

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

FOX FACTORY, INC.,
Petitioner

v.

SRAM, LLC,
Patent Owner

Case IPR2024-00492
Patent No. 7,147,207

**DECLARATION OF ALEXANDER SLOCUM, PH.D. IN SUPPORT OF
INTER PARTES REVIEW OF U.S. PATENT 7,147,207**

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I, Alexander H. Slocum, declare as follows:

I. INTRODUCTION

1. I have been retained as a technical expert in the field of engineering and mechanical devices by Finnegan, Henderson, Farabow, Garrett & Dunner, LLP (“Finnegan”) on behalf of FOX Factory, Inc. (“FOX”). This Declaration is in support of *inter partes* review of claims 1-3, 7, 8, and 10-12 (“the Challenged Claims”) of U.S. Patent No. 7,147,207 (“the ’207 patent”).

2. I am being compensated for my work on this matter at my standard rate of \$800.00 per hour. My compensation in no way depends on the outcome of this proceeding, the content of my testimony, or any issues involved in or related to this proceeding. In preparing this Declaration, I reviewed and considered the ’207 patent, the prosecution history of the ’207 patent, and the prior art references that I discuss in this Declaration. In addition to these materials, I may consider additional documents and information in forming any supplemental opinions. To the extent I am provided additional documents or information, including any expert declarations filed by Patent Owner in this proceeding, I may offer further opinions.

3. Based on my experience, knowledge of the art at the relevant time, analysis of the prior art references, and the understanding a person of ordinary skill in the art would have of the claim terms in light of the specification, it is my opinion that the

Challenged Claims of the '207 patent are unpatentable based on the prior art references discussed below.

II. QUALIFICATION AND EXPERIENCE

4. I am the Walter M. May and A. Hazel Professor of Mechanical Engineering at the Massachusetts Institute of Technology (“MIT”). I received an undergraduate degree in Mechanical Engineering from MIT in 1982. I received a Master’s degree in Mechanical Engineering from MIT in 1983. I received a Ph.D. in Mechanical Engineering from MIT in 1985. I have over 30 years of experience in teaching and directing research related to mechanical engineering and precision machine design. A copy of my curriculum vitae is attached hereto as Exhibit A.

5. From 1982 to 1986, I worked as a mechanical engineer for the National Institute for Standards and Technology (NIST, which was then called the “National Bureau of Standards” or NBS) under the United States Department of Commerce. From 1985 to 1989, I was an Assistant Professor of Civil Engineering at MIT. From 1989 to 1990, I was a visiting professor of mechanical engineering at the Cranfield Institute of Technology. Since 1991, I have been and continue to be a professor of mechanical engineering at MIT.

6. I have published extensively and have numerous patents that have resulted in many successful products. I hold 170+ patents issued in the US and abroad,

including many that relate to fluid systems and mechanical design, including damping systems.

7. I have taught many thousands of students and supervised hundreds of student theses. Complete lists are provided in Exhibit A.

8. I am a member of the National Academy of Engineering (“NAE”) and am active in several engineering societies and have received many design and teaching awards and professional honors. I consult extensively with industry on the development of new products and I have also helped start several successful companies.

9. My principal research interest is precision engineering and precision machine design. I currently serve as the director of the Precision Engineering Research Group at MIT (pergatory.mit.edu). Precision engineering addresses the design and manufacture of all manner of things from consumer products, machines, devices, fixtures and other structures that have and require critical tolerances, and that are very repeatable and stable over time. For over 30 years, I have been focused on the design and development of precision machines, medical devices and other products, often specifically on the structural design and coupling and interconnection of components in those products. In particular, I am an acknowledged world expert on precision machine structures, bearings, and couplings between mechanical elements

and maintain a free video lecture resource for industry and academia (*See, e.g.*, <https://www.youtube.com/@FUNdaMENTALs42>).

10. In addition, I have significant experience with recreational biking (off and on-road), having owned many bikes over the years. I love bicycle riding and have completed 22 Ironman 140.6 races and am very familiar with bicycle design and maintenance. I also ride my bikes on trails that span many miles around my farm in New Hampshire. My most extensive ride was the White Rim 100-mile ride which I did with my friend in one day (13 hours), unsupported—we took all our own stuff. A video shows my taped-on flashlight, milkcrate for hauling water, and yes, embarrassingly walking up one very nasty hill: <https://www.youtube.com/watch?v=eCHDJcdD2wE>.

11. Based on my education and experience, I am qualified to opine on the subject matters at hand and in this Declaration.

III. LEGAL STANDARDS

A. Claim Construction

12. I have been informed by counsel and I understand that the first step in determining the patentability of a patent claim is for the claim terms to be properly construed. I understand that claim terms are construed in light of the claim language, the patent specification, and the prosecution history of the patent. I also understand that extrinsic sources, for example, dictionaries, treatises, textbooks, etc., may shed

light into the meaning of claim terms. I further understand that a claim term is given its plain and ordinary meaning as understood by those skilled in the art if that claim term does not need construction.

B. Anticipation

13. I am not an attorney and have not been asked to offer my opinion on the law. However, as an expert offering an opinion on whether the Challenged Claims of the '207 patent are unpatentable, I have been told that I am obliged to follow existing law.

14. I have been told the following legal principles apply to an analysis of patentability pursuant to 35 U.S.C. § 102, a provision in the patent law regarding anticipation. I have been told that, in an *inter partes* review proceeding, patent claims may be deemed unpatentable if it is shown by preponderance of the evidence that the claims were anticipated by prior art patents or printed publications.

15. I have been told that for a claim to be anticipated under § 102, every limitation of the claimed invention must be disclosed by a single prior art reference, viewed from the perspective of a person of ordinary skill in the art.

C. Obviousness

16. I have been told that under 35 U.S.C. § 103(a), “[a] patent may not be obtained although the invention is not identically disclosed or described as set forth in section 102, if the differences between the subject matter sought to be patented and the prior

art are such that the subject matter would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains.” 35 U.S.C. § 103(a).

17. When considering the issues of obviousness, I have been told that I am to do the following:

- a. Determine the scope and content of the prior art;
- b. Ascertain the differences between the prior art and the claims at issue;
- c. Resolve the level of ordinary skill in the pertinent art; and
- d. Consider evidence of secondary indicia of non-obviousness (if available).¹

18. I have been told that the relevant time for considering whether a claim would have been obvious to a person of ordinary skill in the art is the time of alleged invention, which I have assumed is shortly before the effective filing date of the application leading to the '207 patent (November 4, 2004).

19. I have been told that any assertion of secondary indicia of non-obviousness must be accompanied by a nexus between the merits of the invention and the evidence offered.

¹ I am not aware of any secondary indicia, such as commercial success, praise, etc., that would support non-obviousness of the Challenged Claims.

20. I have been told that a reference may be combined with other references to disclose each element of the invention under § 103. I have been told that a reference may also be combined with the knowledge of a person of ordinary skill in the art and that this knowledge may be used to combine multiple references. I have also been told that a person of ordinary skill in the art is presumed to know the relevant prior art. I have been told that the obviousness analysis may account for the inferences and creative steps that a person of ordinary skill in the art would employ.

21. I have been told that whether a prior art reference renders a patent claim unpatentable as obvious is determined from the perspective of a person of ordinary skill in the art. I have been told that there is no requirement that the prior art contain an express teaching or suggestion to combine known elements to achieve the claimed invention, but that a motivation or rationale for combining prior art elements in a way that realizes the claimed invention is required to show obviousness, and that it seeks to counter impermissible hindsight analysis.

22. I have been told that when a work is available in one field, design alternatives and other market forces can prompt variations of it, either in the same field or in another. I have been told that if a person of ordinary skill in the art can implement a predictable variation and would see the benefit of doing so, that variation is likely to be obvious. I have been told that, when there is a design need or market pressure and there are a finite number of predictable solutions, a person of ordinary skill in the art

has good reason to pursue those known options that realizes the claimed invention. In addition, I have been informed and I understand that there must be a reasonable expectation of success—not absolute predictability of success—in combining prior art teachings to arrive at the claimed invention.

IV. DEFINITION OF A PERSON OF ORDINARY SKILL IN THE ART

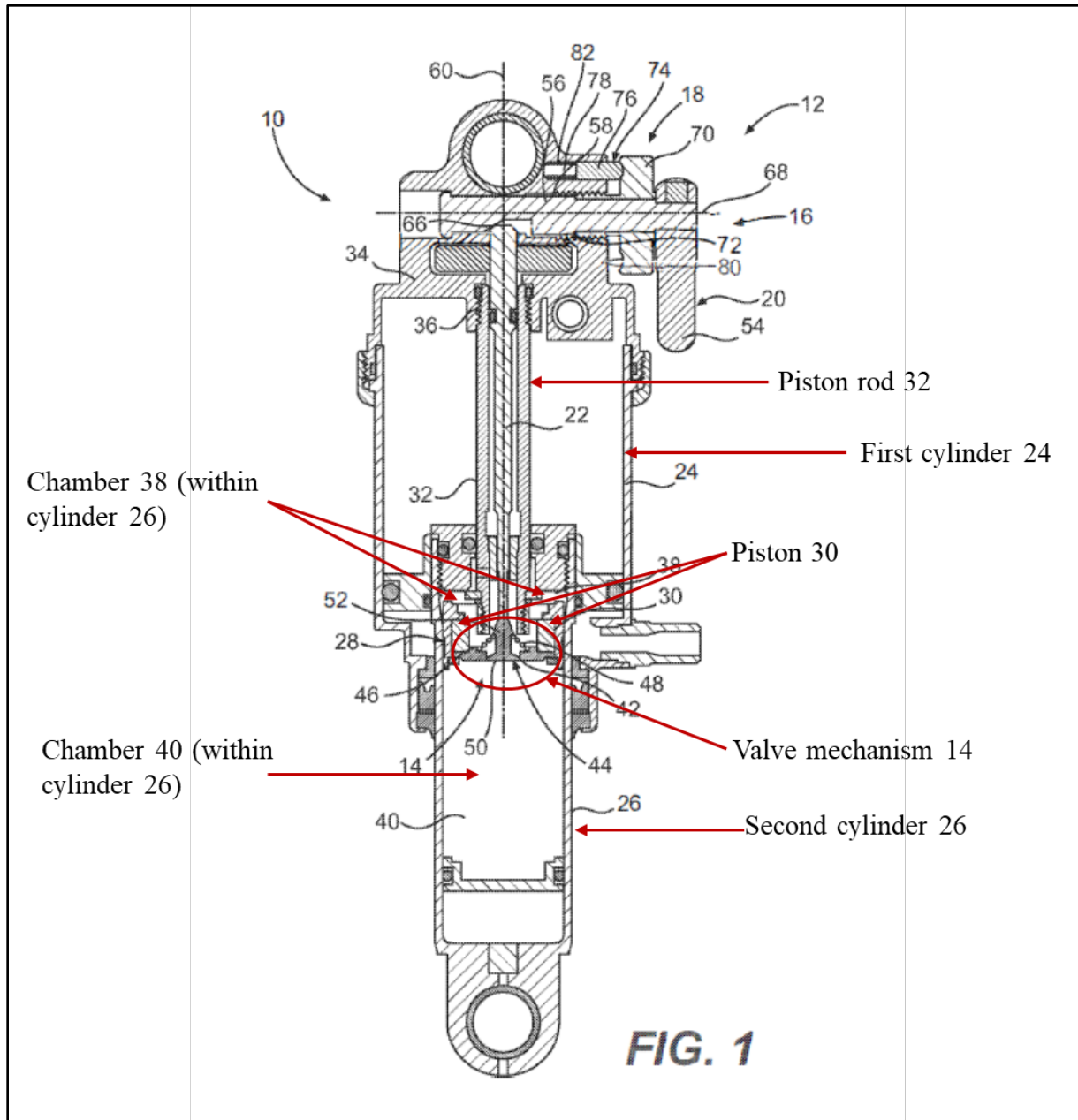
23. A person having ordinary skill in the field of bicycle suspensions and shock absorbers at the time of the claimed invention (i.e., in and around November 4, 2004) would have had (1) a Bachelor's degree in Mechanical Engineering or an equivalent degree, and 1-2 years of experience in design work related to bicycle suspension technology, or (2) at least a Master's degree in Mechanical Engineering or an equivalent degree with a focus on design of mechanical elements, and a good understanding of mechanical design principles.

24. I believe that I have the relevant experience and understanding of one of ordinary skill in this field.

V. OVERVIEW OF THE '207 PATENT

25. The '207 patent is directed to an actuator apparatus for controlling the damping characteristics of a suspension system. Ex. 1001, 1:7-13, Abstract. While the '207 patent asserts that the disclosed actuator apparatus may be used with any type of bicycle suspension system, the exemplary embodiments are discussed with reference to a rear shock absorber. Ex. 1001, 1:22-29, 8:33-39.

26. With reference to the exemplary embodiment from the '207 patent shown in Figure 1, a suspension system 10 includes, among other features, two telescoping cylinders 24, 26, which are displaceable relative to each other during compression and rebound strokes of the suspension system. Ex. 1001, 3:63-66. Second cylinder 26 includes a piston 30, which is connected to a hollow piston rod 32 that extends between piston 30 and a distal end 34 of first cylinder 24. Ex. 1001, 3:66-4:4. Piston 30 divides second cylinder 26 into first and second fluid chambers 38, 40. Ex. 1001, 4:4-6. Piston 30 further includes a fluid passageway 42, which allows fluid to pass between fluid chambers 38, 40 in response to reciprocation of piston 30 in second cylinder 26. Ex. 1001, 4:6-9. Second cylinder 26 further encloses a valve mechanism 14, which controls fluid flow between chambers 38, 40 through passageway 42. Ex. 1001, 4:10-22. By controlling fluid flow between the two chambers, the damping characteristics of suspension system 10 are adjusted to suit the terrain or the rider. Ex. 1001, 1:14-43.

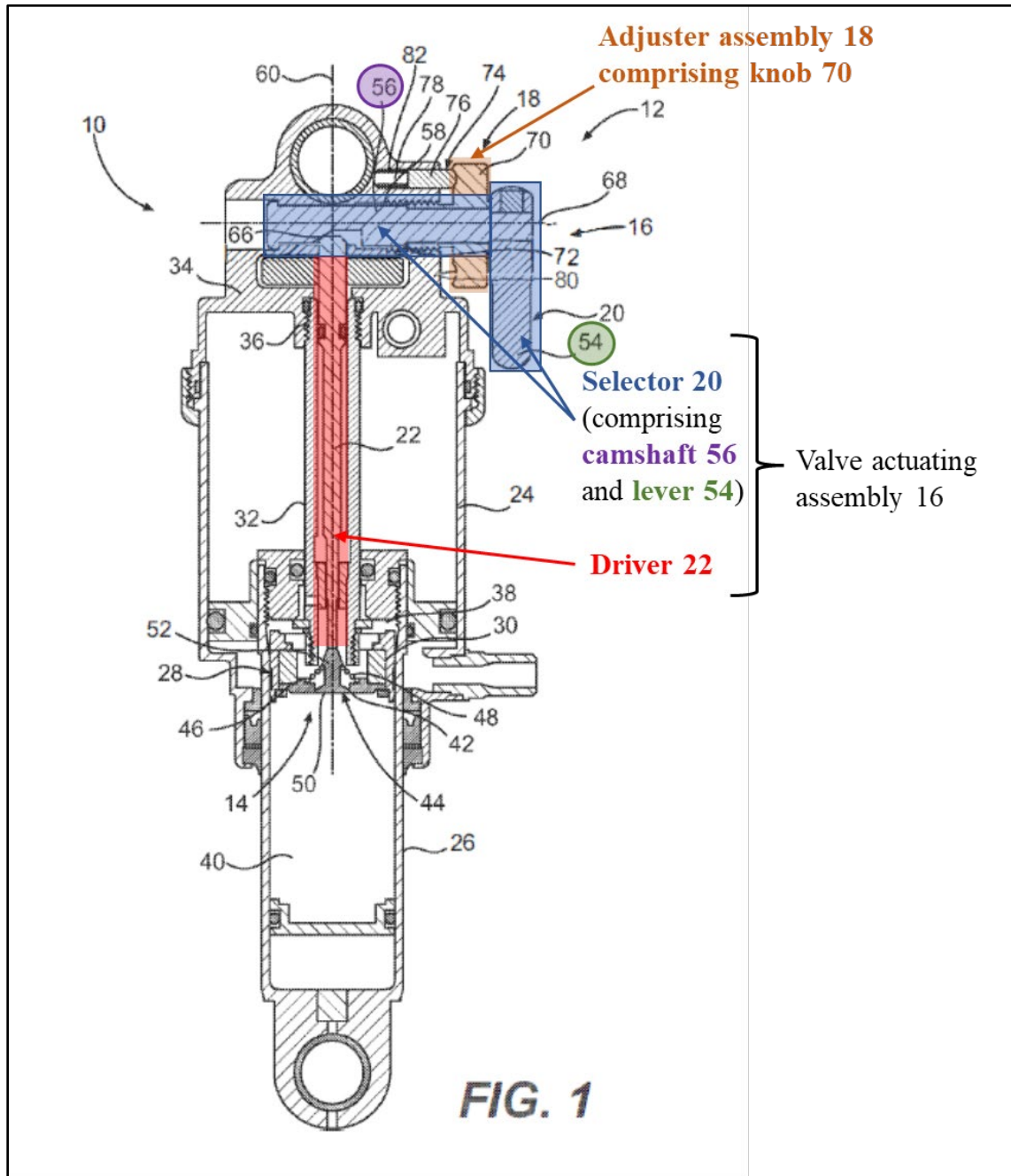


Ex. 1001, Fig. 1 (annotations added).

27. With reference to the embodiment shown in Figures 1-6, an actuator apparatus 12 for controlling fluid flow between chambers 38, 40 comprises:

(1) a valve actuating assembly 16 operable between at least two rider-selectable positions for adjusting valve mechanism 14 between at least two suspension settings,

and (2) an adjuster assembly 18 operably connected to valve actuating assembly 16 to customize the damping characteristics corresponding to at least one suspension setting and independently of the damping characteristics of at least another suspension setting. Ex. 1001, 3:42-53, 1:51-62, 4:4-12. Valve actuating assembly 16 further includes: (1) a selector 20 for selecting between the at least two rider-selectable positions, and (2) a driver 22 that passes through piston rod 32 and is movable axially to adjust valve mechanism 14 to correspond with a selected suspension setting. Ex. 1001, 3:53-62, 1:63-67. Selector 20 includes a rider-operated lever 54 and a camshaft 56 rigidly connected to the lever 54. Ex. 1001, 4:23-25, 1:67-2:2. Driver 22 is biased against camshaft 56 at one end and is operatively engaged with valve mechanism 14 at the other end. Ex. 1001, 4:19-37. In the exemplary embodiment shown in Figures 1-6, camshaft 56 has three cam surfaces 62, 64, 66 engageable with driver 22, which correspond respectively to three rider-selectable positions: open, lockout, and adjustable. Ex. 1001, 4:27-34, 2:2-8.



Ex. 1001, Fig. 1 (annotations added).

28. When lever 54 (of selector 20) is set to the open position, camshaft 56 is rotated until cam surface 62 engages with driver 22 and axially displaces the driver

in such a way that valve 44 (of valve mechanism 14) is opened and fluid is allowed to flow between chambers 38, 40 in response to displacement of piston 30 during a compression or rebound stroke. Ex. 1001, 4:51-59. When lever 54 is set to the lockout position, camshaft 56 is rotated until cam surface 64 engages driver 22 and axially displaces it such that valve 44 is substantially closed and fluid flow between chambers 38, 40 is prevented. Ex. 1001, 4:60-64. When lever 54 is set to the adjustable position, driver 22 engages the angled cam surface 66. Ex. 1001, 4:65-66. To adjust the damping characteristics of suspension system 10 in the adjustable position, a knob 70 of adjuster assembly 18 is rotated to axially move camshaft 56, which varies the point of engagement of driver 22 along the angled cam surface 66, and thereby adjusts the damping characteristics of suspension system 10. Rotation of knob 70 adjusts the level of engagement of camshaft 56 with threads 86 of first cylinder 24, which in turn adjusts the point of engagement of driver 22 with the angled cam surface 66. Ex. 1001, 4:66-5:13. When the damping characteristics are adjusted in the adjustable position, the open and lockout positions corresponding to cam surfaces 62, 64 are not affected. Ex. 1001, 5:14-18, 5:37-47.

