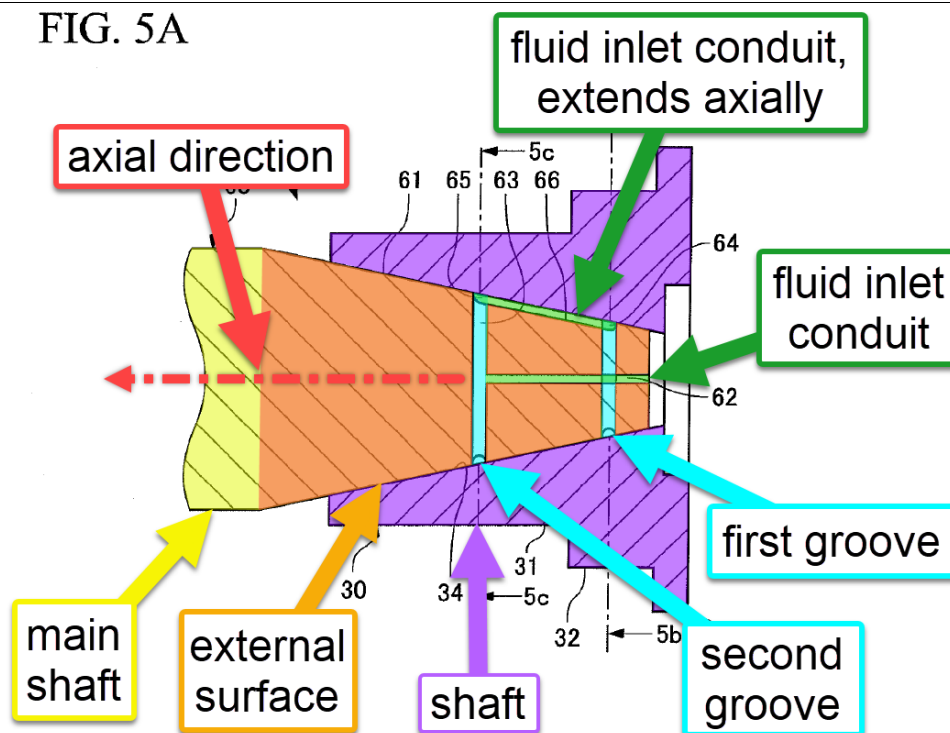
83

While Harless discloses that the fluid inlet conduit extends within the main shaft, a POSITA would recognize this as a design choice. Further, a POSITA would be motivated to make the fluid communication between the first and second groove extend axially along the surface of either the main shaft itself or the sleeve on the shaft. This would gain the advantage of making it easier to clear debris should a portion of the fluid inlet conduit become clogged. Nevertheless, a POSITA would recognize that the manner of fluid communication between the first and second grooves is a design choice and there are multiple options that will work. Such a design choice would amount to nothing more than combining known elements together in known ways to produce known results.

One such example of making the communication groove run on the outside facing surface is demonstrated in US 8,302,754 to Yagi, which a POSITA could easily look to.

⁸³ Exhibit 1018, Figure 1, annotated; Exhibit 1033, Figure 7, annotated

FIG. 5A



84

As shown above, Yagi discloses a tapered interference joint just the same as Piepho and Harless. For example, Yagi describes a tapered shaft and a correspondingly tapered hub which may be coupled together and separated through the use of pressurized oil.⁸⁵ Further, as shown above, Yagi shows a fluid inlet conduit between two axially spaced circumferential grooves.⁸⁶ This portion of the fluid inlet conduit extends axially along the outer surface of the tapered portion of the main shaft.

“In the outer peripheral surface of the taper part 61, there is provided a connecting oil groove 66 one end of which communicates with the second oil groove 65 and which extends in the axial direction toward the frontend of the tapered shaft 60. The other end of the connecting oil groove 66 communicates with a first oil groove 64. The first oil groove 64 is formed along the circumferential direction in the outer peripheral surface of the taper part 61. Some of the oil flowing in the second oil groove 65 passes through the connecting oil groove 66 and reaches the first oil groove 64.”⁸⁷

⁸⁴ Exhibit 1040, Figure 5A, annotated

⁸⁵ Exhibit 1040, 1:6-10, 2:24-28

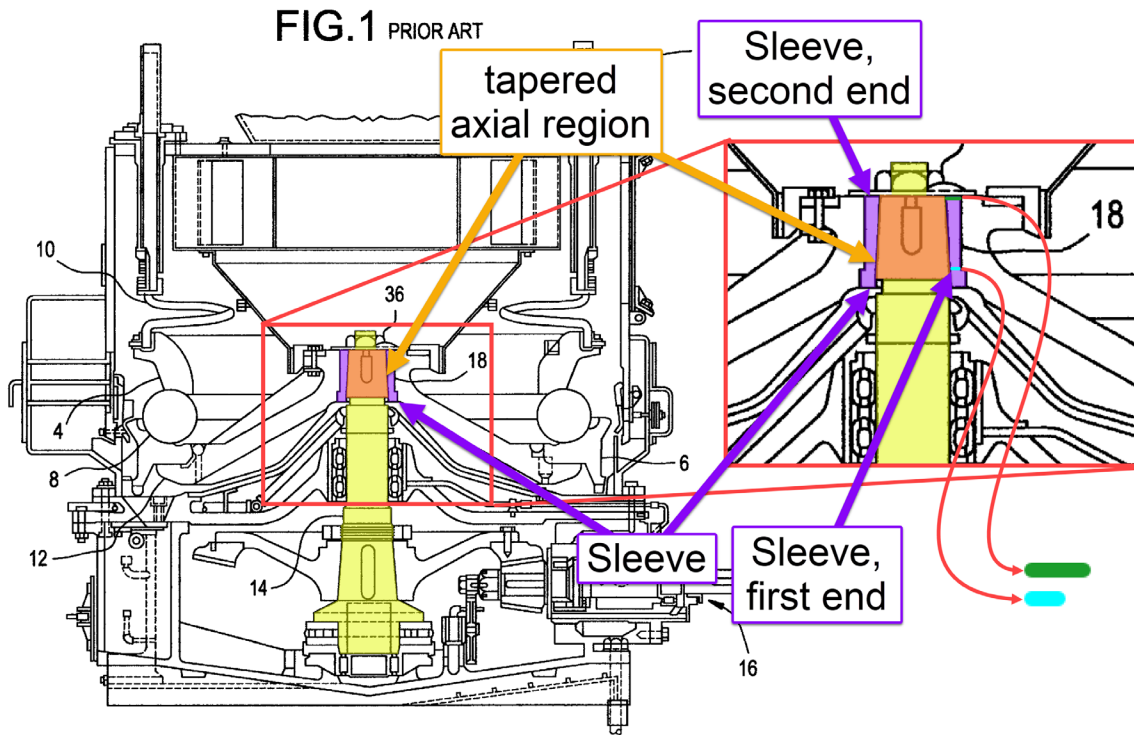
⁸⁶ That the grooves of Yagi extend circumferentially is clearly shown in Figures 5B and 5C of Yagi, which depict cross sections taken that the respective grooves.