29. In summary, in the first embodiment of the '207 patent (Figures 1-6), cam surfaces 62, 64 engage with driver 22 with just rotary motion of camshaft 56 to cause axial motion of the driver. By turning the threaded knob 70 of adjuster assembly 18, which is coaxially located about camshaft 56, camshaft 56 is displaced axially and

its inclined cam surface 66 displaces driver 22 in an axial direction orthogonal to the motion of the camshaft. Thus, in the embodiment shown in Figures 1-6, adjuster assembly 18 is separate from valve actuating assembly 16.

30. In the embodiment shown in Figures 7a-7c, adjuster assembly 18 and selector 20 of valve actuating mechanism 16 are integrated. Ex. 1001, 5:48-6:9. That is, there is no separate knob or other mechanism for adjusting the damping characteristics of the suspension system in the adjustable position. Ex. 1001, 2:13-15, 5:48-6:9. Instead, threads 84 are provided on camshaft 56, which engage with threads 86 on first cylinder 24 to axially displace the camshaft when lever 54 is rotated through one or more complete revolutions. Cam surfaces 62, 64 still engage and cause axial motion of driver 22 by their rotation with camshaft 56 and any axial motion of camshaft 56 does not alter their cam action. Ex. 1001, 5:48-6:9. With continued axial motion of camshaft 56 caused by rotating lever 54, the point at which driver 22 engages with angled cam surface 66 is changed, which in turn changes fluid flow thorough valve mechanism 14 and thereby changes the damping characteristics of suspension system 10. Ex. 1001, 5:48-6:9.

31. Figures 8-10, 11, and 12 present three other embodiments of the claimed invention, respectively. Ex. 1001, 3:30-38. These additional embodiments are functionally and operationally similar to the two embodiments depicted in Figures 1-6 and 7, respectively, but the structural features related to valve actuating

assembly 16 and adjuster assembly 18 are marginally different from those depicted in Figures 1–7. Ex. 1001, 2:16-3:4, 6:10-8:32. For example, lever 54 that rotates camshaft 56 in the embodiments shown in Figures 1-7 is replaced by a control cable 88 that is pulled or released by a remote actuator 90 located on the handlebar of the bicycle. Ex. 1001, 6:10-14.

VI. CLAIM CONSTRUCTION

32. No claim construction of any term or limitation in the Challenged Claims is needed for this IPR; rather the plain meaning of each claim term may be applied.

VII. OVERVIEW OF THE PRIOR ART

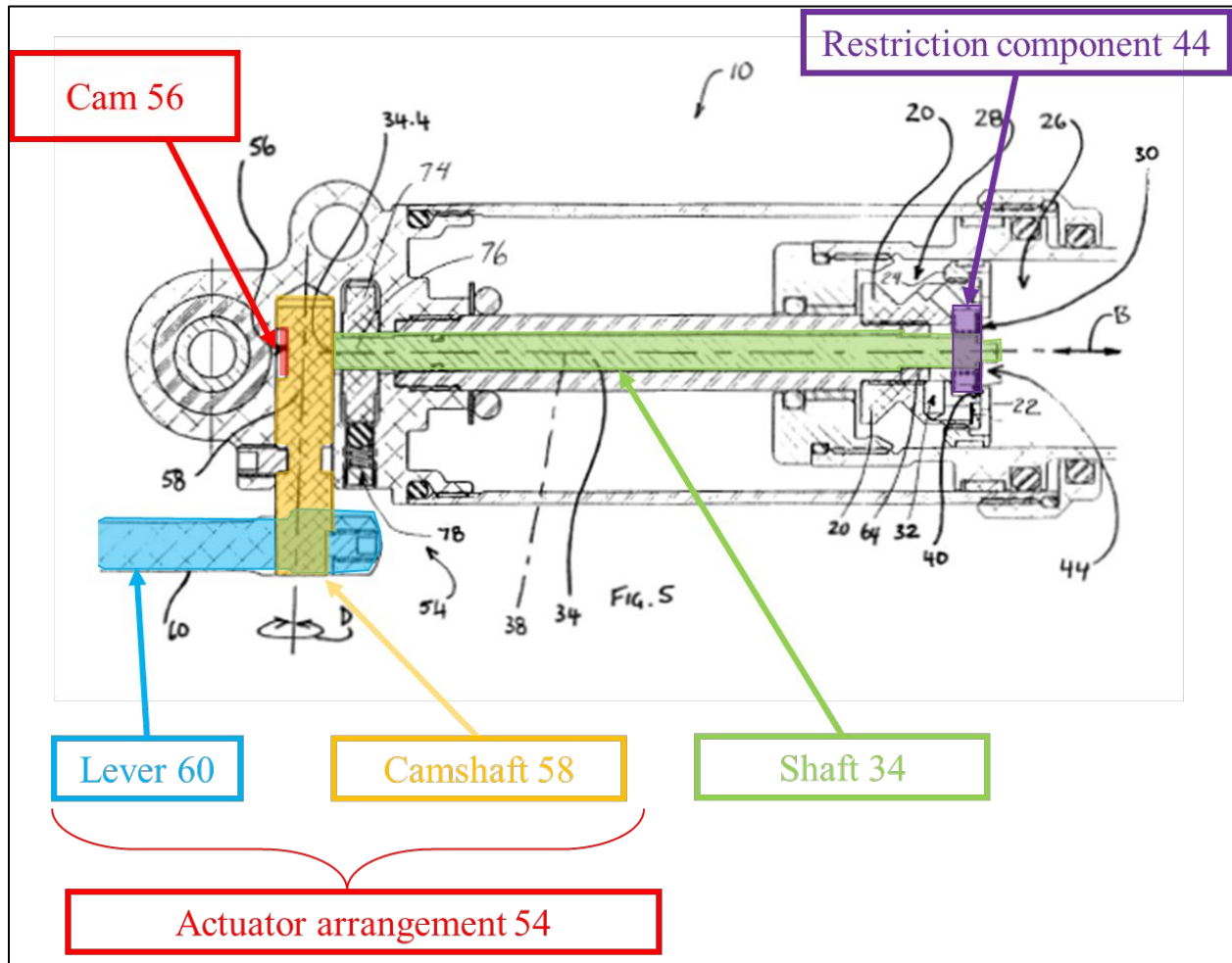
A. U.S. Patent No. 6,360,857 to Fox et al. (“Fox”)

33. Fox discloses a suspension system, specifically a shock absorber 10. Ex. 1005, Figs. 1-4, 6:36-64. With reference to the exemplary embodiment shown in Fox’s Figures 1-8, shock absorber 10 includes, among other features, two telescoping parts 12 and 14, which are displaceable relative to each other during compression and rebound strokes of the shock absorber. Ex. 1005, Figs. 1-4, 6:36-64. Part 12 forms a cylinder 16, which receives a piston 20 for reciprocation within the cylinder. Ex. 1005, Figs. 1-4, 6:36-64. Piston 20 divides cylinder 16 into first and second fluid chambers 26, 28. Ex. 1005, Figs. 1-4, 6:36-64. Two fluid passageways 30, 32 allow fluid to pass between chambers 26 and 28 in response to reciprocation of piston 20 in cylinder 16. Ex. 1005, Figs. 1-4, 6:36-64. Cylinder 16 further encloses

a valve mechanism, referred to as restriction component 44, which controls fluid flow between chambers 26 and 28 through passageway 30 to adjust the compression damping characteristics of shock absorber 10. Ex. 1005, 7:28-8:2, 9:59-10:14. Similarly, shock absorber 10 includes a blocking component 64, which controls resistance to fluid flow through passage 32 to adjust the rebound damping characteristics of shock absorber 10. Ex. 1005, 8:35-50, 10:15-42.

34. Fox's shock absorber 10 comprises an adjustment component, such as a damping adjuster rod or shaft 34, having two degrees of freedom of movement. Ex. 1005, 5:8-32, Abstract, 6:65-7:15. The two degrees of freedom of movement of shaft 34 are associated with adjustment of compression damping and rebound damping characteristics of the shock absorber. Ex. 1005, 5:8-32, Abstract, 6:65-7:15. Specifically, the two degrees of freedom of movement are rotation (or angular displacement) of shaft 34 about its longitudinal axis 38 and translation (or axial displacement) of shaft 34 along its longitudinal axis. Ex. 1005, 5:24-32, 7:16-27. For purposes of this IPR, only axial movement of shaft 34 for adjustment of the compression damping characteristics of shock absorber 10—i.e., only one of the two degrees of freedom of movement of the shaft—is discussed vis-à-vis the Challenged Claims. Ex. 1005, 5:47-53, 9:59-10:14 (discussing that axial displacement of shaft 34 adjusts compression damping characteristics).

35. As shown below in the annotated Figure 4 of Fox, shock absorber 10 further comprises an actuator arrangement 54, which is operatively connected to shaft 34 for axial displacement of shaft 34. Ex. 1005, 8:3-30. Actuator arrangement 54 comprises a camshaft 58 (actuation shaft comprising cam 56), which is arranged to cooperate with shaft 34 to cause shaft 34 to displace axially along its longitudinal axis in response to angular displacement of cam 56 of camshaft 58. Ex. 1005, 8:3-30. Actuator arrangement 54 further comprises a lever 60 connected to camshaft 58. Ex. 1005, 8:3-30. Camshaft 58 is angularly displaced (i.e., rotated) by operation of lever 60 by a user. Ex. 1005, 8:3-30. Rotation of lever 60 angularly displaces camshaft 58, which in turn axially displaces shaft 34 to vary the contact pressure on restriction component 44, and thereby adjusts the compression damping characteristics of shock absorber 10. Ex. 1005, 7:61-8:30. Fox's shock absorber 10 also includes an adjustment knob 74, which causes rotation of shaft 34, and which in turn causes "the blocking component 34 to ride along internal passage 72 thereby variably to block the port 62 so as to change the rebound damping of the shock absorber 10." Ex. 1005, 6:31-43.



Ex. 1005, Fig. 5 (annotations added).

36. In summary, Fox's cam action is due to rotary motion of a lever 60 causing rotary motion of a camshaft 58 whose cam surface 56 in contact with shaft 34 causes axial displacement of the shaft. Ex. 1005, 8:22-30.

B. U.S. Patent No. 6,491,146 to Yi et al. (“Yi”)

37. Yi discloses a shock absorber with adjustable damping characteristics, and in particular, a shock absorber for a bicycle. Ex. 1006, Title, Abstract, 2:66-3:6, Figs. 1-4 and 12.

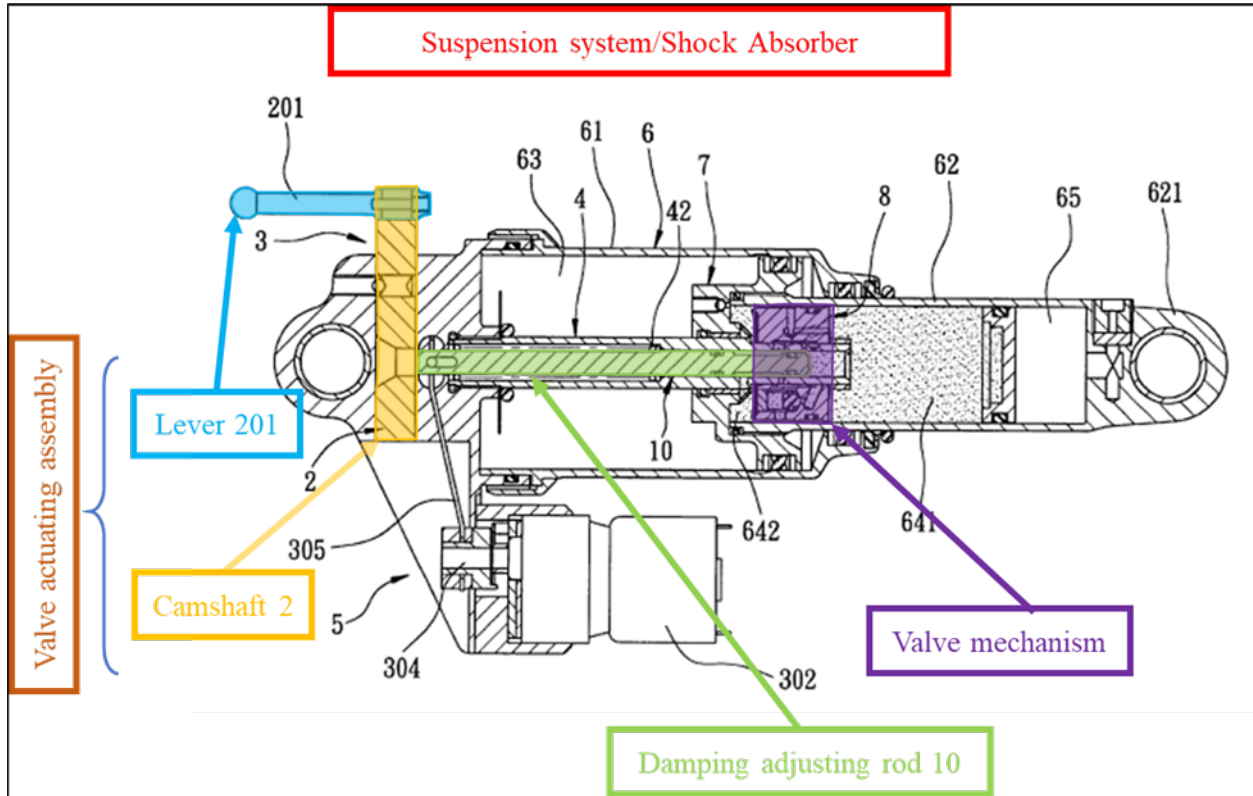
38. Yi’s shock absorber 6 includes, among other features, two cylinders 61 and 62, which are movable relative to each other during compression and extension strokes; a hollow shaft 4; a piston 8; a damping adjusting rod 10; damper fluid up-flow adjusting unit 5; and damper fluid down-flow adjusting unit 3. Ex. 1006, 3:1-6. Cylinders 61 and 62 are movable toward each other in an axial direction during a compression stroke and away from each other during an extension stroke. Ex. 1006, 3:7-10. First cylinder 61 has a first fixed end 611 secured to a rear part of the bicycle frame 100 and a first free end 612 opposite to the first fixed end 611; and second cylinder 62 has a second fixed end 621 secured to a front part of the bicycle frame 100 and a second free end 622 extending through the first free end 612 into cylinder 61. Ex. 1006, 3:11-18. Hollow shaft 4 is disposed in and extends through first cylinder 61 and extends into second cylinder 62 in the axial direction. Ex. 1006, 3:19-21.

39. Shock absorber 6 further includes a valve mechanism comprising four valves, which are configured to regulate the damper-fluid flow during the compression/extension strokes. Ex. 1006, 3:1-4:57. The first and second valves 851

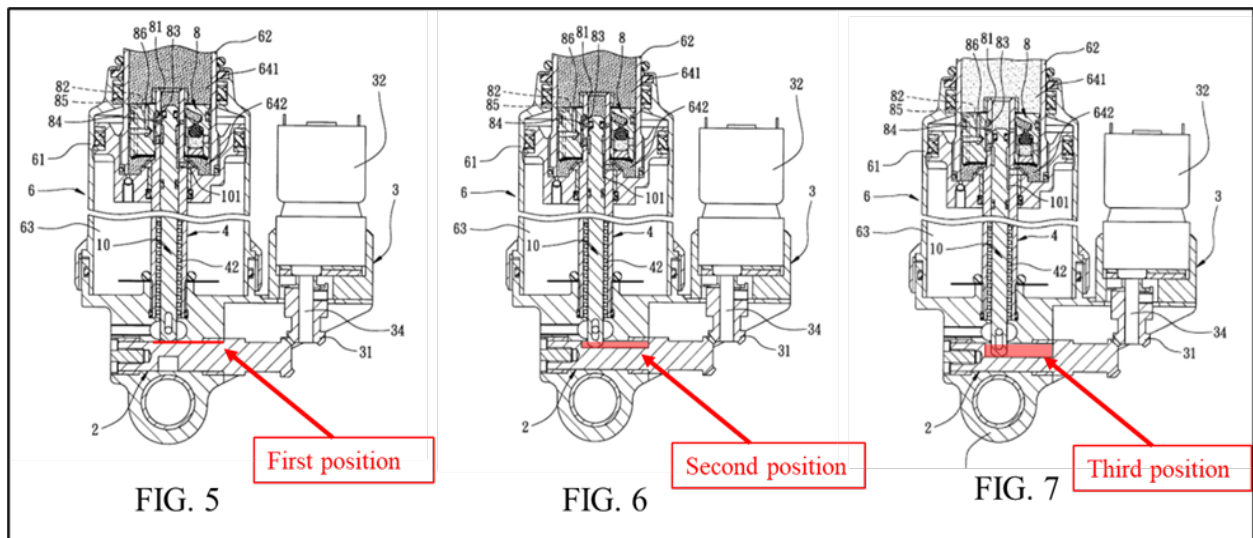
and 831 are associated with two down-flow channels 85 and 87, respectively, operating during the compression stroke. Ex. 1006, 3:48-65. And third and fourth valves 861 and 821 are associated with two up-flow channels 86 and 82, respectively, operating during the extension stroke. Ex. 1006, 3:66-4:10, 4:50-57. For purposes of this IPR, only adjustment of the compression damping characteristics of Yi's shock absorber is discussed vis-à-vis the Challenged Claims.

40. A piston 8 is disposed in second cylinder 62 and creates chambers 641 and 642 on opposite sides of the piston, which are filled with a damper fluid. Ex. 1006, 3:33-59. The down-flow channels 85 and 87 are formed in piston 8. Ex. 1006, 3:33-59. First valve 851 is mounted on one side of piston 8 in second chamber 642, and is associated with first down-flow channel 85 for permitting unrestricted low-velocity flow of the damper fluid from chamber 641 to chamber 642 via first down-flow channel 85 during a compression stroke, in which first and second cylinders 61, 62 move toward each other in the axial direction, thereby moving hollow shaft 4 and piston 8 into second cylinder 62 and compressing the damper fluid in chamber 642. Ex. 1006, 3:33-59. Second valve 831 is associated with the second down-flow channel 87 for permitting medium-velocity flow of the damper fluid from chamber 641 to chamber 642 via the second down-flow channel 87 and the first opening 83 during a compression stroke. Ex. 1006, 3:33-59.

41. A damping adjusting rod 10 is disposed fittingly in hollow shaft 4 and is movable in the axial direction to three axial positions to adjust compression damping characteristics. Specifically, axial movement of damping adjustment rod 10 (1) adjusts the medium-velocity damper-fluid flow through second down-flow channel 87 and the first opening 83 in first (closed) and second (open) axial position, and (2) allows high-velocity damper-fluid flow through openings 83 and 84 in the third axial position. Ex. 1006, 4:18-49, 5:38-46. Shock absorber 6 further includes a valve actuating assembly operatively connected to the valve mechanism. Valve actuating assembly comprises a down-flow adjusting unit 3 which includes a camshaft 2 (eccentric shaft 2 of Fig. 12, which is the same type of shaft as camshaft 56 of the '207 patent, *see, e.g.*, Figs. 5a-5c) operatively engaged with an end 16 of damping adjusting rod 10. Ex. 1006, 5:38-46. Camshaft 2 is rotatable (turnable) so as to move damping adjusting rod 10 in the axial direction to the three axial positions, as shown below. Ex. 1006, 5:38-46. As shown in annotated Fig. 12 of Yi below, shock absorber 6 further comprises a user-operatable lever (handle 201) arranged to operate camshaft 2. Ex. 1006, 5:51-57. Rotation of camshaft 2 axially moves damping adjusting rod 10 to allow user-adjustment of the compression damping characteristics of shock absorber 6 when riding the bicycle on rough roads. Ex. 1006, 5:51-57.



Ex. 1006, Fig. 12 (annotations added).