⁸⁷ Exhibit 1040, 6:58-67, emphasis added

A POSITA would be further motivated to combine these elements to simplify the equipment and process for making and breaking interference fits as discussed above, and would have every expectation of success as the technology was already well developed and documented.

Challenged Claim	Obvious by Prior Art?
9P. A gyratory crusher main shaft assembly for a crusher comprising:	YES: While the preamble to a claim is generally not considered limiting, see claim element 1P.
9a. a shaft body having a radially outward facing external surface, and a first end and a second end,	YES: See element 1a.
9a3. an axial region of the shaft body extending from the second end and being tapered relative to a longitudinal axis of the shaft body such that a cross sectional area of the shaft body at the tapered axial region decreases in a direction from the first end to the second end,	YES: See element 1b.
9a4. a shaft sleeve mounted on the tapered axial region,	YES: See element 1c.
9a5. and at least one groove indented at the external surface and positioned at the tapered axial region,	YES: See element 1d1.
9a6. the at least one groove being arranged to receive a pressurised[sic] fluid to facilitate mounting and dismounting of the sleeve at the shaft body; and	YES: See element 1d2.
9b. a sleeve fitted over the tapered axial region, the sleeve having a tapered wall thickness, such that the wall thickness at a second end of the sleeve is greater than the wall thickness at a first end of the sleeve.	YES: Polinski in view of Piepho and Harless discloses a sleeve fitted over the tapered axial region, the sleeve having a tapered wall thickness, such that the wall thickness at a second end of the sleeve is greater than the wall thickness at a first end of the sleeve.
Both Polinski and Piepho disclose a sleeve fitted over the region at the second (top) end of the main shaft. In Piepho, this portion is tapered inwards and thus	

the sleeve that is fitted to it is also tapered. Further, the external surface of the sleeve is cylindrical which makes it so the wall thickness of the sleeve is greater at the second end of the sleeve than it is at the first end of the sleeve.



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As shown above, Piepho discloses a sleeve fitted over the tapered region. The sleeve is cylindrical on its outermost surface but mates with the tapered shaft internally. In order to accomplish this, the sleeve wall itself is tapered.

*“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).**”⁸⁹*

As shown above, the sleeve is fitted over the tapered axial region using an interference fit. Further, it has a tapered internal surface matching that of the tapered axial region of the main shaft and a cylindrical external surface. Thus, it has a wall thickness that tapers from a thicker portion at the second end, to a thinner portion at the first end.

⁸⁸ Exhibit 1018, Figure 1, annotated

⁸⁹ Exhibit 1018, 3:23-31, emphasis added.

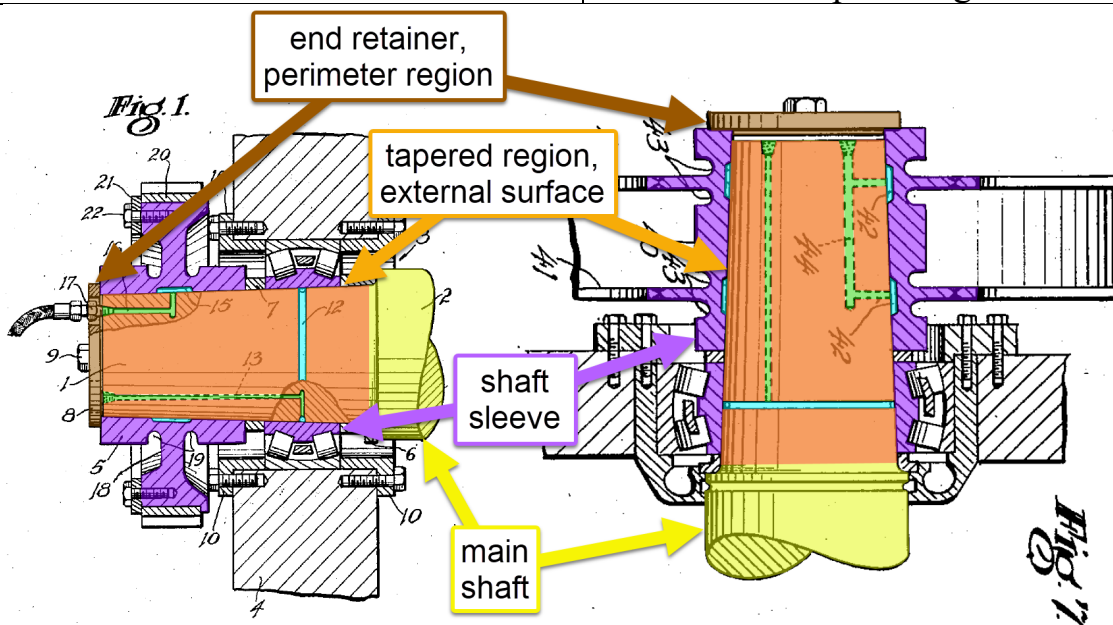
This combination of Polinski in view of Piepho and Harless is the result of combining known elements using known methods to produce predictable results. A POSITA would understand that a bushing that on one side mates with a cylindrical bore and on the other side mates with a tapered portion of a shaft will naturally have a wall thickness that tapers from one end to the other in order to fill the space between the two surfaces. A POSITA would expect success in combining these elements as it had been done in the prior art.