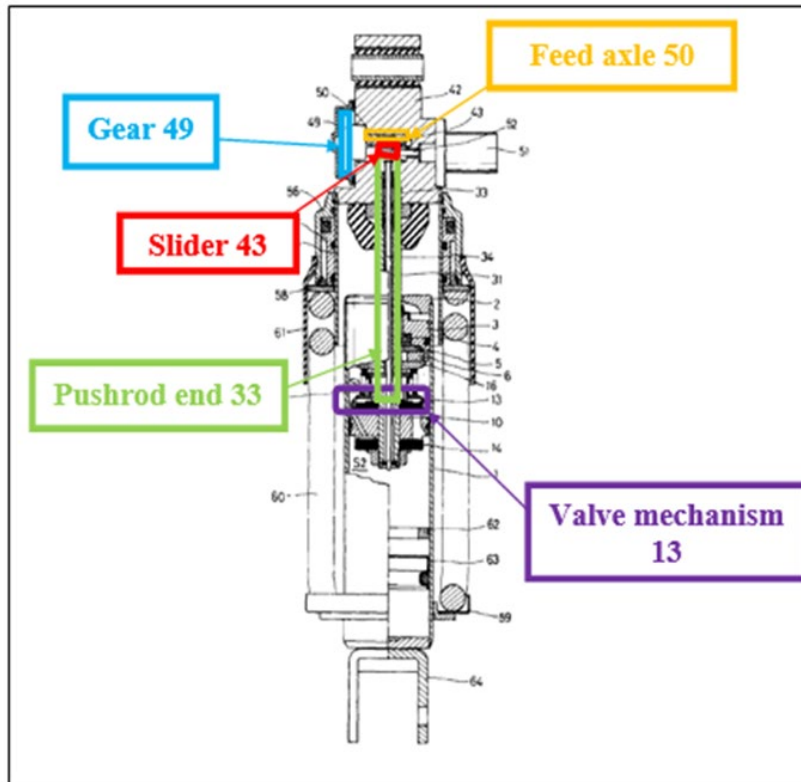
Ex. 1006, Figs. 5-7 (annotations added).

**C. Japanese Utility Model Registration No. JP2516279 to Ohta
("JP'279")**

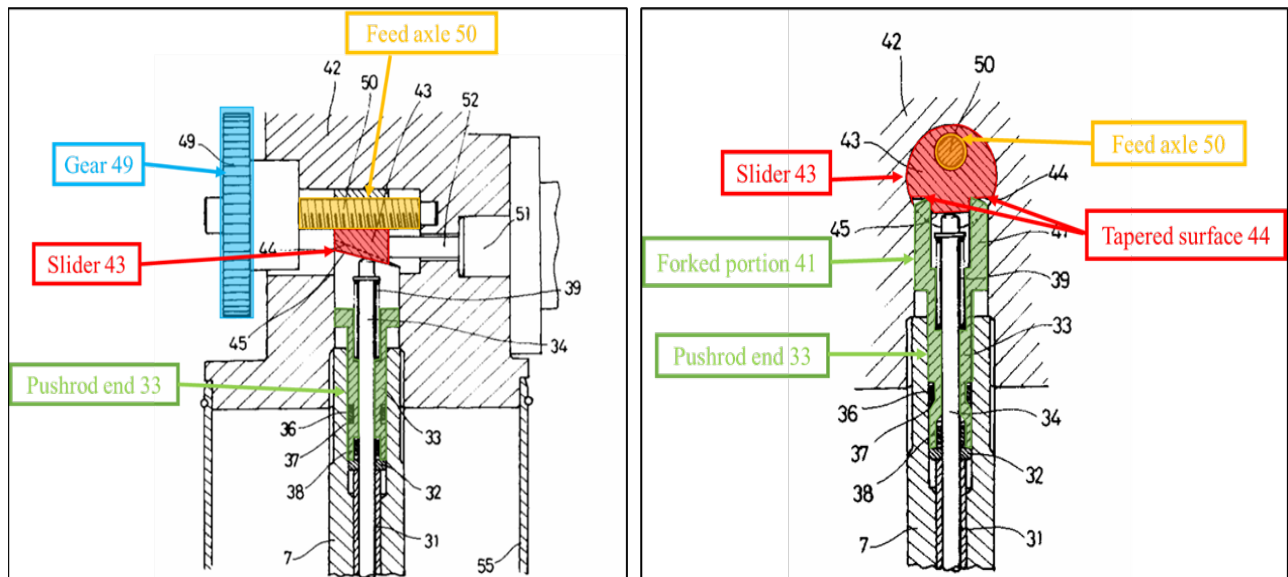
42. JP'279 also discloses a suspension system, specifically a hydraulic shock absorber. Ex. 1007, Title, 1, 2, Fig. 1. With reference to the exemplary embodiment shown in Figures 1-5 of JP'279, the hydraulic shock absorber includes a cylinder 1 and a hollow rod 7 displaceable relative to each other during compression and rebound/extension strokes of the hydraulic shock absorber. Ex. 1007, 3. A piston 10 divides the cylinder 1 into an upper oil chamber S1 and a lower oil chamber S2. Ex. 1007, Title, 3, Fig. 1. Two fluid passageways formed in piston 10 (compression-side oil passage 11 and extension-side oil passage 12) allow fluid to pass between oil chambers S1 and S2 in response to reciprocation of piston 10 in cylinder 1. Ex. 1007, 5. Specifically, when hollow rod 7 is lowered in chamber 1 during a compression stroke, hydraulic oil (fluid) in lower oil chamber S2 passes through the compression-side oil passage 11 into upper oil chamber S1 by pushing up a compression-side valve 13, thereby producing a compression damping force. Ex. 1007, 5. Similarly, when hollow rod 7 rises during a rebound/extension stroke, hydraulic oil in upper oil chamber S1 passes through the extension-side oil passage 12 into lower oil chamber S2 by pushing down an extension-side valve 14, thereby producing a rebound damping force. Ex. 1007, 5, Fig. 1.

43. Cylinder 1 encloses a slider 43 with two sloped surfaces (cams) 44 and 45, whose axial motion causes (orthogonal) axial motion of a pushrod 34, which varies the compression and extension damping characteristics of the hydraulic shock absorber by adjusting the opening pressure forces on compression-side valve 13 and extension-side valve 14, respectively. Ex. 1007, 5-6. For purposes of this IPR, only adjustment of the compression damping characteristics of JP'279's hydraulic shock absorber is discussed vis-à-vis the Challenged Claims.

44. In particular, as shown below in annotated Fig. 4 of JP'279, the hydraulic shock absorber comprises an adjuster assembly for fine-tuning the compression-side damping force, including a motor 47, a pushrod end 33, an adjusting lever 22, and slider 43. Ex. 1007, 5-6. When motor 47 is driven, it rotates a feed axle 50 via gears 48 and 49, moving slider 43 in a radial direction, and advancing or retracting push rod end 33. The forked portion 41 of pushrod end 33 slides along tapered (i.e., sloped) surface 44 of slider 43. Ex. 1007, 4, Figs. 1, 3-5. This advancement or retraction of pushrod end 33 causes adjusting lever 22 to move up or down, thereby altering the opening pressure force on the compression-side valve mechanism 13 and adjusting the compression damping force. Ex. 1007, 5-6. That is, by adjusting the position at which pushrod end 33 abuts tapered surface 44 of slider 43, the compression damping characteristics of the hydraulic shock absorber may be finely adjusted. Ex. 1007, 5-6.



Ex. 1007, Fig. 1 (annotations added).



Ex. 1007, Figs. 4-5 (annotations added).

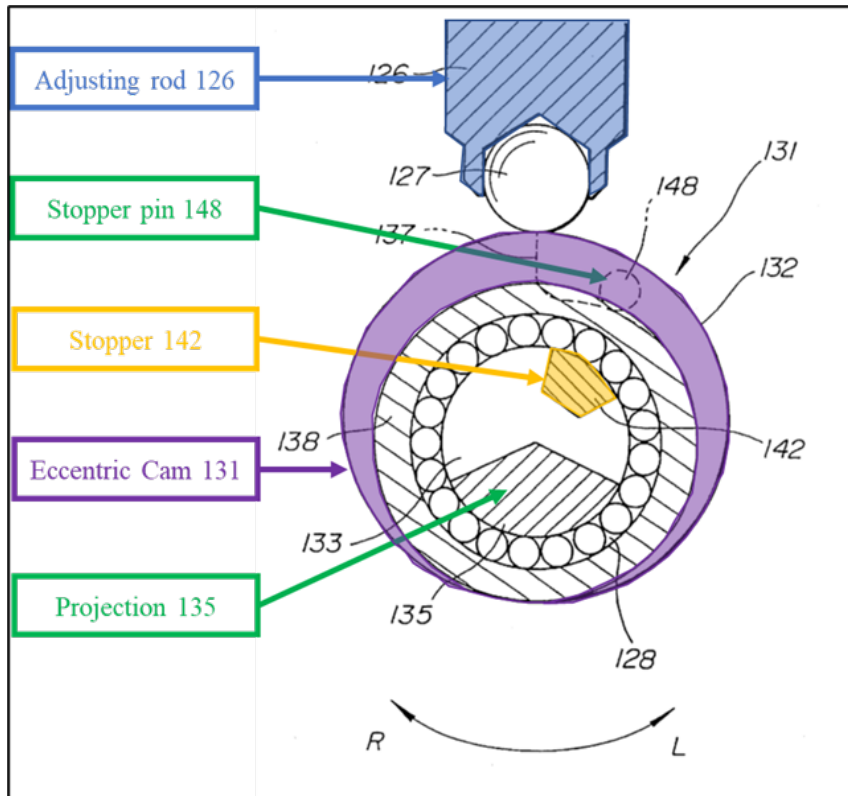
D. U.S. Patent No. 5,597,054 to Nagai et al. (“Nagai”)

45. Nagai discloses a suspension system, specifically a hydraulic damper having a hydraulic damper assembly 101. Ex. 1008, Fig. 5, 5:48-65. With reference to the exemplary embodiment shown in Nagai’s Figures 5-9, damper assembly 101 includes, among other features, a cylinder 102 and hollow rod 108, which are displaceable relative to each other during compression and rebound strokes of the shock absorber. Ex. 1008, Fig. 5, 5:48-65. Cylinder 102 receives a piston 110 in sliding contact with the inner surface of the cylinder. Ex. 1008, Fig. 5, 5:48-65. Piston 110 divides cylinder 102 into upper and lower oil chambers S3, S4. Ex. 1008, Fig. 5, 5:48-65. An oil passage 111 allows damping fluid (oil) to pass between chamber S4 to S3 in response to reciprocation of piston 110 in cylinder 102 during a compression stroke. Ex. 1008, Fig. 5, 5:48-65, 3:16-26. A valve mechanism 112 allows for opening and closing of oil passage 111. Ex. 1008, 5:48-65. Upper chamber S3 further communicates with an oil chamber S5 in an auxiliary tank 108 via a bypass oil passage 125. Ex. 1008, 5:66-67, 6:20-30. By varying the cross-sectional area of bypass oil passage 125 with a rod or needle valve 126, the compression damping characteristics of damper assembly 101 may be adjusted. Ex. 1008, 6:20-46, 7:56-60.

46. Specifically, and as shown in Nagai’s Figures 6 and 7, damper assembly 101 includes a damping force adjusting mechanism 170, which comprises an eccentric

cam 131 (having cam surface 132) and adjusting rod 126. Ex. 1008, 6:32-46. The eccentric cam 131 is arranged to cooperate with adjusting rod 126 and to cause adjusting rod 126 to displace axially in response to angular displacement of eccentric cam 131. Ex. 1008, 6:32-46. Axial displacement of adjusting rod 126 in turn varies the cross-sectional area of bypass oil passage 125, and thereby adjusts the compression dampening characteristics of damper assembly 101. Ex. 1008, 7:56-60.

47. As shown in Figures 8 and 9 of Nagai, eccentric cam 131 has shafts 133, 134 extending in opposite directions of cam 131. Ex. 1008, 6:47-54. Shaft 133 has a cross-sectionally sectorial projection 135 (*see* FIG. 7) on an end face thereof. Ex. 1008, 6:47-54. Nagai additionally includes a stopper bolt 141 that is threaded into the camshaft housing 115 adjacent to shaft 133 and has on its inner end an integral stopper 142, which is configured to engage with projection 135 of eccentric cam 131 to limit an angular position of the cam with respect to adjusting rod 126. Ex. 1008, 6:55-7:6, Figs. 6, 7 (annotated below). The damping force of damper assembly 101 may be controlled by controlling the angular range of cam 131 through engagement between stopper 142 and projection 135. Ex. 1008, 7:6-13. Damper assembly 101 may further include a stopper pin 148, which may be set to limit the maximum angular displacement of cam 131. Ex. 1008, 6:47-7:13.



Ex. 1008, Fig. 7 (annotations added).

VIII. THE CHALLENGED CLAIMS OF THE '207 PATENT ARE UNPATENTABLE OVER THE PRIOR ART

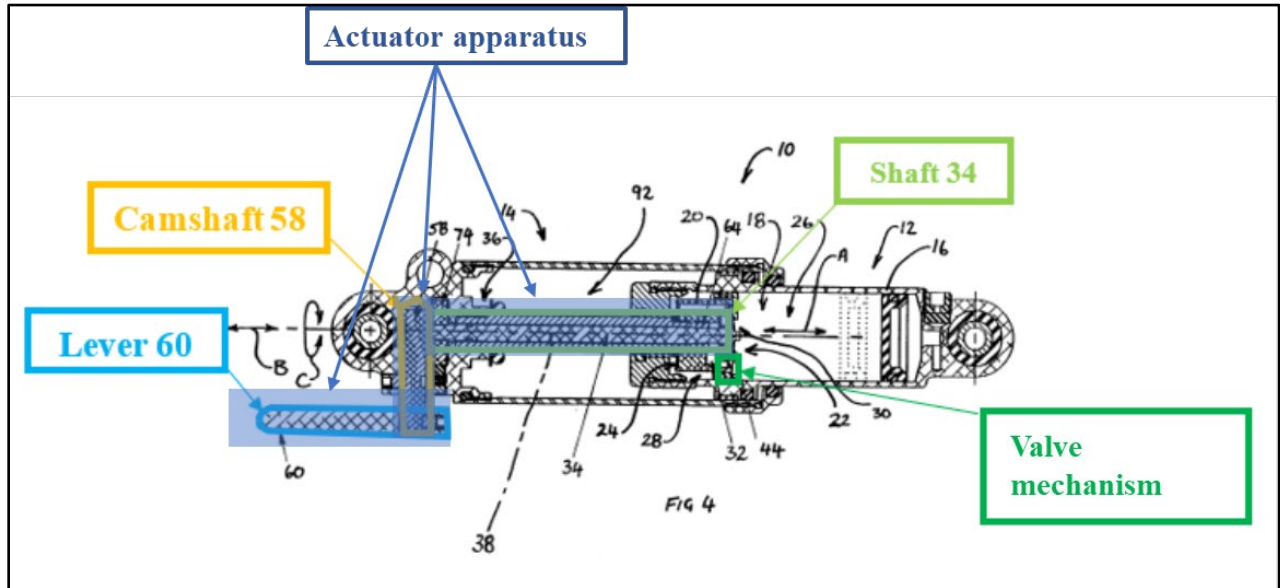
A. Ground 1: Claims 1-3, 7, 8, and 10-12 Are Anticipated by Fox

1. Independent Claim 1

- a. Claim term 1.0 (“An actuator apparatus for controlling a valve mechanism of a suspension system, the actuator apparatus comprising:”)**

48. Fox discloses a shock absorber 10, which is a “suspension system.” Ex. 1005, 6:36-38, Title, Abstract. Fox further discloses an “actuator apparatus,” comprising a camshaft 58, lever 60, and shaft 34. Ex. 1005, 6:65-7:27, 8:3-30. The “actuator

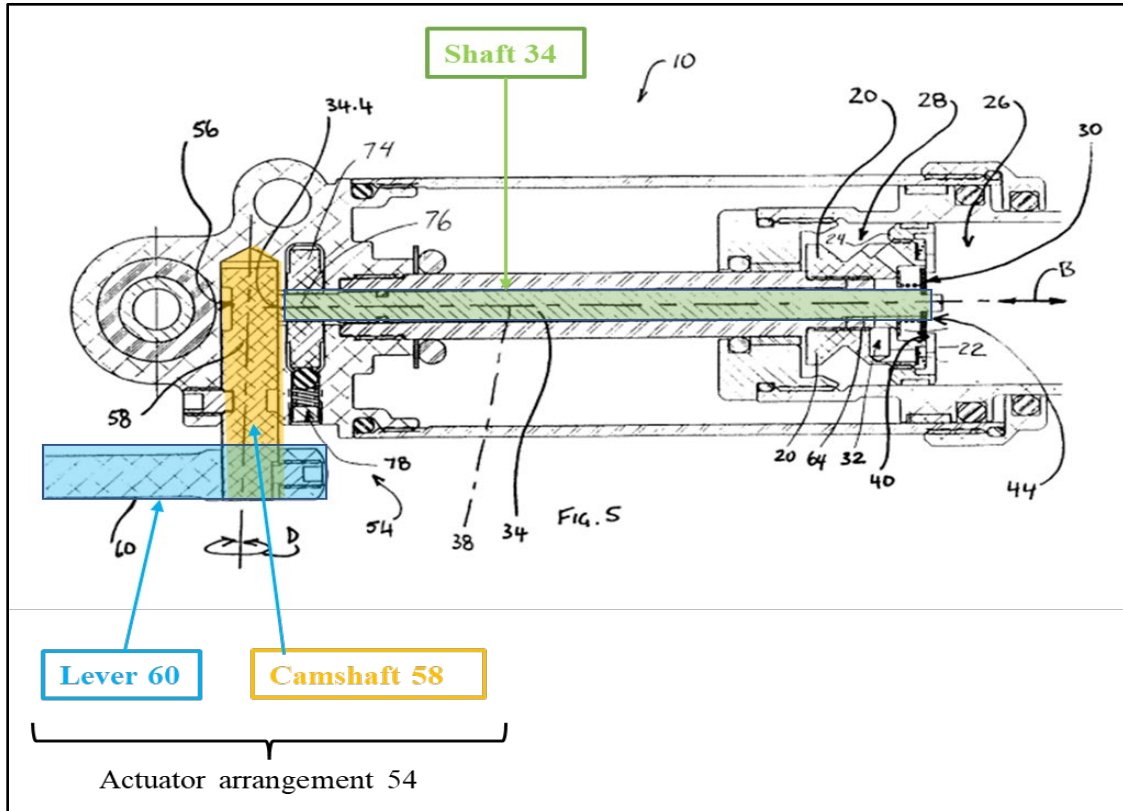
apparatus” controls restriction component 44, i.e., a “valve mechanism,” and thereby adjusts the compression damping characteristic of shock absorber 10.



Ex. 1005, Fig. 4 (annotations added).

- b. **Claim term 1.1 (“a valve actuating assembly operatively connected to the valve mechanism, the valve actuating assembly including a camshaft rotatable between at least two positions to adjust the valve mechanism between various suspension settings”)**

49. Fox’s “actuator apparatus” includes a “valve actuating assembly” comprising actuator arrangement 54 and shaft 34. Ex. 1005, Fig. 5 (annotated below). Actuator arrangement 54 comprises camshaft 58 and lever 60. Ex. 1005, 8:3-30. Shaft 34 functions as a damping adjuster and actuator arrangement 54 functions as a damping adjuster driver. Ex. 1005, 8:31-34.