10P. The assembly as claimed in claim 9,

YES: As shown above, Polinski in view of Piepho and Harless discloses the assembly as claimed in claim 9.

10a1. further comprising an end retainer releasably mounted at the second end of the shaft body and having a perimeter region extending radially outward beyond the external surface at the tapered region,

YES: Polinski in view of Piepho and Harless discloses a main shaft assembly further comprising an end retainer releasably mounted at the second end of the shaft body and having a perimeter region extending radially outward beyond the external surface at the tapered region.



C.A. Harless

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⁹⁰ Exhibit 1033, Figures 1 and 2, annotated

As shown above, Harless discloses an end retainer mounted at the second end (topmost as previously shown) of the main shaft. The identical structure between Figures 1 and 7 of Harless is shown above. As can be seen in the figure, the end retainer is fastened to the end of the tapered region of the main shaft and extends radially outward beyond the external surface of the tapered region. This design feature helps to retain and apply force to the sleeve components as shown above, consistent with the specification:

*“The hub of the gear 5. and the inner race of the bearing 3 are located axially of the shaft by means of spacer rings 6 and 7 **and a cap plate or washer 8 attached to the end of the shaft** as by means of screws 9.”⁹¹*

“The invention may also be applied to double webbed gears where both webs extend radially, and such an application is shown in Figure 7.

...

The construction and operation is otherwise the same as in the embodiments previously described.”⁹²

As described above, for the retainer plate, the construction and operation of Figure 7 is the same as that of previously described embodiments such as that of Figure 1. As described regarding figure 1, retainer (cap plate or washer 8) is attached to the main shaft which retains the sleeve components (hub 5 and inner bearing race 3).

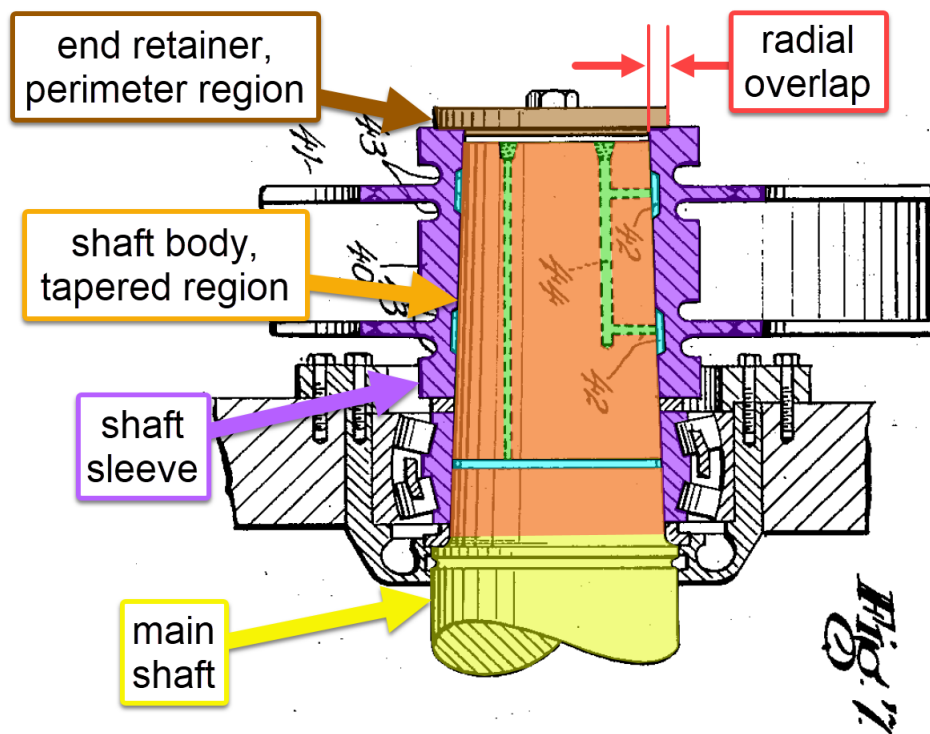
This combination of Polinski in view of Piepho and Harless is the result of combining known elements using known methods to produce predictable results. It is well-known and customary to include a retainer such as shown in Harless in an assembly using a tapered interference joint.

10a2. the perimeter region positioned to radially overlap the sleeve at the second end of the sleeve to inhibit axial separation of the sleeve from the shaft body.

YES: The perimeter region of the end retainer overlaps the sleeve components at the second end of the sleeve to inhibit axial separation of the sleeve from the shaft body.

⁹¹ Exhibit 1033, 1:66-69, emphasis added

⁹² Exhibit 1033, 4:16-18, 22-23



C.A. Harless

As shown above, the perimeter region of the end retainer (the outermost surface) extends radially beyond the tapered region of the main shaft of Harless, and thus it overlaps with the sleeve components. This overlap acts to inhibit the axial separation of the sleeve components from the shaft body.