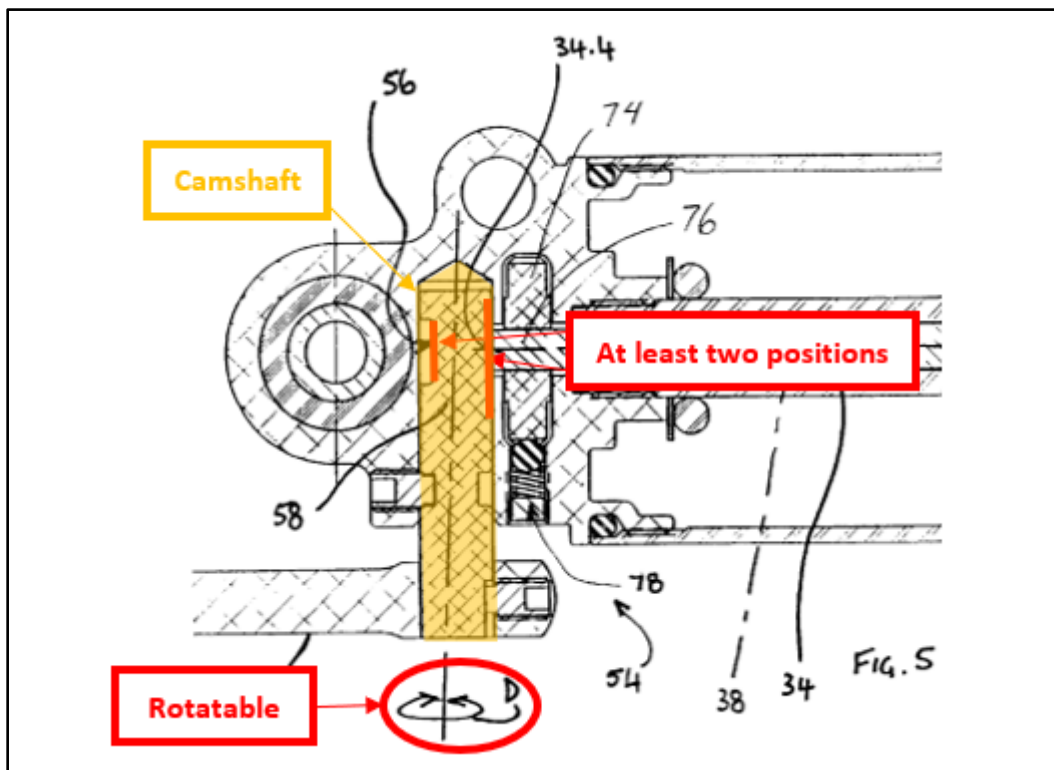


Ex. 1005, Fig. 5 (annotation added).

50. The “valve actuating assembly” (i.e., actuator arrangement 54 and shaft 34) is operatively connected to the “valve mechanism” (i.e., restriction component 44).

Ex. 1005, 7:61-8:2, 8:9-22. Specifically, rotation (angular displacement) of camshaft 58 results in axial displacement of shaft 34, which in turn varies a contact pressure of restriction component 44 against seat formation 40 (which covers a port 42 of passage 30) and thereby varies the resistance to fluid flow from chamber 26 to 28 through port 42 in response to displacement of piston 20 in chamber 26 during a compression stroke. Ex. 1005, 7:8-11, 7:28-41, 7:61-8:2, 9:59-10:14.

51. Camshaft 58 of the “valve actuating assembly” is rotatable between at least two positions—which correspond to a rotary cam surface 56 and a non-recessed cam surface as shown in annotated Figure 5 below—to adjust the “valve mechanism” (restriction component 44) between an open and a closed/lockout compression damping settings. Ex. 1005, 7:61-8:2, 9:59-10:14.



Ex. 1005, Fig. 5 (enlarged and annotations added).

52. Specifically, a person skilled in the art (POSITA) would have understood from the disclosure of Fox that when camshaft 58 is rotated to a position where end 34.4 of shaft 34 is in contact with a non-recessed portion of camshaft 58, as shown in Figures 4-6, then shaft 34 is axially displaced far enough so as to

sufficiently pre-load restriction component 44 to inhibit resilient deformation of component 44, and thereby seal or block off port 42. Ex. 1005, 6:11-16, 11:33-39, 6:22-30. Thus, rotation of camshaft 58 to a position where a non-recessed portion of camshaft 58 is in contact with shaft 34 causes a closed or lockout compression damping setting. Likewise, a POSITA would have understood from the disclosure of Fox that when camshaft 58 is rotated to a position where end 34.4 of shaft 34 is in contact with cam surface 56, then shaft 34 is not extended fully so that restriction component 44 can yield in response to increased pressure during a compression stroke and allow passage of fluid from chamber 26 to 28 through port 42. Ex. 1005, 7:52-8:2, 8:9-22, 8:31-34. Thus, rotation of camshaft 58 to a position where cam surface 56 is in contact with shaft 34 causes an open setting for compression damping.

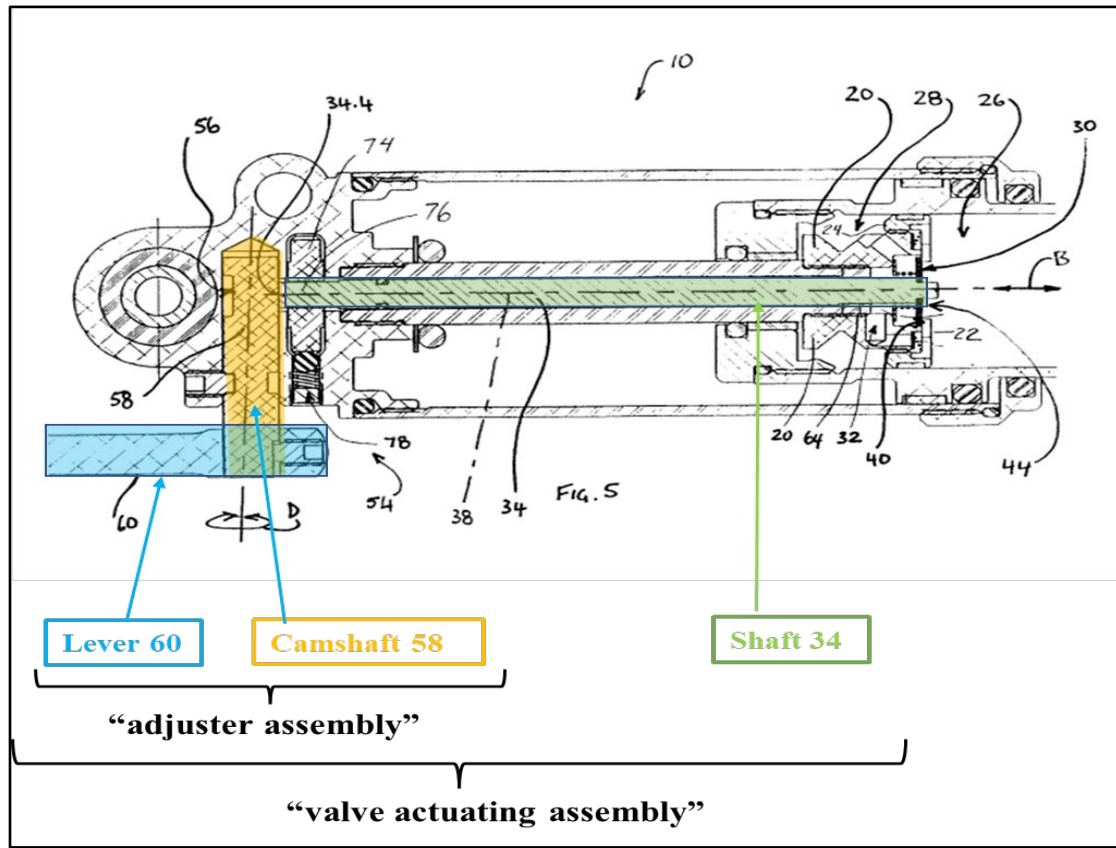
- c. **Claim term 1.2 (“an adjuster assembly operatively connected to the valve actuating assembly for adjusting the damping characteristics corresponding to at least one of the positions of the valve actuating assembly independently of the damping characteristics corresponding to another position of the valve actuating assembly.”)**

53. Actuator arrangement 54 of Fox’s shock absorber 10 also functions as an “adjuster assembly” that is operatively connected to Fox’s “valve actuating assembly,” which includes actuator arrangement 54 and shaft 34. Actuator

arrangement 54 adjusts the damping characteristics corresponding to at least the open position of the “valve actuating assembly.”

54. Although there is structural overlap between Fox’s “valve actuating assembly” and “adjuster assembly,” the ’207 patent’s specification allows such overlap between the recited features. According to the ’207 patent’s specification, the “adjuster assembly” may be integrated into the “valve actuating assembly.” Ex. 1001, 5:52-53 (“The adjuster assembly 18 is formed integrally with the selector 20.”), 3:53-57 (“The valve actuating assembly 16 includes a selector 20 . . .”). More specifically, in the embodiment shown in FIGS. 7a, 7b, and 7c of the ’207 patent, adjuster assembly 18 and selector 20 of valve actuating mechanism 16 are integrated. Ex. 1001, 5:48-6:9, claim 6 (reciting that “the adjuster assembly is formed integrally with the selector of the valve actuating assembly”). The ’207 patent discloses that one complete rotation of lever 54 changes the rotational orientation of the camshaft, which causes axial displacement of driver 22, but the driver will be further axially displaced when angled cam surface 66 (of the camshaft) is axially displaced by the screw thread action of the one rotation. Ex. 1001, 5:48-6:9. That is, there is no separate mechanism for adjusting the damping characteristics in at least one position of the “valve actuating assembly” in the embodiment shown in FIGS. 7a, 7b, and 7c of the ’207 patent. Ex. 1001, 5:48-6:9, claim 6. Thus, it is my understanding that based on the disclosure of the ’207 patent, it is appropriate to map the claimed “valve

actuating assembly” to shaft 34 and actuator arrangement 54 (i.e., camshaft 58 and lever 60), and to further map the claimed “adjuster assembly” to actuator arrangement 54.



Ex. 1005, Fig. 5 (annotations added).

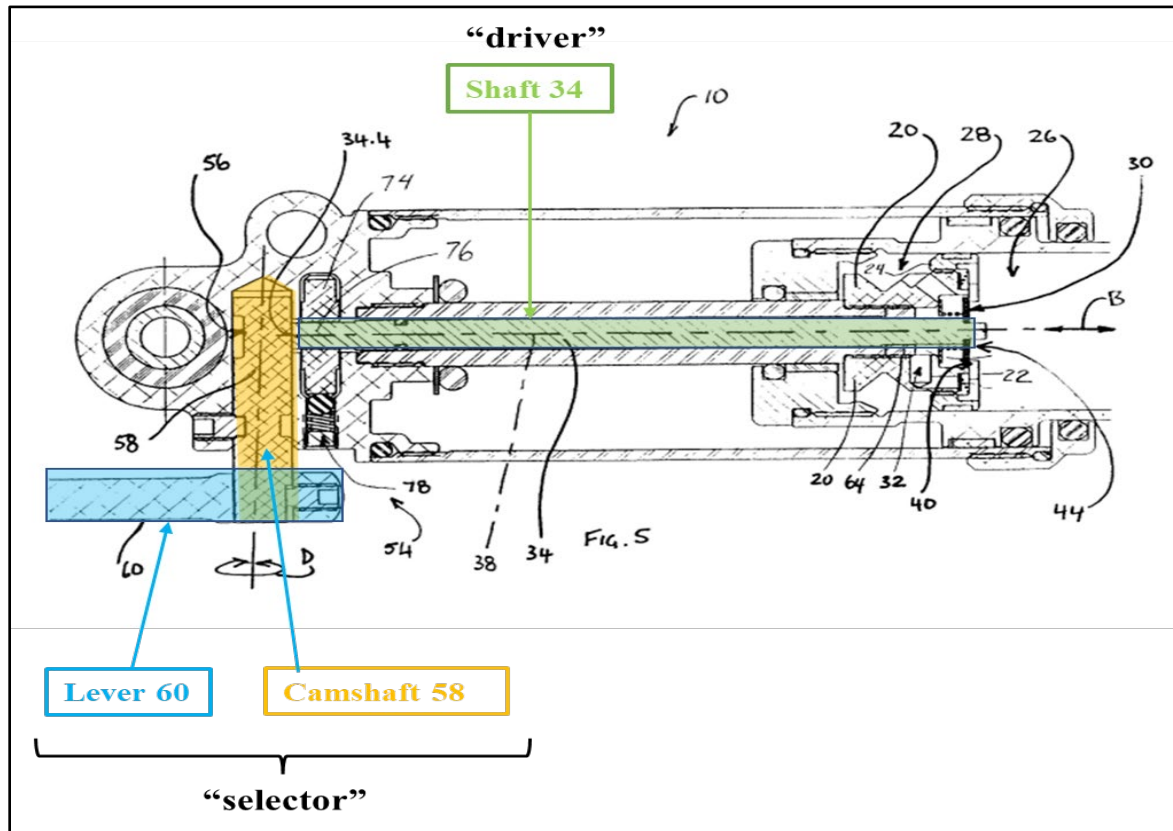
55. Fox’s “adjuster assembly,” i.e., actuator 54, varies the damping characteristics of shock absorber 10 in the open setting of compression damping, i.e., when shaft 34 is in engagement with rotary cam surface 56. Specifically, when shaft end 34.1 abuts rotary cam surface 56, then any rotation (angular displacement) of cam surface 56 varies the contact pressure of shaft end 34.1 on restriction component 44, and

thereby varies the characteristics of the open compression damping setting. Ex. 1005, 7:61-8:30, 5:47-53, 11:11:15, 13:14-18. That is, when shaft end 34.4 abuts rotary cam surface 56, the axial position of shaft 34 can be varied by rotating cam surface 56, which would vary the force acting on resilient component 44 and thereby vary the characteristics of the open compression damping setting. Moreover, adjustment of the compressing damping characteristics in the open position of the “valve actuating assembly” is independent of the damping characteristics in the closed/lockout position, i.e., when shaft 34 abuts a non-recessed cam surface of camshaft 58.

2. Claim 2 (“The actuator apparatus of claim 1 wherein the valve actuating assembly comprises: a driver movable to adjust the valve mechanism between various suspension settings; and a selector operatively connected to the driver and rotatable between the positions.”)

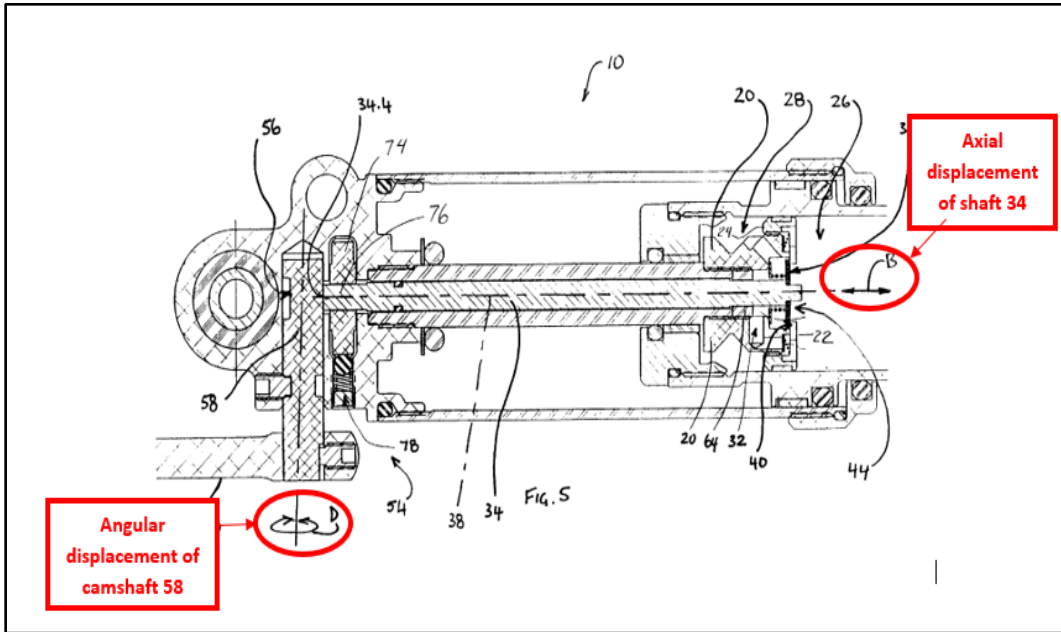
56. As discussed with reference to claim 1, Fox’s shock absorber 10 (the “suspension system”) comprises a shaft 34 and an actuator arrangement 54, which together form a “valve actuating assembly.” Shaft 34 functions as a “driver” that is movable axially along its longitudinal axis 38 relative to piston 20 to adjust restriction component 44 (the “valve mechanism”) between an open and a closed/lockout position of compression damping. Ex. 1005, 7:61-8:2, 8:13-22, 8:31-34, 11:33-39. Actuator arrangement 54, which comprises camshaft 58 and lever 60, functions as a “selector” and can be rotated between the open and closed/lockout

compression damping positions to selectively adjust the axial position of shaft 34 along its axis 38 by operation of the lever (i.e., actuator arrangement 54 is a “selector operable connected to the driver”). Ex. 1005, 8:3-34.



Ex. 1005, Fig. 5 (annotations added).

57. Thus, actuator arrangement 54 (the “selector”) is operatively connected to shaft 34 (the “driver”), such that angular displacement/rotation of camshaft 58 of the “selector” results in axial displacement of the “driver.” Ex. 1005, 8:3-9.



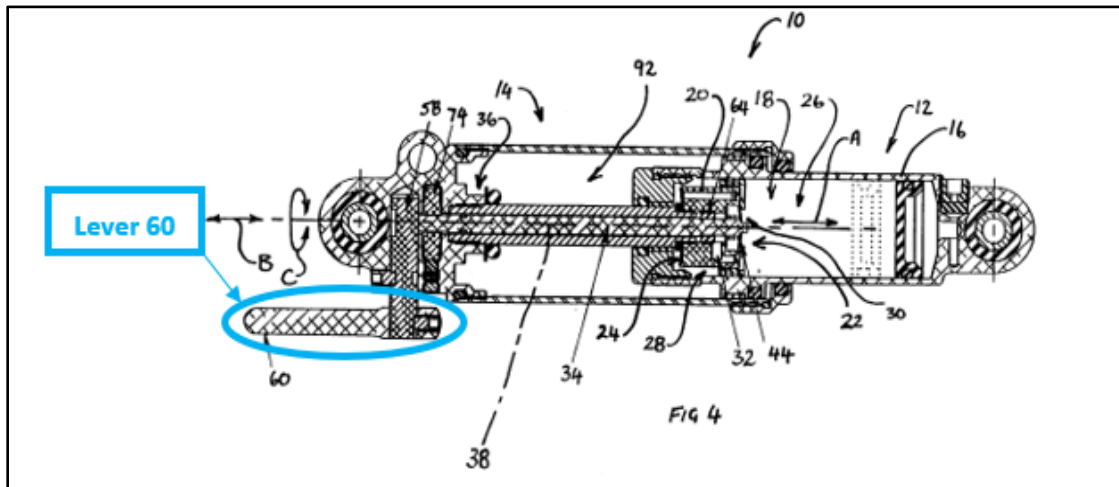
Ex. 005, Fig. 5 (annotations added).

3. Claim 3

a. Claim term 3.1 (“The actuator apparatus of claim 2 wherein the selector comprises: a lever operable between the positions”)

58. As discussed with reference to claim 2, actuator arrangement 54 (i.e., the “selector”) comprises a camshaft 58 and a lever 60 (the “lever”). Lever 60 is connected to camshaft 58. Ex. 1005, Figs. 4-5, 8:22-25. Lever 60 is operable between the open and the closed/lockout compression damping positions, which then angularly displaces camshaft 58 between the two compression damping positions. Ex. 1005, 8:3-30. Specifically, operation of lever 60 causes camshaft 58 to be rotated (angularly displaced) between the two compression damping positions, which then causes shaft 34 to be axially displaced along its longitudinal axis 38 to vary the

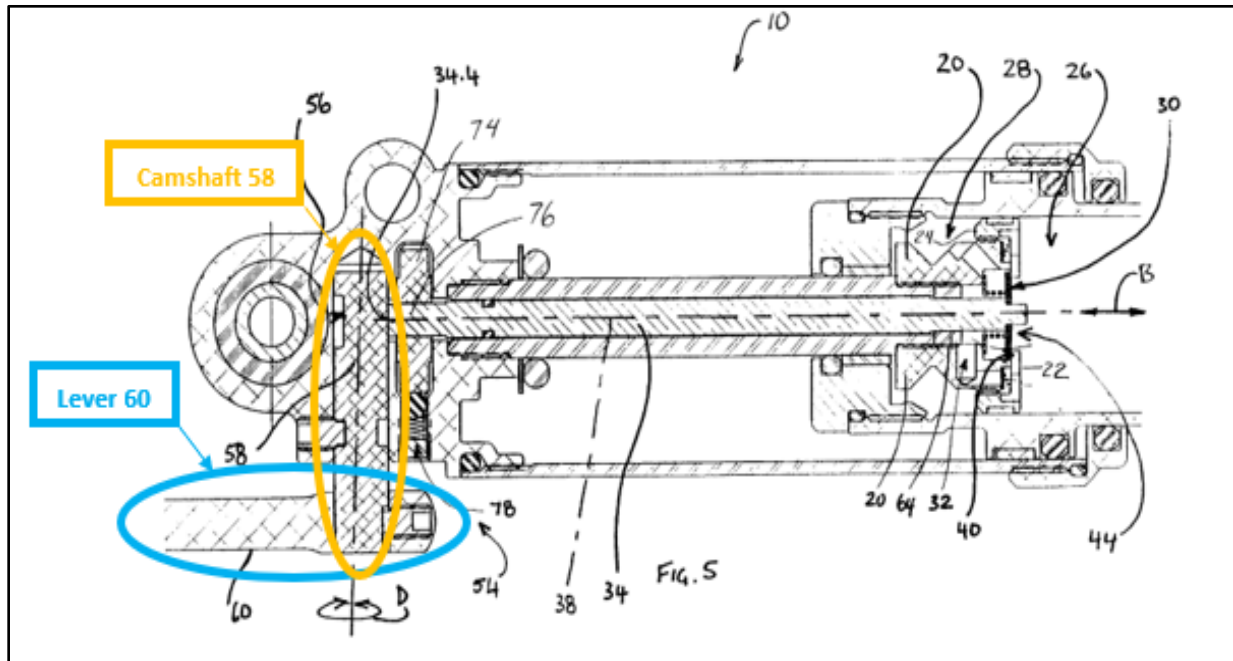
contact pressure on restriction component 44 (the “valve mechanism”), which then adjusts the compression damping characteristics of restriction component 44 to an open setting or a closed/lockout setting. Ex. 1005, 8:3-30.