*"The hub of the gear 5. and the inner race of the bearing 3 are located axially of the shaft by means of spacer rings 6 and 7 and a cap plate or washer 8 attached to the end of the shaft as by means of screws 9."*⁹³

This combination of Polinski in view of Piepho and Harless is the result of combining known elements using known methods to produce predictable results. As discussed previously, it is ubiquitous to provide a retainer such as Harless shows for a tapered interference joint. A retainer will not retain anything unless it has radial overlap as shown in the Harless reference.

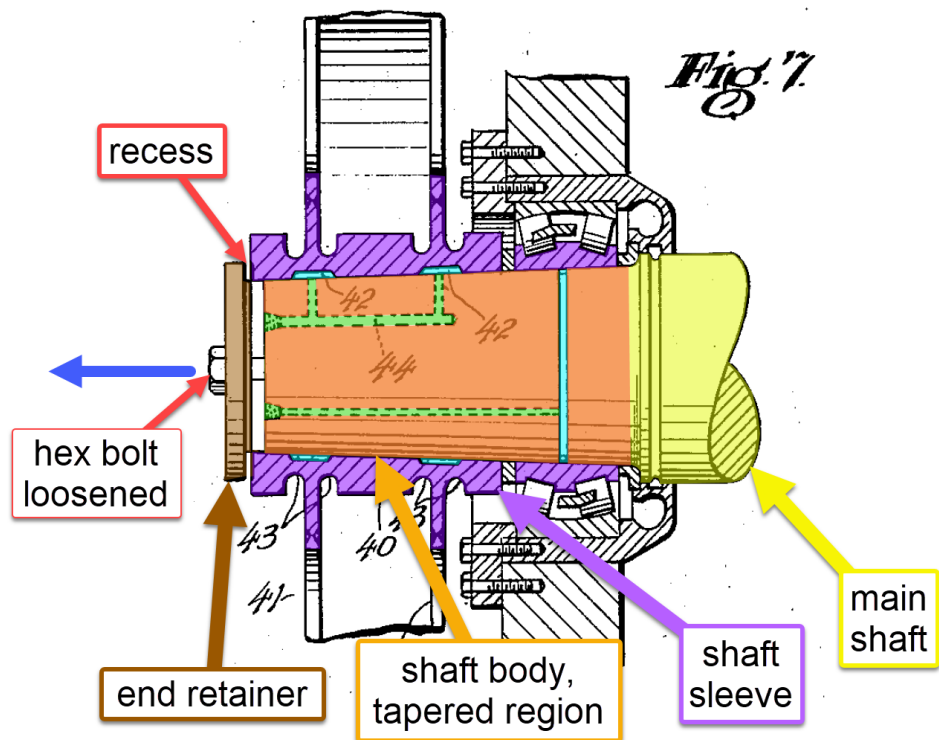
11P. The assembly as claimed in claim 10,

YES: As shown above, Polinski in view of Piepho and Harless discloses the assembly as claimed in claim 10.

⁹³ Exhibit 1033, 1:66-69

11a. wherein the end retainer includes a recess extending circumferentially at the perimeter region to allow axial movement of the sleeve into the recess.	YES: Harless discloses that the end retainer includes a recess extending circumferentially at the perimeter region to allow axial movement of the sleeve into the recess.
Harless discloses a removal process as follows: <i>“To remove a gear, itis only necessary-to backoff the bolts 9 slightly and introduce oil under pressure through the bore 16 so as to expand the gear hub, whereupon the gear will slide back against the washer 8 with no difficulty and may then be removed.”⁹⁴</i> As described above, in order to remove a component such as a sleeve or a bearing, a user must first partially back off the retaining bolt in the end retainer. As shown in the figures of the patent, particularly Figure 7, the end retainer has an undercut shoulder. A POSITA would understand that this undercut shoulder allows the end retainer to seat itself in a centered condition. Shown below, I have adjusted Figure 7 to show what will happen when a user follows the instructions described in the citation above:	

⁹⁴ Exhibit 1033, 3:18-22



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As shown above, when the hex bolt is partially loosened (as described in the specification), it allows the end retainer to shift away from the sleeve. When this shift happens, a recess is left between the end retainer sleeve. A POSITA would understand that this recess extends circumferentially at the perimeter region of the end retainer. As a user continues to follow the instructions outlined in the specification of Harless, pressurized oil will be pumped into the bore (16 in Figure 1 which is 44 in Figure 7 above). The pressurized oil will act to release the interference fit between the sleeve and the tapered portion of the shaft and shift it into the recess under the end retainer. A POSITA would be motivated to follow these instructions, not only because they are given in conjunction with the apparatus of Harless, but because it is well-known that partially backing off the end retainer allows the tapered interference fit to be broken but keeps the components from falling off the shaft itself and potentially being damaged from striking the ground.⁹⁶

This combination of Polinski in view of Piepho and Harless is the result of combining known elements using known methods to produce predictable results.

⁹⁵ I note that I added the bolt shank in under the end retainer, just as a POSITA would understand it to be there, and as it is clearly illustrated in companion figures such as Figures 3, 4, 5, and 8.

⁹⁶ Exhibit 1035, at 4:57-62

12P. The assembly as claimed in claim 9,	YES: As shown above, Polinski in view of Piepho and Harless discloses the assembly as claimed in claim 9.
12a. further comprising a fluid inlet conduit extending axially from the second end of the shaft body in fluid communication with the at least one groove to allow a fluid to be supplied to the at least one groove from the second end of the shaft body.	YES: See element 2a.
13P. The assembly as claimed in claim 9,	YES: As shown above, Polinski in view of Piepho and Harless discloses the assembly as claimed in claim 9.
13a. further comprising a fluid inlet conduit extending radially through the wall thickness of the sleeve in fluid communication with the at least one groove to allow a fluid to be supplied to the at least one groove through the sleeve.	YES: In view of the combination of Polinski in view of Piepho and Harless, A POSITA would further recognize an optional ordinary design choice of including a fluid inlet conduit extending radially through the wall thickness of the sleeve in fluid communication with the at least one groove to allow a fluid to be supplied to the at least one groove through the sleeve.
As discussed previously, the prior art is replete with teachings regarding the manner in which tapered interference joints can be implemented for machinery. A designer such as a POSITA has many teachings in the prior art regarding the different design choices available to them. The manner in which fluid is delivered to the grooves is commonly implemented through either the shaft or through the sleeve mounted on the shaft. For example, a technical paper dating back to 1993, titled “Hydraulic Removal of Coupling Hubs – Keyed and Keyless” shows both the option of feeding fluid through the sleeve as shown below:	

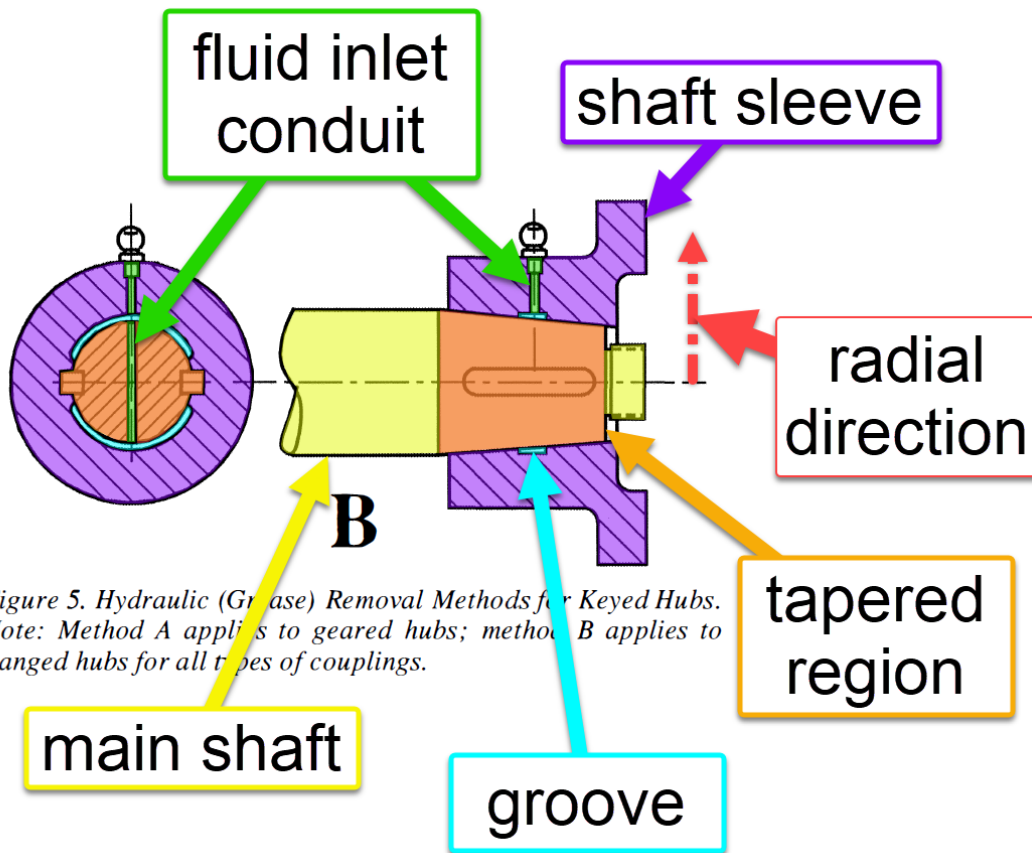


Figure 5. Hydraulic (Grease) Removal Methods for Keyed Hubs. Note: Method A applies to geared hubs; method B applies to flanged hubs for all types of couplings.

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As shown above, a main shaft is provided with a tapered region. A sleeve element is fit onto the tapered portion of the main shaft. A fluid inlet conduit is provided which is oriented to pass through the wall of the sleeve in the radial direction. From there, fluid is delivered to the at least one circumferential groove which substantially encompasses the entirety of the shaft. This technical paper goes on to describe this arrangement as follows:

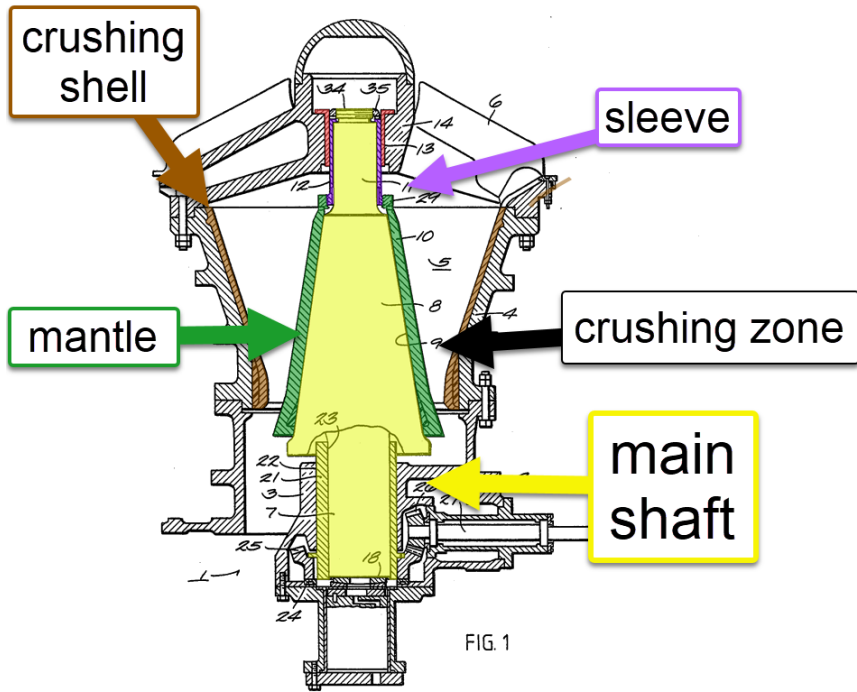
“Two hubs are shown in Figure 5 modified for removal using a grease gun. Automotive-type guns can deliver a pressure of about 10,000 psi. Considering that 0.001 interference creates a contact pressure of 8,300 psi (for $D/d = 1.5$), grease guns can easily overcome the contact pressure generated by interference. ... The groove that distributes grease around the bore must be machined so that it does not break into the keyway”⁹⁸