Ex. 1005, Fig. 4 (annotation added).

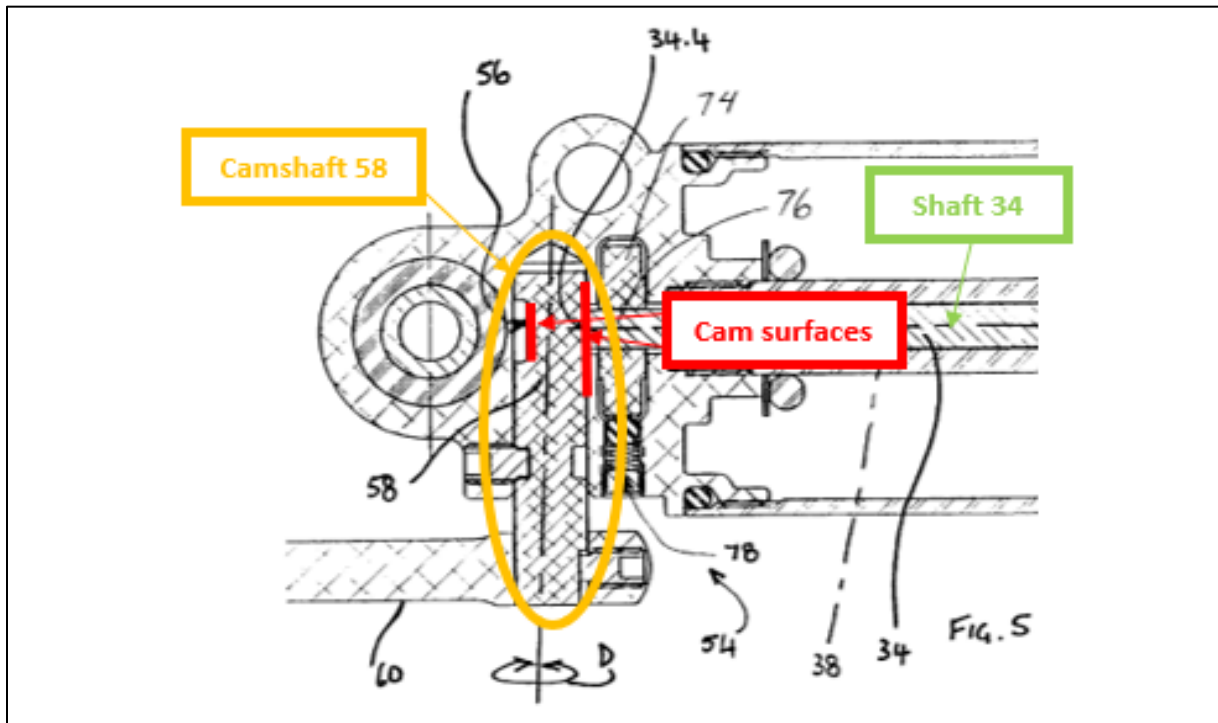
- b. **Claim term 3.2 (“the camshaft operatively connected to the lever, and at least two cam surfaces corresponding to the positions of the lever, the cam surfaces configured to be engageable with the driver.”)**

59. Camshaft 58 (the “camshaft”) is operatively connected to lever 60 (the “lever”). Ex. 1005, Figs. 4-5, 8:22-25.



Ex. 1005, Fig. 5 (annotations added).

60. Camshaft 58 comprises at least two cam surfaces, a rotary cam surface 56 and a non-recessed cam surface, which correspond to the open and the closed/lockout compression damping positions of lever 60, respectively. These cam surfaces are configured to operatively engage with end 34.4 of shaft 34 (the “driver”). Ex. 1005, 7:52-8:30. Specifically, when lever 60 is operated such that cam surface 56 abuts end 34.4 of shaft 34, then shaft 34 causes restriction component 44 to be in an open setting for compression damping. Ex. 1005, 7:52-8:30. When lever 60 is operated such that a non-recessed portion of camshaft 58 abuts end 34.4 of shaft 34, as shown in Figure 4-6, then shaft 34 causes restriction component 44 to be in a closed/lockout setting for compression damping.



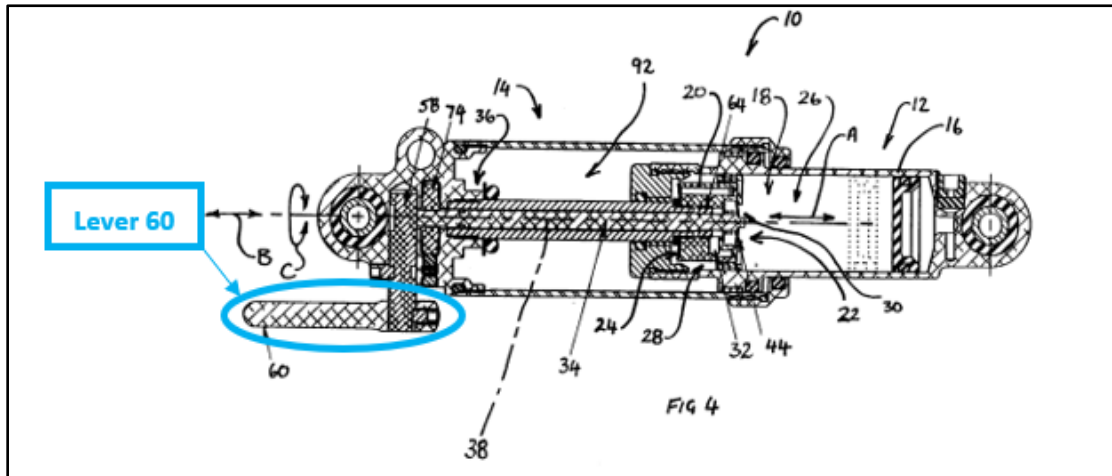
Ex. 1005, Fig. 5 (enlarged and annotations added).

4. Claim 7

- a. Claim term 7.1 (“The actuator apparatus of claim 2 wherein the selector comprises: a lever operable between the positions”)

61. As discussed with reference to claim term 3.1, actuator arrangement 54 (i.e., the “selector”) comprises a camshaft 58 and a lever 60 (the “lever”). Lever 60 is connected to camshaft 58. Ex. 1005, Figs. 4-5, 8:22-25. Lever 60 is operable between the open and the closed/lockout compression damping positions, which then angularly displaces camshaft 58 between the two compression damping positions. Ex. 1005, 8:3-30. Specifically, operation of lever 60 causes camshaft 58 to be rotated (angularly displaced) between the two compression damping positions, which then

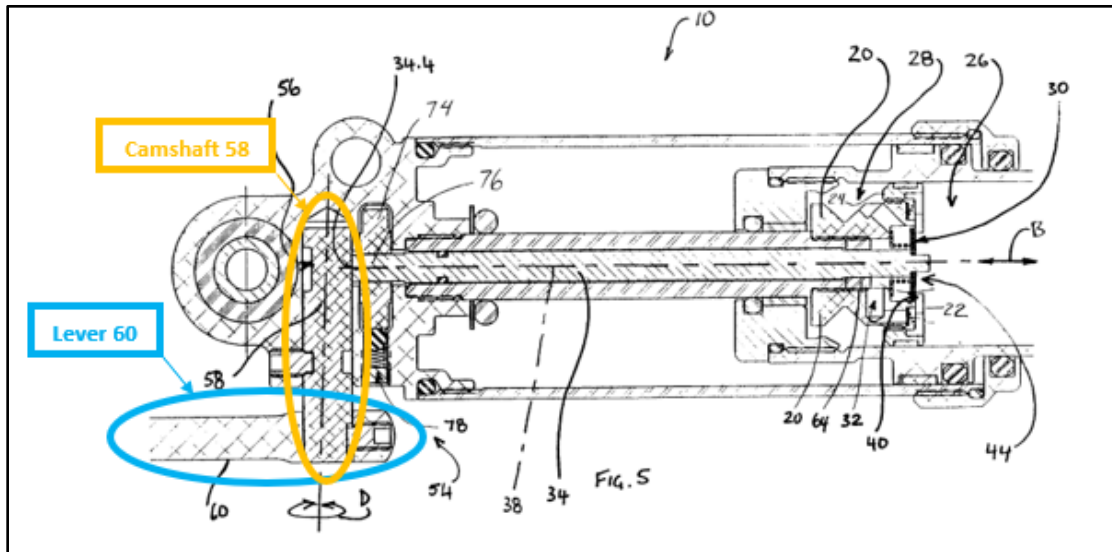
causes shaft 34 to be axially displaced along its longitudinal axis 38 to vary the contact pressure on restriction component 44 (the “valve mechanism”), which then adjusts the compression damping characteristics of restriction component 44 to an open setting or a closed/lockout setting. Ex. 1005, 8:3-30.



Ex. 1005, Fig. 4 (annotation added).

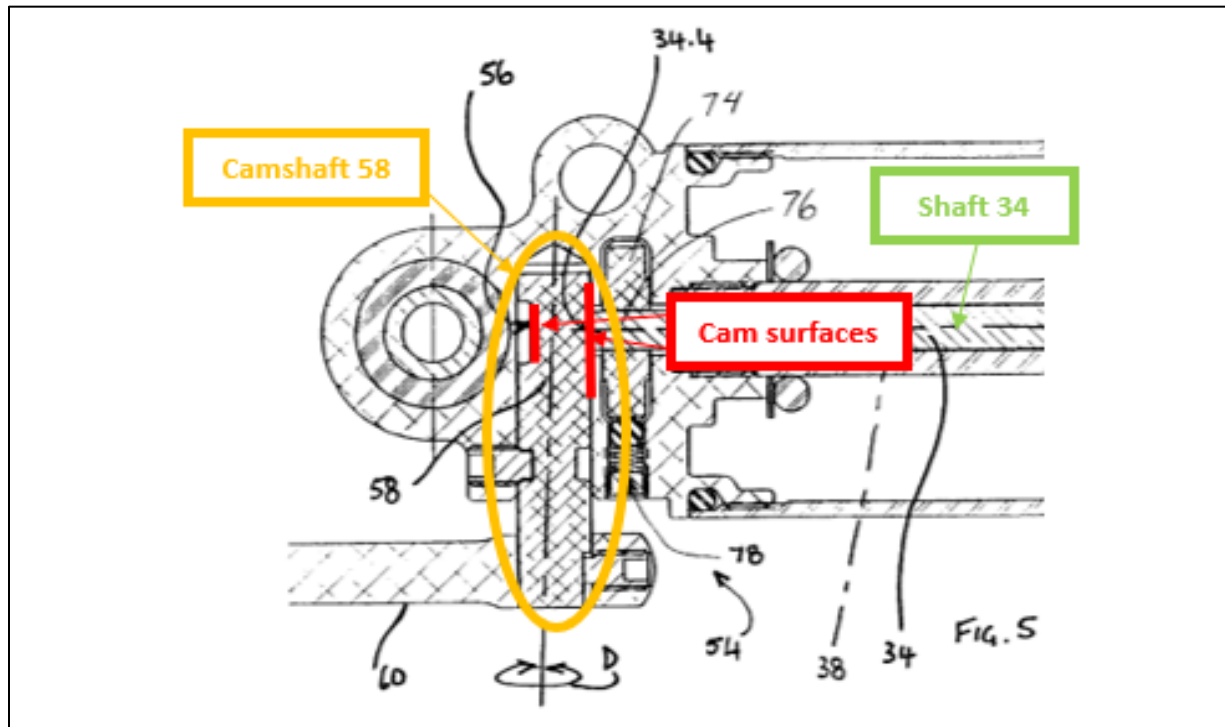
- b. **Claim term 7.2 (“the camshaft having at least two cam surfaces corresponding to the positions of the lever, the camshaft operatively connected to the lever”)**

62. Camshaft 58 (the “camshaft”) is operatively connected to lever 60 (the “lever”). Ex. 1005, Figs. 4-5, 8:22-25.



Ex. 1005, Fig. 5 (annotations added).

63. Camshaft 58 comprises at least two cam surfaces, a rotary cam surface 56 and a non-recessed cam surface, which correspond to the open and the closed/lockout compression damping positions of lever 60, respectively. Specifically, different circumferential regions (cam surfaces) of camshaft 58 control the axial displacement of shaft 34 (the “driver”). These cam surfaces are configured to operatively engage with end 34.4 of shaft 34. Ex. 1005, 7:52-8:30. Specifically, when lever 60 is operated such that cam surface 56 abuts end 34.4 of shaft 34, then shaft 34 causes restriction component 44 to be in an open setting for compression damping. Ex. 1005, 7:52-8:30. When lever 60 is operated such that a non-recessed portion of camshaft 58 abuts end 34.4 of shaft 34, as shown in Figure 4-6, then shaft 34 causes restriction component 44 to be in a closed/lockout setting for compression damping.

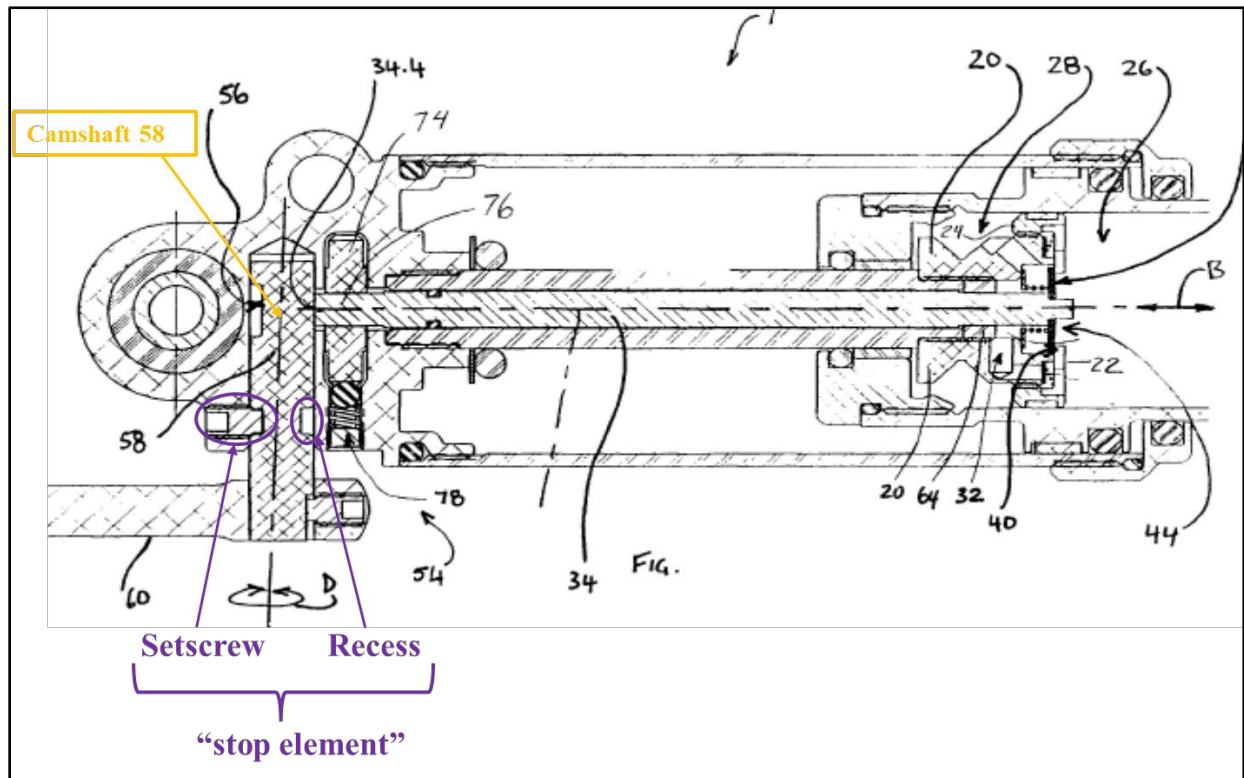


Ex. 1005, Fig. 5 (enlarged and annotations added).

- c. **Claim term 7.3 (“a stop element rotatable with the selector and configured to abut against the adjuster assembly to prevent over-rotation of the lever.”)**

64. Based on the figures of Fox, a person skilled in the art would understand that the “selector” (camshaft 58 and lever 60) of Fox’s shock absorber 10 includes a stop element, which is a combination of a recess on camshaft 58 and a setscrew on the body of shock absorber 10 that engages with the recess as camshaft 58 rotates. *See* Ex. 1005, Fig. 5 (annotated below). The “stop element” blocks rotation of camshaft 58 after some predetermined degree of rotation of lever 60 and thereby prevents over-rotation of the lever. Specifically, the setscrew allows rotation of camshaft 58

and lever 60 only when it is positioned within the recess; when the setscrew reaches either ends of the recess, further rotation of camshaft 58 and lever 60 is prevented. Thus, Fox's "stop element" limits the maximum angular displacement of camshaft 58.



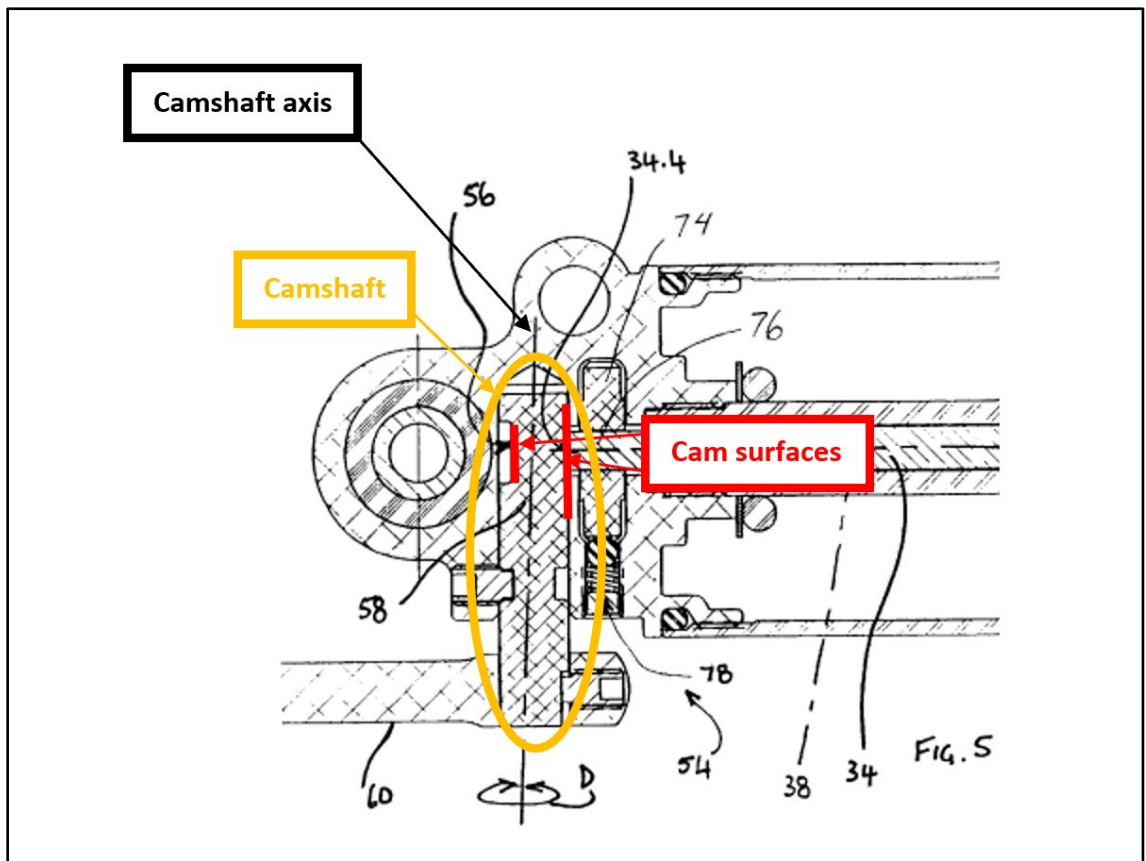
Ex. 1005, Fig. 5 (enlarged and annotated).