As shown above, a POSITA would recognize that it is a design choice as to whether the fluid is routed through the shaft or through the sleeve. Further, a POSITA would have an expectation of success as making this design choice

⁹⁷ Exhibit 1039, pg. 6, annotated

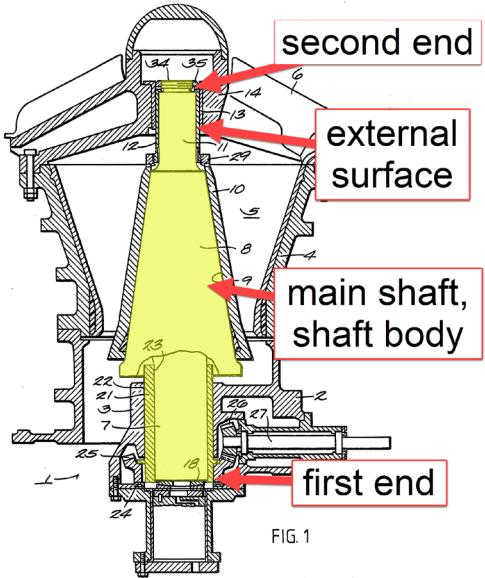
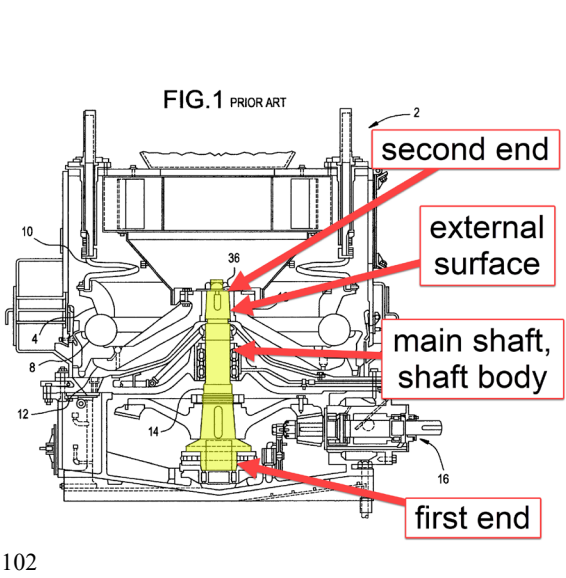
⁹⁸ Exhibit 1039, pg. 6

would amount to nothing more than combining known elements using known methods to produce predictable results.

Challenged Claim	Obvious by Prior Art?
14P. A gyratory crusher comprising;	YES: While the preamble is generally not considered limiting, Polinski discloses a gyratory crusher.
As shown above, and consistent with the specification, Polinski discloses a gyratory crusher. For example, the crusher includes a main shaft which carries a mantle and is gyrated on an off-vertical axis creating a crushing zone between the mantle and the crushing shell. <i>“The present invention relates to gyratory crushers and, in particular, to the main shaft supporting the crusher head or mantle within the crusher.”⁹⁹</i> 	
14a1. a main shaft including a shaft body having a radially outward facing external surface, a first end for positioning at a lower region of the crusher and a second end for	YES: Polinski and Piepho disclose a main shaft including a shaft body having a radially outward facing external surface, a first end for positioning at a lower region of the crusher and a second end for

⁹⁹ Exhibit 1017, 1:6-8, emphasis added

¹⁰⁰ Exhibit 1017, Figure 1, annotated

positioning at an upper region of the crusher relative to the first end,	positioning at an upper region of the crusher relative to the first end.
	
Polinski shaft body <i>“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 <u>a centrally located gyratable main shaft 7.</u>”¹⁰³</i>	Piepho shaft body <i>“The bottom ring 6 is driven by the yoke 12 which is attached to a vertical main shaft assembly 14 of the pulverizer.”¹⁰⁴</i>
As shown above, both Polinski and Piepho have a main shaft which is a shaft body. It has a radially outward facing external surface. Further, it has a first end and a second end. The first end is at a lowermost position and the second end is at a topmost position.	
14a2. an axial region of the shaft body extending from the second end and being tapered relative to a longitudinal axis of the shaft body such that a cross sectional area of the shaft body at the	YES: See element 1b.