65. Because the recess is formed on camshaft 58, a portion of the “stop element,” i.e., the recess, is rotatable with the “selector.” The setscrew portion of the “stop element” abuts against camshaft 58, which forms a portion of Fox’s “adjuster assembly” (*see* claim term 1.2, above). Therefore, Fox’s shock absorber 10

comprises a “stop element” rotatable with the “selector” and configured to abut against the “adjuster assembly” to prevent over-rotation of the “lever.”

5. Claim 8 (“The actuator apparatus of claim 7 wherein the cam surfaces are disposed substantially parallel to the camshaft axis.”)

66. As shown in annotated Figure 5 of Fox below, the cam surfaces on camshaft 58, (i.e., the rotary cam surface 56 and the non-recessed cam surface), are disposed substantially parallel to the longitudinal axis of camshaft 58.



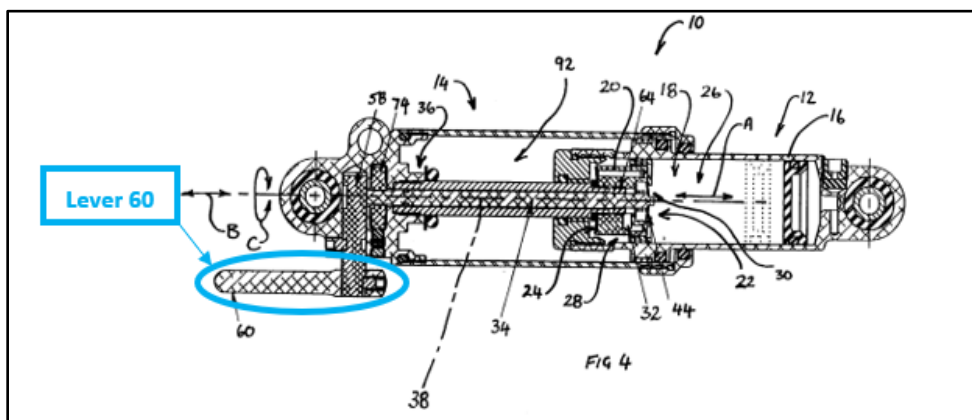
Ex. 1005, Fig. 5 (enlarged and annotations added).

6. Claim 10

a. Claim term 10.1 (“The actuator apparatus of claim 2 wherein the selector comprises: a lever operable between the positions”)

67. As discussed with reference to claim terms 3.1 and 7.1, actuator arrangement 54 (i.e., the “selector”) comprises a camshaft 58 and a lever 60 (the “lever”).

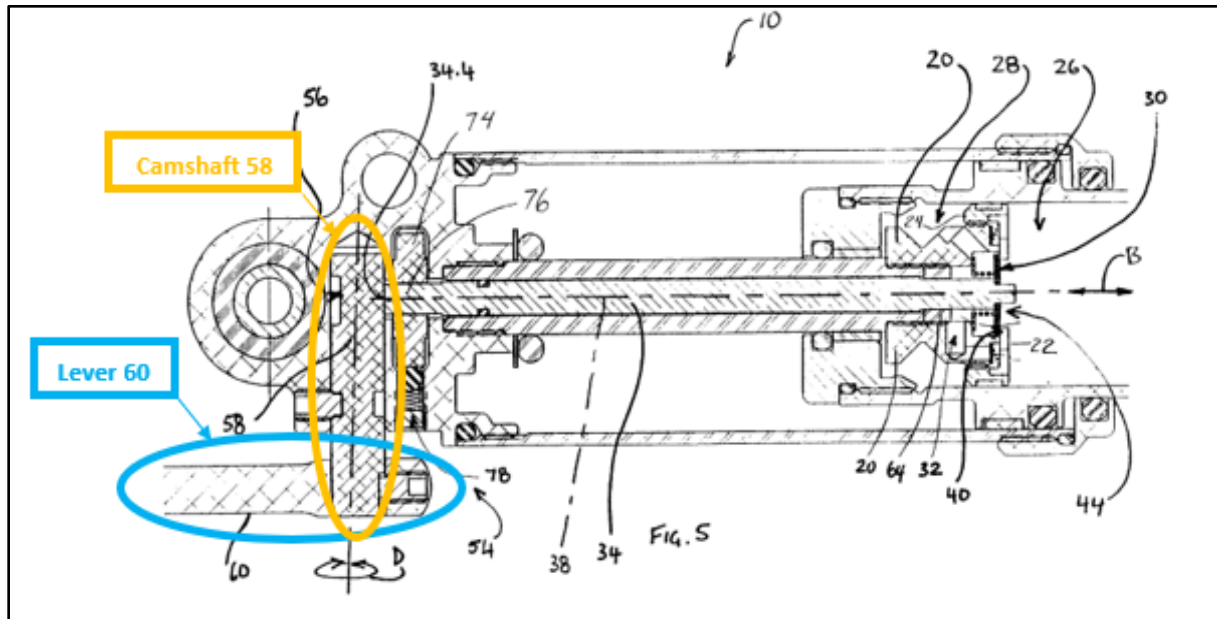
68. Lever 60 is connected to camshaft 58. Ex. 1005, Figs 4-5, 8:22-25. Lever 60 is operable between the open and the closed/lockout compression damping positions, which then angularly displaces camshaft 58 between the two compression damping positions. Ex. 1005, 8:3-30. Specifically, operation of lever 60 causes camshaft 58 to be rotated (angularly displaced) between the two compression damping settings, which then causes shaft 34 to be axially displaced along its longitudinal axis 38 to vary the contact pressure on restriction component 44 (the “valve mechanism”), which then adjusts the compression damping characteristics of restriction component 44 to an open position or a closed/lockout position. Ex. 1005, 8:3-30.



Ex. 1005, Fig. 4 (annotation added).

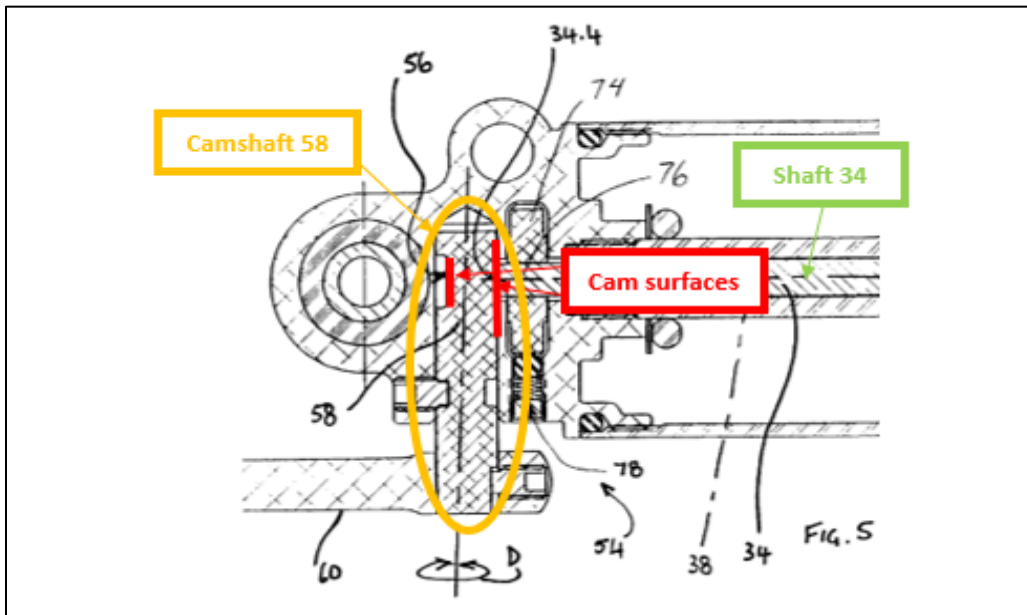
- b. Claim term 10.2 (“the camshaft having a plurality of cam surfaces, at least one of said cam surfaces configured to be engageable with the driver, the cam surfaces corresponding to the positions of the lever, the cam surfaces disposed substantially parallel to the axis of the camshaft, the camshaft operatively connected to the lever.”)**

69. As discussed with reference to claim 2, actuator arrangement 54 (i.e., the “selector”) comprises a camshaft 58 and a lever 60 (the “lever”). Lever 60 is operatively connected to camshaft 58. Ex. 1005, Figs. 4-5, 8:22-25. Camshaft 58 is angularly displaceable between the open and the closed/lockout compression damping position by operation of lever 60. Ex. 1005, 8:3-30. Specifically, operation of lever 60 causes camshaft 58 to be rotated (angularly displaced), which then causes shaft 34 to be axially displaced along its longitudinal axis 38, which in turn adjusts the compression damping characteristics of restriction component 44 (the “valve mechanism”) to an open position or a closed/lockout setting. Ex. 1005, 8:3-30.



Ex. 1005, Fig. 5 (annotations added).

70. Camshaft 58 comprises at least two cam surfaces, a rotary cam surface 56 and a non-recessed cam surface, which correspond respectively to the open and the closed/lockout compression damping positions of lever 60, respectively. These cam surfaces are configured to operatively engage with end 34.4 of shaft 34 (the “driver”). Ex. 1005, 7:52-8:30. Specifically, when lever 60 is operated such that cam surface 56 of camshaft 58 abuts end 34.4 of shaft 34, then shaft 34 causes restriction component 44 to be in an open setting for compression damping. Ex. 1005, 7:52-8:30. When lever 60 is operated such that a non-recessed portion of camshaft 58 abuts end 34.4 of shaft 34, as shown in Figure 4-6, then shaft 34 causes restriction component 44 to be in a closed/lockout setting for compression damping.



Ex. 1005, Fig. 5 (enlarged and annotations added).

71. As shown in annotated Figure 5 of Fox, above, the cam surfaces on camshaft 58, i.e., the rotary cam surface 56 and the non-recessed cam surface, are disposed substantially parallel to the longitudinal axis of camshaft 58.

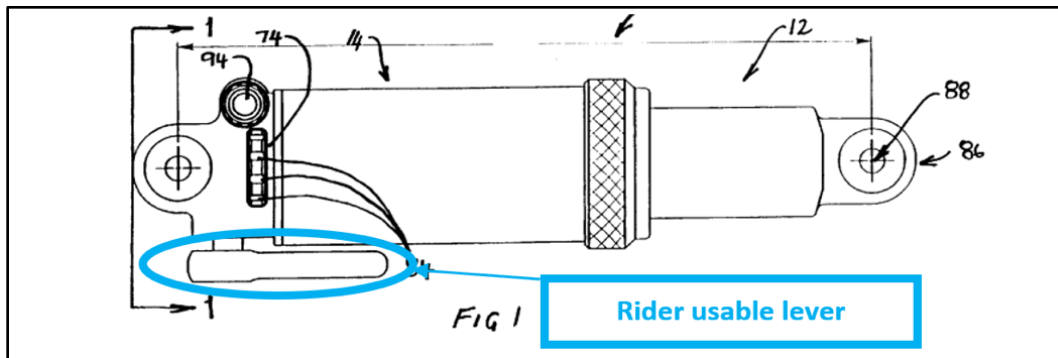
7. Claim 11 (“The actuator apparatus of claim 10 wherein the adjuster assembly is operatively connected to the driver to position the driver relative to camshaft of the selector.”)

72. As discussed with reference to claim term 1.2 and claim 2, Fox’s actuator arrangement 54 (i.e., camshaft 58 and lever 60) serves as both an “adjuster assembly” and a “selector.” Lever 60 of the “adjuster assembly” (and the “selector”) is operatively connected to shaft 34 (the “driver”) to position shaft 34 relative to camshaft 58 of the “selector” (and “adjuster assembly”).

73. Specifically, camshaft 58 is rotatable between the open and the closed/lockout compression damping positions by operation of lever 60. Ex. 1005, 8:3-30. As camshaft 58 is rotated by operation of lever 60, the cam surfaces on camshaft 58 engage with end 34.4 of shaft 34 (the “driver”). Ex. 1005, 7:52-8:30. That is, when lever 60 is operated such that cam surface 56 of camshaft 58 abuts end 34.4 of shaft 34, then shaft 34 causes restriction component 44 to be in an open setting for compression damping. Ex. 1005, 7:52-8:30. When lever 60 is operated such that a non-recessed portion of camshaft 58 abuts end 34.4 of shaft 34, as shown in Figure 4-6, then shaft 34 causes restriction component 44 to be in a closed/lockout setting for compression damping.

8. Claim 12 (“The actuator apparatus of claim 1 wherein the positions of the valve actuating assembly are rider-selectable positions.”)

74. As discussed with reference to claim 3, camshaft 58 of the “valve actuating assembly” is angularly displaceable between the open and the closed/lockout compression damping positions by operation of lever 60. Ex. 1005, 8:3-30. Lever 60 enables a rider to select the damping positions because “the lever 60 is positioned outside the rest of the shock absorber 10 so as to enable a user selectively to adjust the axial position of the shaft 34 along its axis 38 by operation of the lever 60 outside the rest of the shock absorber 10.” Ex. 1005, 8:25-30, Fig. 1 (annotated below).



Ex. 1005, Fig. 1 (annotation added).

B. Ground 2: Claims 1-3, 7, 8, and 10-12 Are Rendered Obvious by Fox in View of JP'279 and Nagai

- 1. A POSITA would have been motivated to combine Fox, JP'279, and Nagai, and would have reasonably expected success in doing so**

75. As discussed in Sections VII.A and VIII.A.1.a, Fox discloses a suspension system, specifically a shock absorber 10. Ex. 1005, Figs. 1-4, 6:36-64. JP'279 also discloses a suspension system, specifically a hydraulic shock absorber. Ex. 1007, Title, 2, Fig. 1; *see also* Section VII.C. Nagai further discloses a suspension system, specifically a hydraulic damper. Ex. 1008, Fig. 5, 5:48-65; *see also* Section VII.D. Thus, Fox, JP'279, and Nagai are in the same technical field of suspension systems. Each of these references also teaches adjustment mechanisms for controlling compression damping characteristics of the suspension system. Ex. 1005, Abstract, 1:25-35; Ex. 1007, 1, 2; Ex. 1008, 1:10-13. A POSITA would therefore have

considered Fox, JP'279, and Nagai together when investigating adjustment mechanisms for controlling compression damping in a suspension system.

76. As discussed in Section VIII.A (Ground 1), Fox discloses every limitation of the Challenged Claims. Even assuming that Fox does not disclose an “adjuster assembly” as claimed in claim 1, it would have been obvious to a POSITA to modify the Fox suspension system to include elements of JP'279's “adjuster assembly” for fine-tuning of the damping characteristics in the open compression damping setting in Fox's suspension system. Specifically, a POSITA would have been motivated to add JP'279's tapered surface 44 on cam surface 56 of Fox's camshaft 58. Ex. 1005, 8:3-30; Ex. 1007, 6. For example, a rotary cam may have an axial taper on part of its surface, such that the shaft/rod end contacting (engaging) the tapered surface causes the shaft to be displaced axially by axial motion of the cam. This is illustrated below.

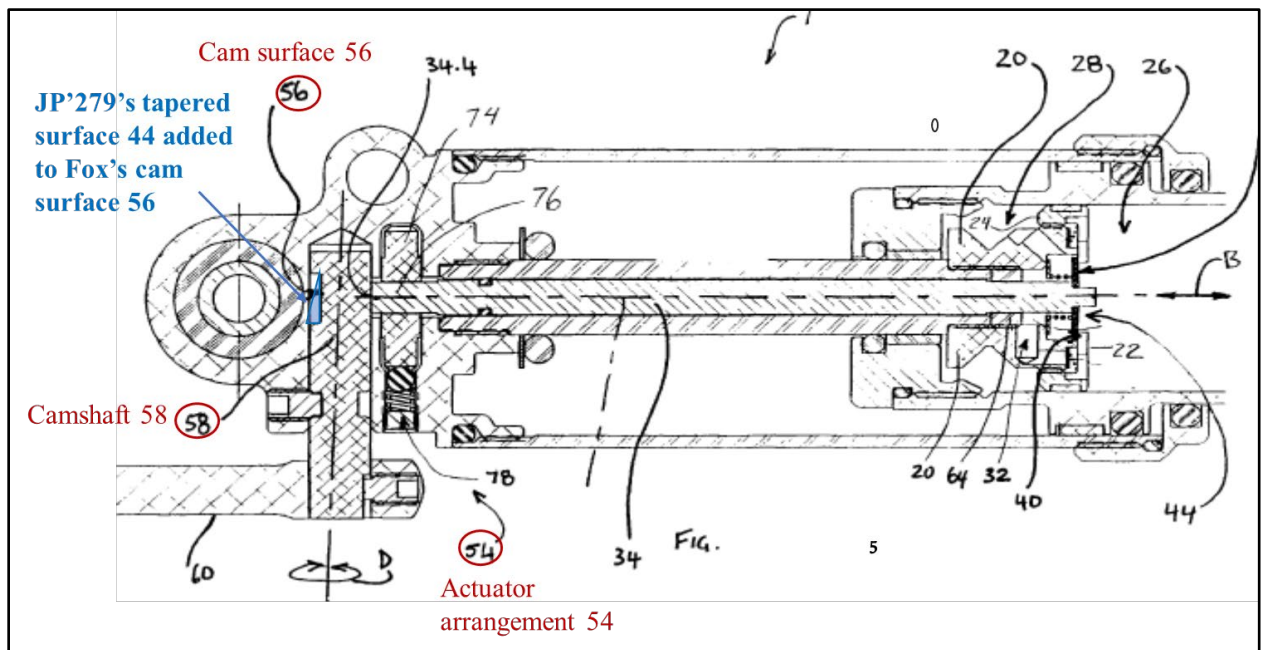
77. Fox notes that “it would be desirable to provide a shock absorber with easily-adjustable [rebound damping] and/or [compression damping] characteristics or values to enable a user of [a] mountain bicycle to adjust the [rebound damping] and [compression damping] characteristics of the shock absorber.” Ex. 1005, 1:61-65. Relatedly, JP'279 discloses capabilities of “fine adjustment.” Ex. 1007, 6. Thus, a POSITA in November 2004 would have recognized the need for fine adjustment of compression damping and would have seen that modification of Fox in view of

JP'279 would improve the suspension system of Fox by permitting fine adjustment of the compression damping characteristics by use of an added cam feature, such as JP'279's tapered surface 44 on slider 43.

78. A POSITA would have understood based on the disclosure of Fox that fine-tuning of damping characteristics is preferred since “the ideal damping force requirements or profiles can vary depending on (among other things) factors such as rider weight, rider skill, the particular terrain conditions, and the like.” Ex. 1005, 1:56-60. The listed factors highlight the variability of damping conditions, and thus illustrate the need for fine adjustment of damping settings as disclosed in JP'279. Ex. 1007, 6.

79. Implementation of JP'279's “adjuster assembly” into the Fox suspension system would have been well within the skills of a POSITA in November 2004. Indeed, a skilled artisan would simply need to implement JP'279's tapered surface 44 within at least a part of Fox's cam surface 56, as shown below, such that the position at which Fox's shaft 34 engages cam surface 56 may be varied axially (i.e., along the camshaft longitudinal axis), thereby finely adjusting the compression damping characteristics of Fox's suspension system. A POSITA would also have readily known how to axially move Fox's camshaft 58 (modified to have JP'279's tapered surface 44) along the camshaft's longitudinal axis using a manual push-pull mechanism actuatable by a rider, or with a motorized mechanism as taught by

JP'279. *See* Ex. 1007, 5-6. Moreover, a POSITA would have known to use a mechanism such as Nagai's stopper bolt 141 to move/slide Fox's camshaft 58 axially. Nagai's stopper bolt 141 would have been configured to engage with Fox's camshaft 58 and would have been used to advance and retract the camshaft along its longitudinal axis.