¹⁰¹ Exhibit 1017, Figure 1, annotated

¹⁰² Exhibit 1018, Figure 1 annotated

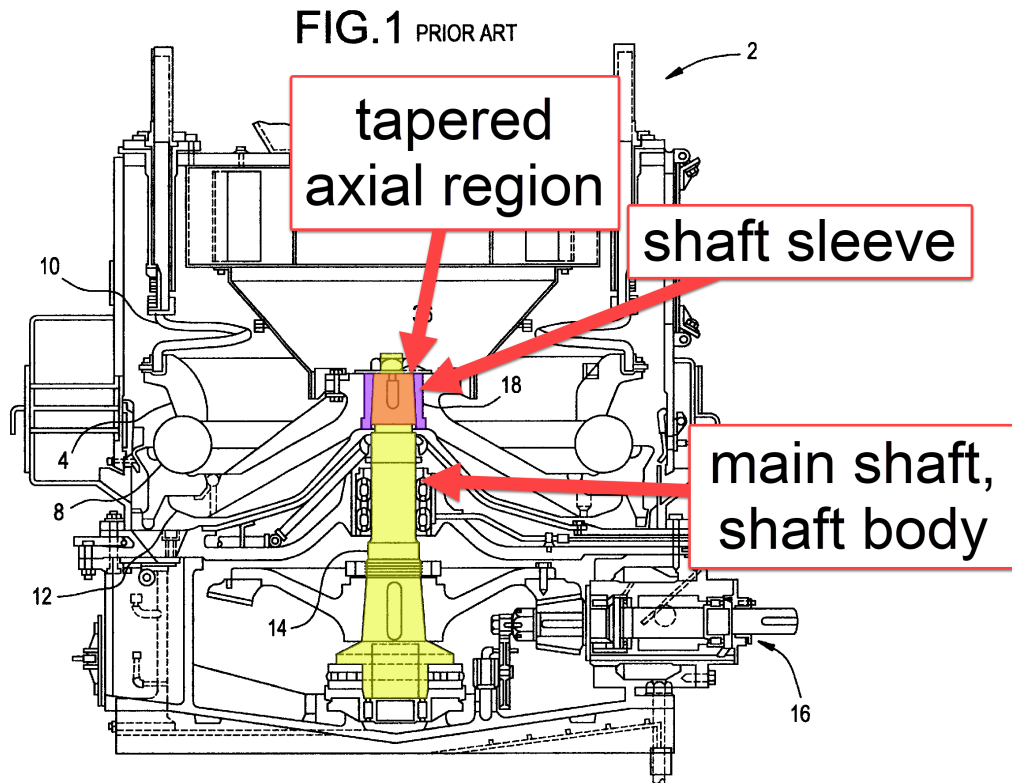
¹⁰³ Exhibit 1017, 2:32-37, emphasis added

¹⁰⁴ Exhibit 1018, 1:26-27

tapered axial region decreases in a direction from the first end to the second end,

14a4. the tapered axial region being configured to mount a shaft sleeve;

YES: Polinski in view of Piepho discloses that the tapered axial region is configured to mount a shaft sleeve.



As shown above, Piepho teaches a sleeve mounted on the tapered axial region at the second end of the main shaft. This sleeve is the bushing 18 (highlighted in purple above).

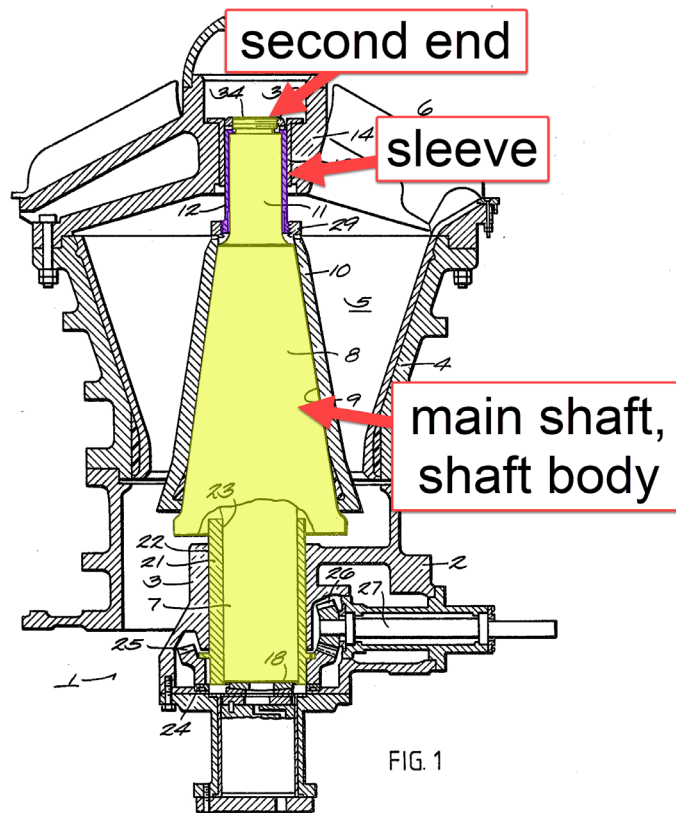
*“The present invention provides an intervening material between the shaft end (25) and the mating bore in yoke bushing (18) fitted within the bore of yoke (12) to prevent fretting damage. For accurate alignment and for reliable Support of the yoke, this joint (21) must be capable of accepting radial, axial, and bending or overturning loads. **Preferably, the joint (21) is a tapered joint with the tapered end (25) of shaft (14).**”*¹⁰⁶

¹⁰⁵ Exhibit 1018, Figure 1, annotated

¹⁰⁶ Exhibit 1018, 3:23-31, emphasis added.

A POSITA would understand that as Piepho demonstrates mounting a sleeve on the tapered region of the main shaft, this would necessarily mean that the tapered region of the main shaft is configured to mount a sleeve as demonstrated.

Further, the main shaft of Polinski also has a sleeve. The sleeve of Polinski is fitted over a cylindrical portion of the main shaft body of Polinski, however, a POSITA would be motivated to use the tapered sleeve of Piepho as it aids in alignment and fit-up.