Ex. 1005, Fig. 5 (modified, annotated) (showing Fox's shock absorber modified to have JP'279's tapered surface 44 for fine adjustment of compression damping).

80. In the ever-continuing quest for better pimpleperformance through repeatable tuning of a ride to different conditions, a POSITA would also have been motivated to include Nagai's limiting means, i.e., projection 135 and stopper 142, in Fox's suspension system to set the angular displacement to within an optimum range. As Nagai notes, incorporating a limiting means would ensure that "no inappropriate

damping forces are generated by the damper assembly.” Ex. 1008, 2:22-40. A POSITA would have understood from the disclosure of Nagai that inclusion of a limiting means would ensure “optimum damping forces.” Ex. 1008, 2:22-40. A POSITA would have recognized that although Fox’s setscrew and groove mechanism limits the maximum angular displacement of camshaft 58, Nagai’s stopper 142 would allow the user to set an optimum range of rotation of the camshaft and thereby optimize the damping forces.

81. Further, modifying Fox’s camshaft 58 to have a projection 135 configured to engage with Nagai’s stopper 142 would have been well within the skills of a POSITA in November 2004. A POSITA would have readily known from the disclosures of Fox and Nagai that Nagai’s stopper bolt 141 could have been easily integrated with Fox’s camshaft housing, and that stopper bolt 141 would have served the dual purpose of (1) axially displacing Fox’s camshaft 58 for fine-tuning of compression damping forces, and (2) setting optimum damping forces. *See* Ex. 1008, 6:55-7:13.

82. In the Fox suspension system modified in view of JP’279 and Nagai, Fox’s shaft 34 would engage the tapered surfaces 44 of JP’279’s slider 43 integrated into cam surface 56 of Fox’s camshaft 58. Rotation of Fox’s lever 60 would operate the “valve actuating assembly” to select between an open or a closed/lockout compression damping position. Ex. 1005, 7:61-8:2, 6:22-30, 8:3-30. While in the

open position, actuation of Nagai's stopper bolt 141 would axially displace Fox's camshaft 58, which would vary the position at which shaft 34 abuts tapered surface 44, thereby finely adjusting the damping characteristics of the open position. *See* Ex. 1005, 7:61-8:2. Furthermore, in the modified Fox suspension system, Fox's camshaft 58 would include a projection, such as projection 135 of Nagai, which would have been configured to engage with Nagai's stopper 142 provided on stopper bolt 141. *See* Ex. 1008, 6:55-7:13.

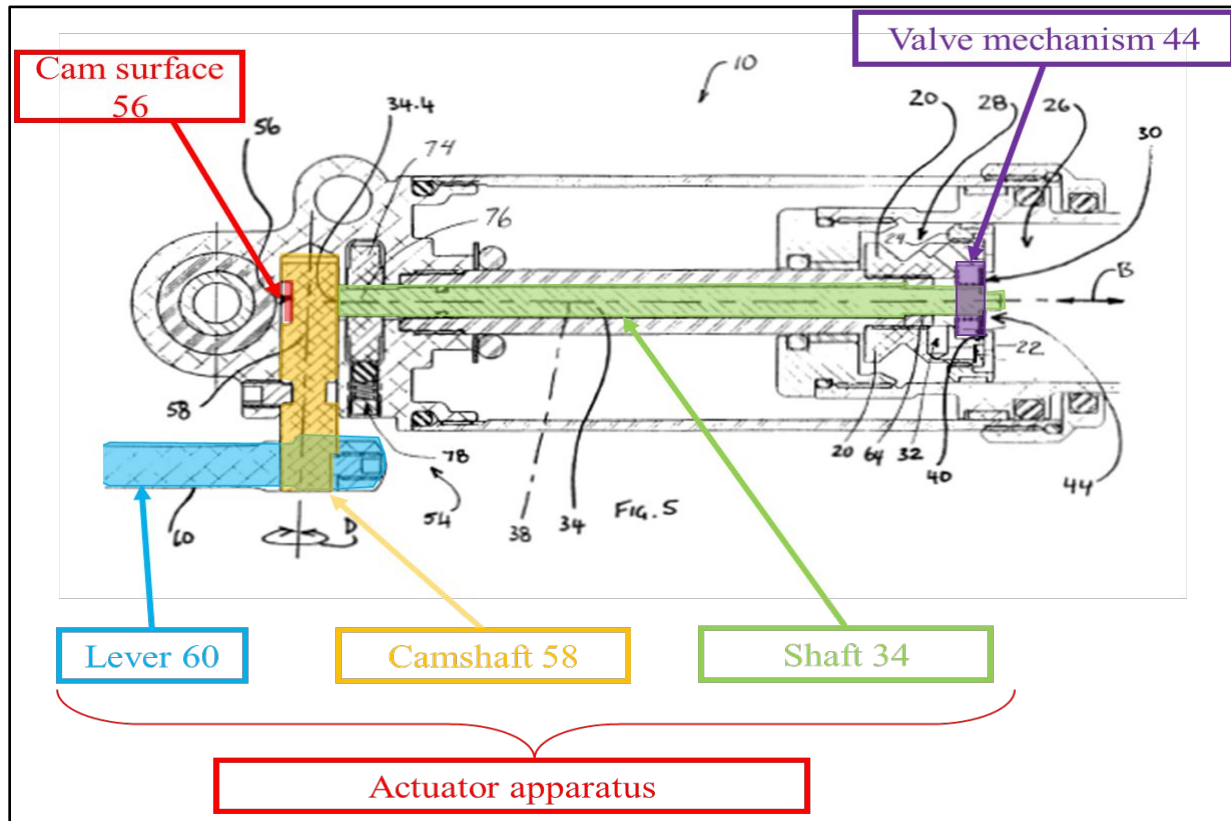
83. The modifications described above would have involved only a combination of known prior art elements according to known methods to yield predictable results. Moreover, the modifications discussed above are simple mechanical adaptations that are well described in the prior art. Therefore, a POSITA would have readily expected success in making those modifications to yield the known benefits of fine-tuning the compression damping characteristics of the suspension system and setting a maximum or optimum range of damping forces.

2. Independent Claim 1

a. Claim term 1.0 (“An actuator apparatus for controlling a valve mechanism of a suspension system, the actuator apparatus comprising:”)

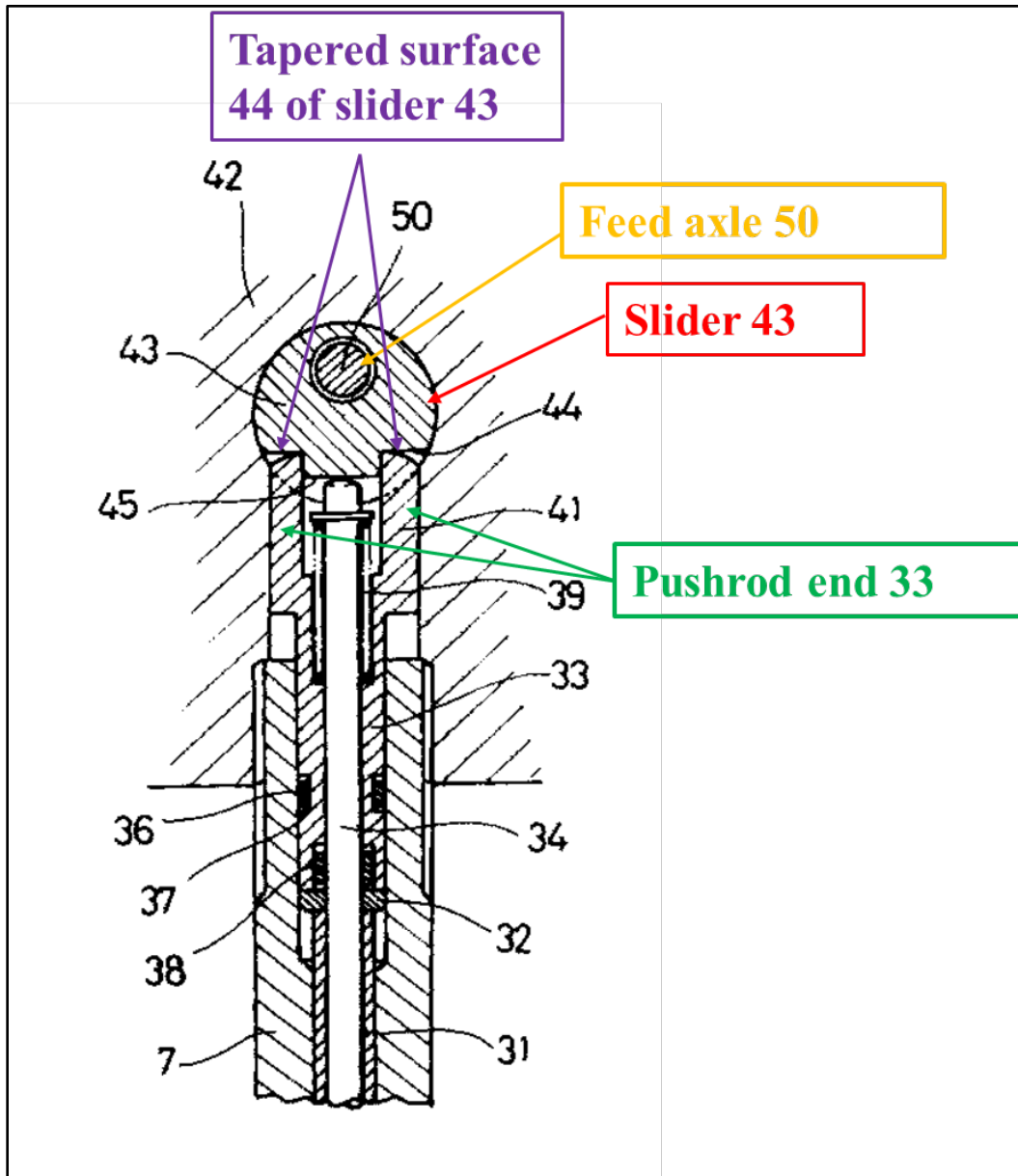
84. Fox discloses a shock absorber 10, which is a “suspension system.” Ex. 1005, 6:36-64, Title, Abstract. Fox further discloses an “actuator apparatus,” comprising a

camshaft 58, lever 60, and shaft 34. Ex. 1005, 6:65-7:27, 8:3-30. The “actuator apparatus” controls restriction component 44, i.e., a “valve mechanism,” and thereby adjusts a compression damping characteristic of shock absorber 10.



Ex. 1005, Fig. 5 (annotations added).

85. JP’279 discloses a hydraulic shock absorber, which is a “suspension system.” Ex. 1007, Title, 1, 2. JP’279 further discloses an “actuator apparatus,” comprising gear 49, feed axle 50, slider 43, and pushrod end 33, which facilitates fine adjustment of the compression damping characteristics of JP’279’s shock absorber. Ex. 1007, Title, 4.



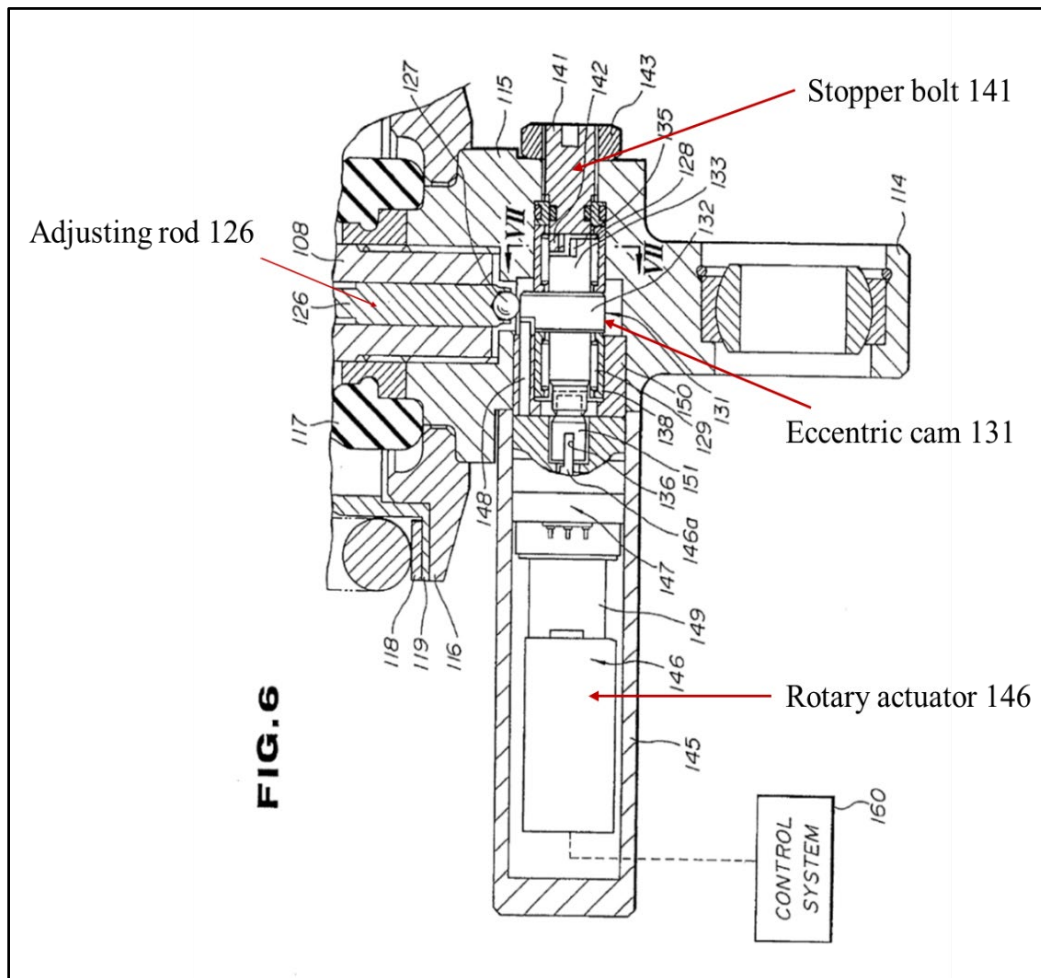
Ex. 1007, Fig. 5 (annotations added).

86. Nagai further discloses a damper assembly, which is a “suspension system.”

Ex. 1008, 5:48-65. Nagai’s damper assembly includes an “actuator apparatus,” which comprises a rotary actuator 146, eccentric cam 131, and adjusting rod 126.

Ex. 1008, 6:32-46, 7:56-60. “When the rotary actuator 146 is energized, the

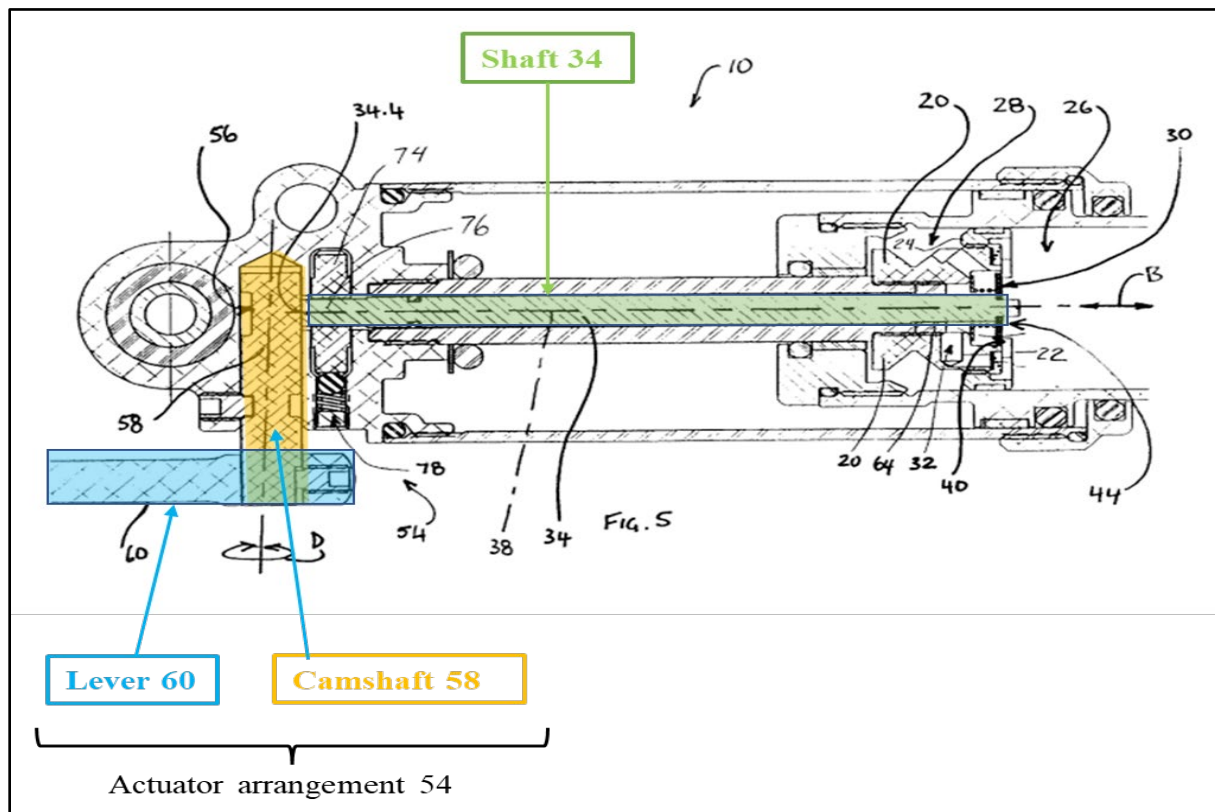
eccentric cam 131 is rotated to axially move the adjusting rod 126 for thereby varying the cross-sectional area of the bypass oil passage 125. Therefore, the damping forces generated by the piston 110 can be adjusted by the adjusting rod 126.” Ex. 1008, 7:56-60. Nagai’s “actuator apparatus” also includes a stopper bolt 141, which is configured to engage with cam 131 and limit angular displacement of the cam. Ex. 1008, 6:55-7:13.



Ex. 1008, Fig. 6 (annotations added).

- b. **Claim term 1.1 (“a valve actuating assembly operatively connected to the valve mechanism, the valve actuating assembly including a camshaft rotatable between at least two positions to adjust the valve mechanism between various suspension settings”)**

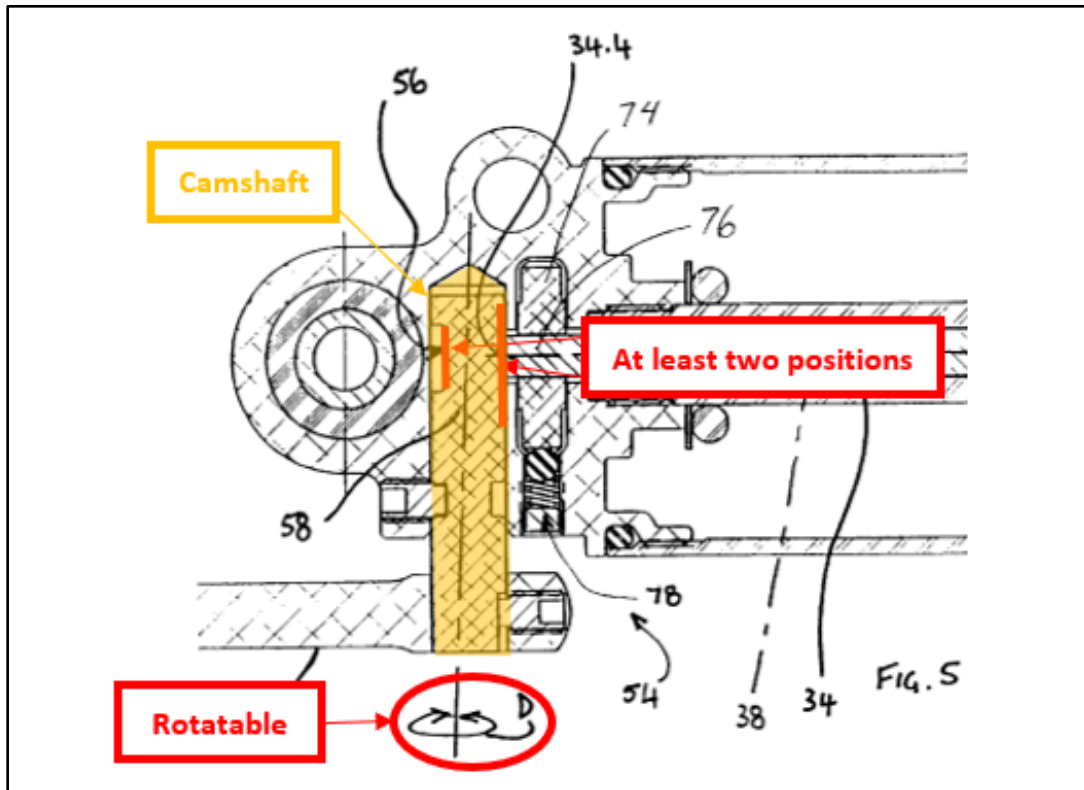
87. Fox’s “actuator apparatus” includes a “valve actuating assembly” comprising actuator arrangement 54 and shaft 34. Ex. 1005, Fig. 5. Actuator arrangement 54 comprises camshaft 58 and lever 60. Ex. 1005, 8:3-30. Shaft 34 functions as a damping adjuster and actuator arrangement 54 functions as a damping adjuster driver. Ex. 1005, 8:31-34.