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As shown above, Polinski already has a shaft with a sleeve fitted onto the second end. Thus, it would be very straightforward for a POSITA to incorporate the tapered second end and sleeve of Piepho and thereby gain the benefits taught in the prior art and broadly understood by any POSITA.

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

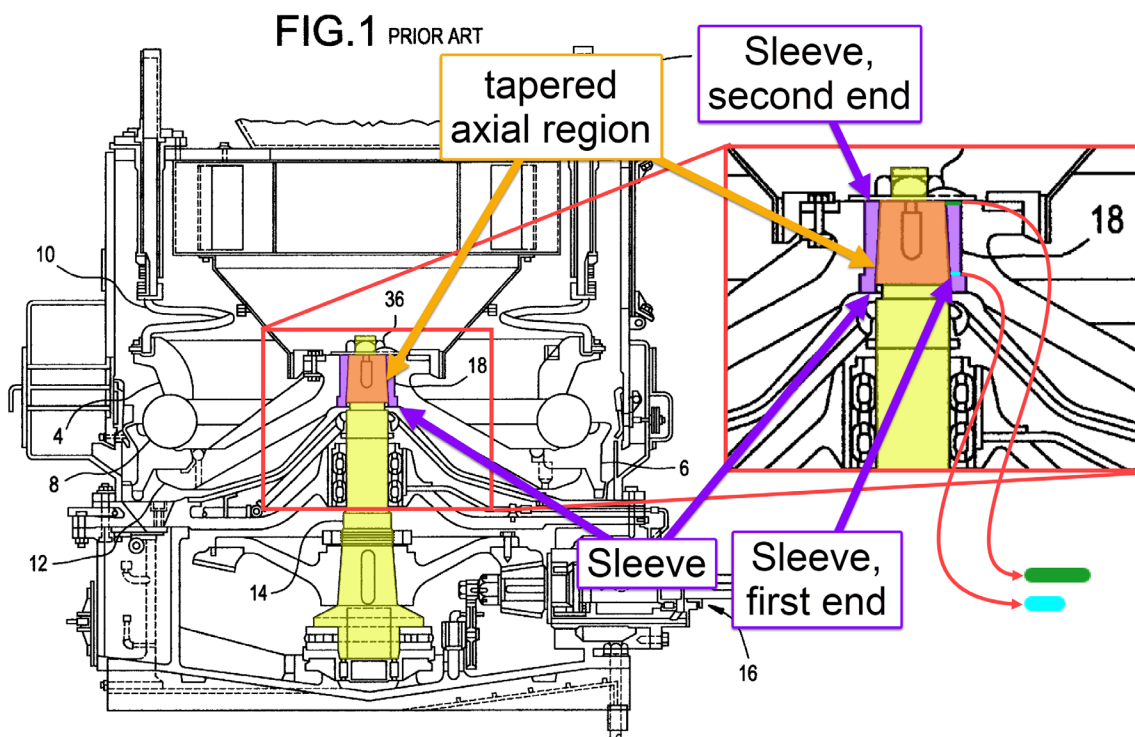
¹⁰⁷ Exhibit 1017, Figure 1, annotated

describes, as the tapered shaft aids in accurate alignment which is notoriously more difficult with purely cylindrical shafting.

14b. a sleeve fitted over the tapered axial region, the sleeve having a tapered wall thickness such that a wall thickness at a second upper end of the sleeve is greater than a wall thickness at a first lower end of the sleeve; and

YES: Polinski in view of Piepho discloses a sleeve fitted over the tapered axial region, the sleeve having a tapered wall thickness such that a wall thickness at a second upper end of the sleeve is greater than a wall thickness at a first lower end of the sleeve.

Both Polinski and Piepho disclose a sleeve fitted over the region at the second end of the main shaft. In Piepho, this portion is tapered inwards and thus the sleeve that is fitted to it is also tapered. Further, the external surface of the sleeve is cylindrical which makes it so the wall thickness of the sleeve is greater at the second end of the sleeve than it is at the first end of the sleeve.



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As shown above, Piepho discloses a sleeve fitted over the tapered region. The sleeve is cylindrical on its outermost surface but mates with the tapered shaft internally. In order to accomplish this, the sleeve wall itself is tapered.

*“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).**”*¹⁰⁹

As shown above, the sleeve is fitted over the tapered axial region using an interference fit. Further, it has a tapered internal surface matching that of the tapered axial region of the main shaft and a cylindrical external surface. Thus, it has a wall thickness that tapers from a thicker portion at the second end, to a thinner portion at the first end.

This combination of Polinski in view of Piepho is the result of combining known elements using known methods to produce predictable results.

14c1. at least one groove indented at the external surface and positioned at the tapered axial region,	YES: See element 1d1.
14c2. the at least one groove being arranged to receive a pressurised[sic] fluid to facilitate mounting and dismounting of the sleeve at the shaft body.	YES: See element 1d2.

95. As shown above, the combination of Polinski in view of Piepho and in further view of Harless renders obvious the Asserted Claims of the '090 patent. A POSITA will be familiar with the common design elements normally used in conjunction with tapered interference joints. Further a POSITA will be familiar with many of the available design choices that can be made with tapered interference joints. The '090 patent merely describes the use of ordinary and highly predictable design elements used for tapered interference fits as would be

¹⁰⁹ Exhibit 1018, 3:23-31, emphasis added.

expectable when used on the main shaft of a gyrating rock crusher.

IX. CONCLUSION

96. For these reasons, it is my opinion that challenged claims of the '090 patent would have been obvious to a person of ordinary skill in the art.

97. 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 August 29, 2024 in Meridian, ID.

David G. Smith, PE, CSP