Ex. 1005, Fig. 5 (annotation added).

88. The “valve actuating assembly” (i.e., actuator arrangement 54 and shaft 34) is operatively connected to the “valve mechanism” (i.e., restriction component 44). Ex. 1005, 7:61-8:2, 8:9-22. Rotation (angular displacement) of camshaft 58 results in axial displacement of shaft 34, which in turn varies the contact pressure of restriction component 44 against seat formation 40 (which covers a port 42) and thereby varies the resistance to fluid flow from chamber 26 to 28 through port 42 in response to displacement of piston 20 in chamber 26 during a compression stroke. Ex. 1005, 7:8-11, 7:28-41, 7:61-8:2, 9:59-10:14.

89. Camshaft 58 of the “valve actuating assembly” is rotatable between at least two positions—corresponding to cam surface 56 and a non-recessed cam surface as shown in annotated Figure 5 below—to adjust the “valve mechanism” (restriction component 44) between open and closed/lockout compression damping settings. Ex. 1005, 7:61-8:2, 9:59-10:14.



Ex. 1005, Fig. 5 (enlarged and annotations added).

90. Specifically, a POSITA would have understood from the disclosure of Fox that when camshaft 58 is rotated to a position where end 34.4 of shaft 34 is in contact with a non-recessed portion of camshaft 58, as shown in Figures 4-6, then shaft 34 is axially displaced far enough so as to sufficiently pre-load restriction component 44 to inhibit resilient deformation of component 44, and thereby sealing or blocking off port 42. Ex. 1005, 6:11-16, 11:33-39, 6:22-30. Thus, rotation of camshaft 58 to a position where a non-recessed portion of camshaft 58 is in contact with shaft 34 causes a closed or lockout compression damping setting. Even though not shown explicitly in a figure, a POSITA would likewise have understood from the disclosure

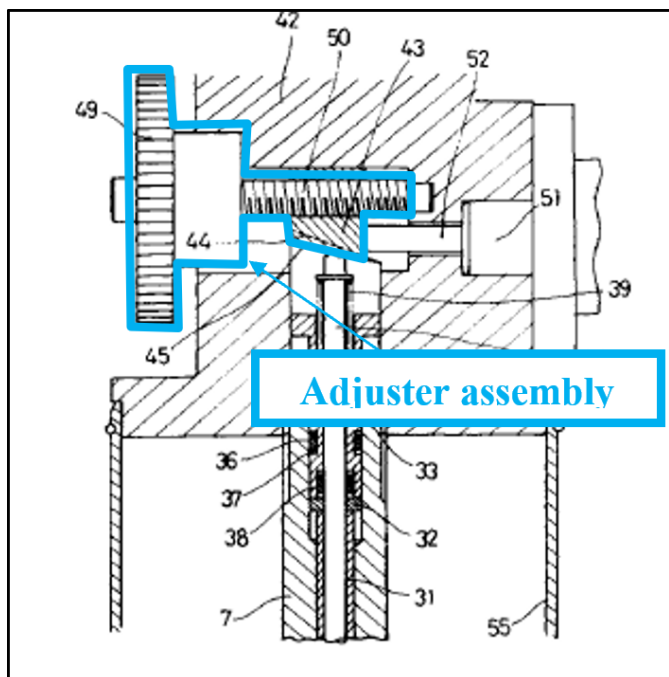
of Fox that when camshaft 58 is rotated to a position where end 34.4 of shaft 34 is in contact with cam surface 56, then shaft 34 is not extended fully and restriction component 44 can resiliently yield in response to increased pressure during a compression stroke to allow passage of fluid from chamber 26 to 28 through port 42. Ex. 1005, 7:61-8:30. Thus, rotation of camshaft 58 to a position where shaft 34 is in contact with cam surface 56 causes an open setting for compression damping.

- c. **Claim term 1.2 (“an adjuster assembly operatively connected to the valve actuating assembly for adjusting the damping characteristics corresponding to at least one of the positions of the valve actuating assembly independently of the damping characteristics corresponding to another position of the valve actuating assembly.”)**

91. A POSITA would have been motivated to modify the suspension system of Fox to include an “adjuster assembly” that is separate from the “valve actuating assembly” (i.e., actuator arrangement 54 and shaft 34) to finely adjust the compression damping characteristics in the open compression damping setting. A POSITA would have readily understood that, although Fox’s suspension system allows adjustment of compression damping when shaft 34 is in engagement with cam surface 56 (of Fox’s camshaft 58) as discussed in Section VIII.A.1.c, above, an “adjuster assembly” as taught by JP’279 would allow fine-tuning of the damping characteristics beyond that possible with Fox’s actuator arrangement 54 because

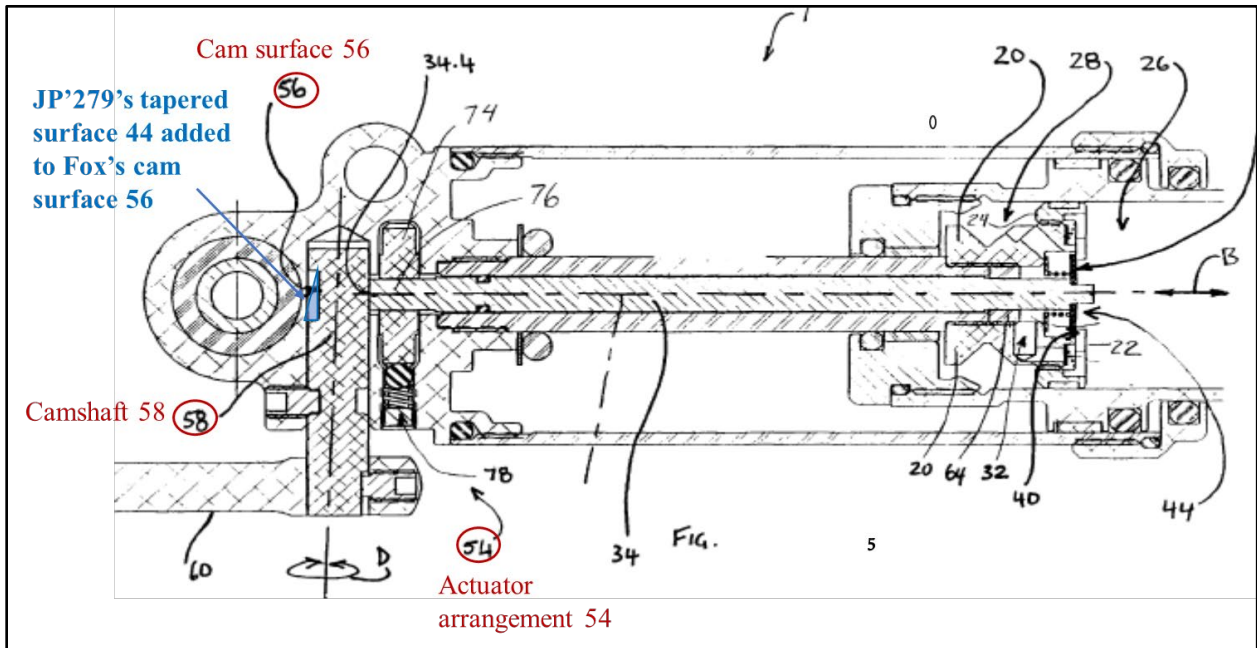
JP'279's "adjuster assembly" allows fine adjustments, and thus further improve Fox's suspension system.

92. The "adjuster assembly" of JP'279 includes a slider 43 with tapered surface 44 and a mechanism for axially displacing slider 43 using gear 49 and feed axle 50, as shown below. Ex. 1007, 5-6, Fig. 4.



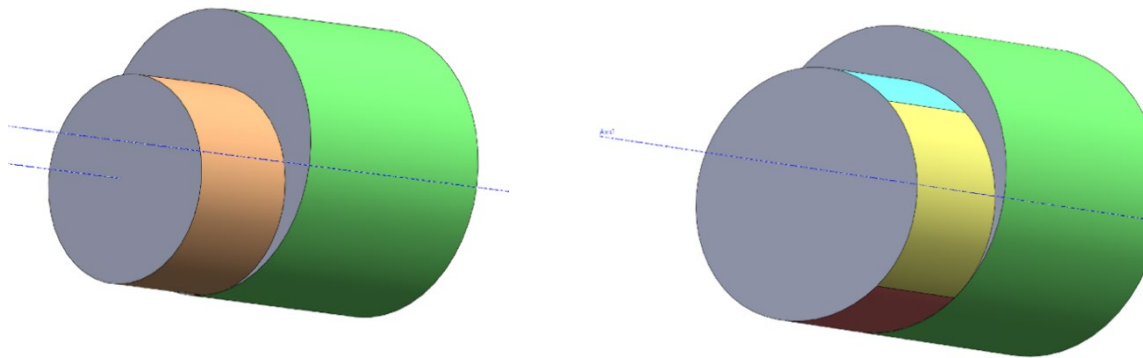
Ex. 1007, Fig. 4 (annotations added).

93. A POSITA would have known they would achieve fine-tuning adjustment by adding the tapered surface 44 of JP'279's "adjuster assembly" to Fox's cam surface 56, as shown below.

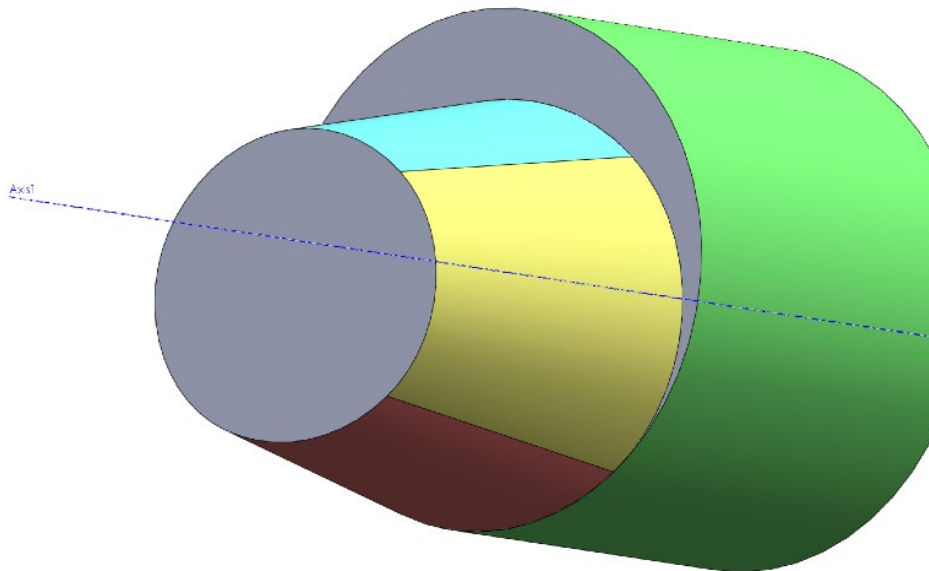


Ex. 1005, Fig. 5 (annotations added).

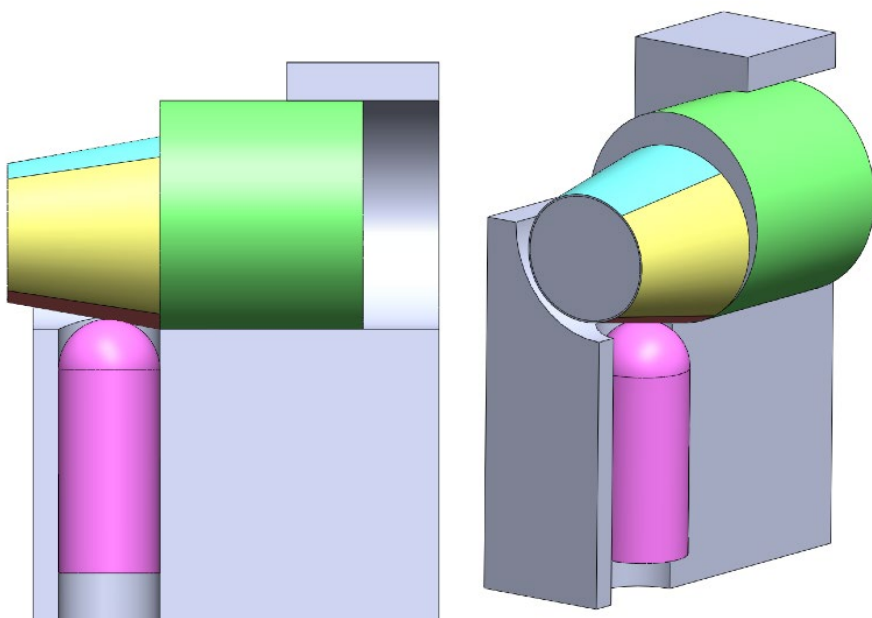
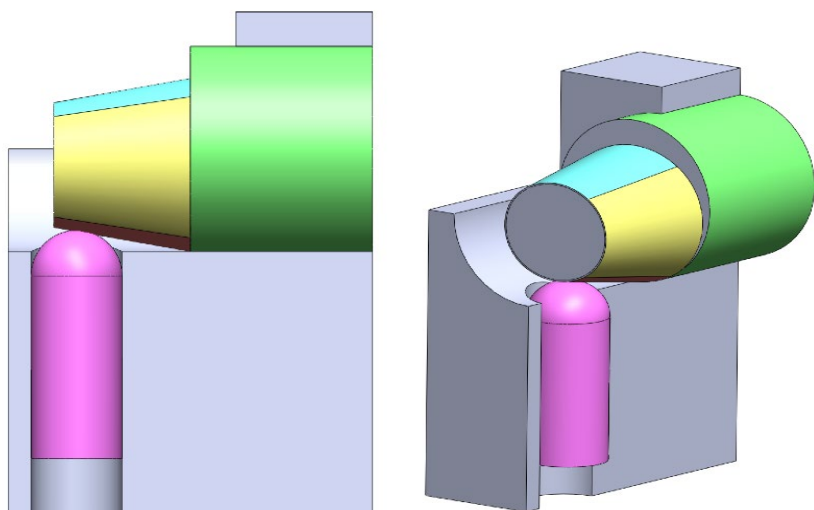
94. Below, I have created solid models illustrating in 3D such an exemplary arrangement, where tapered surfaces are added to a cam for fine adjustment of cam action. On the left is a simple eccentric cylinder cam and on the right is a set of tangent arcs to create three different cam radii regions for finer adjustment of cam action.

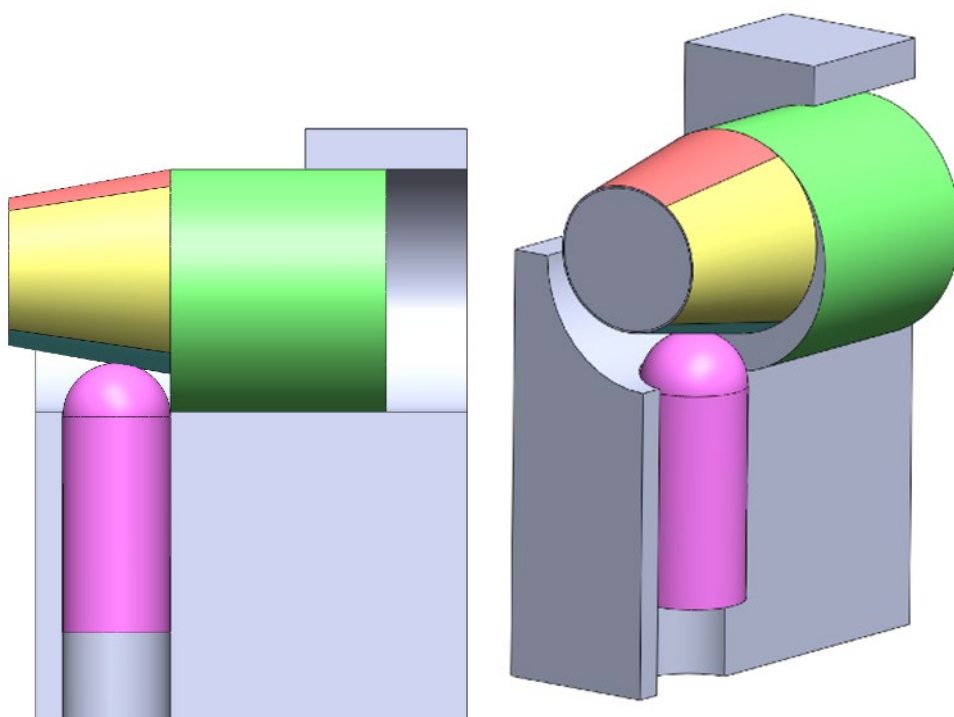
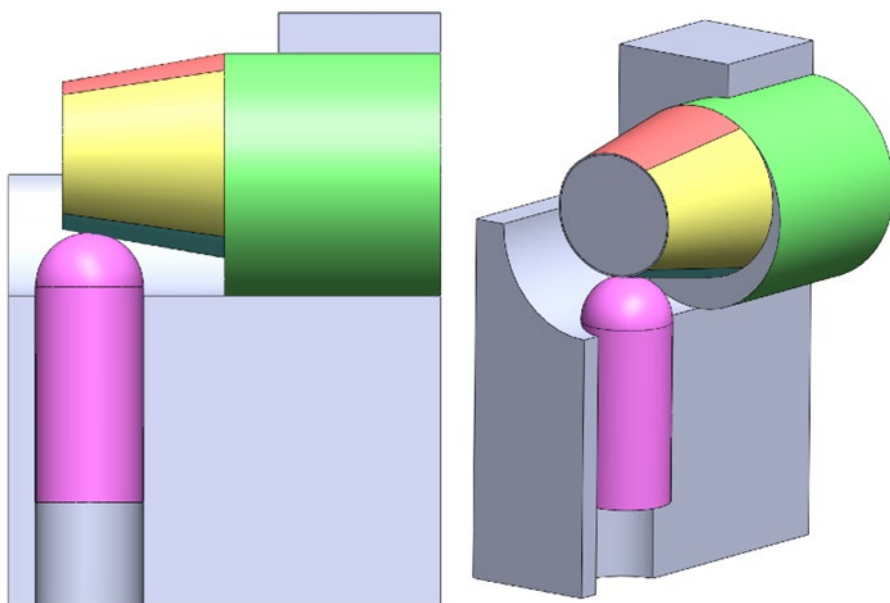


95. Either of these cam surfaces may also be tapered in accordance with JP'279 such that cam action (displacement of the rod end contacting the cam) may occur by rotation and/or axial motion of the camshaft (green):



96. Below I show a rod (shaft) in contact with the cam where the rod has been actuated by rotation of the camshaft and then also by axial motion of the camshaft as per JP'279's "adjuster assembly" mechanism, for example (not shown):





I created these cam models as a POSITA would, and they are drawn as continuous curved surfaces, but they could have more pronounced flat regions at specific rotation angles. Curved surfaces typically engage a flat, and the flat can be on the cam or the rod; it is a design choice. To feel a “click” or positive engagement at a particular position intended to give discrete axial positioning of a rod, the rod end can be flat, and there can be flats on the cam surfaces at specific circumferential positions. However, for long life (minimizing wear) the flat sections’ edges must be blended (fillets) with adjacent surfaces (sharp edges are to be avoided as they will wear quickly and release particles that are bad for a fluid system, for example).

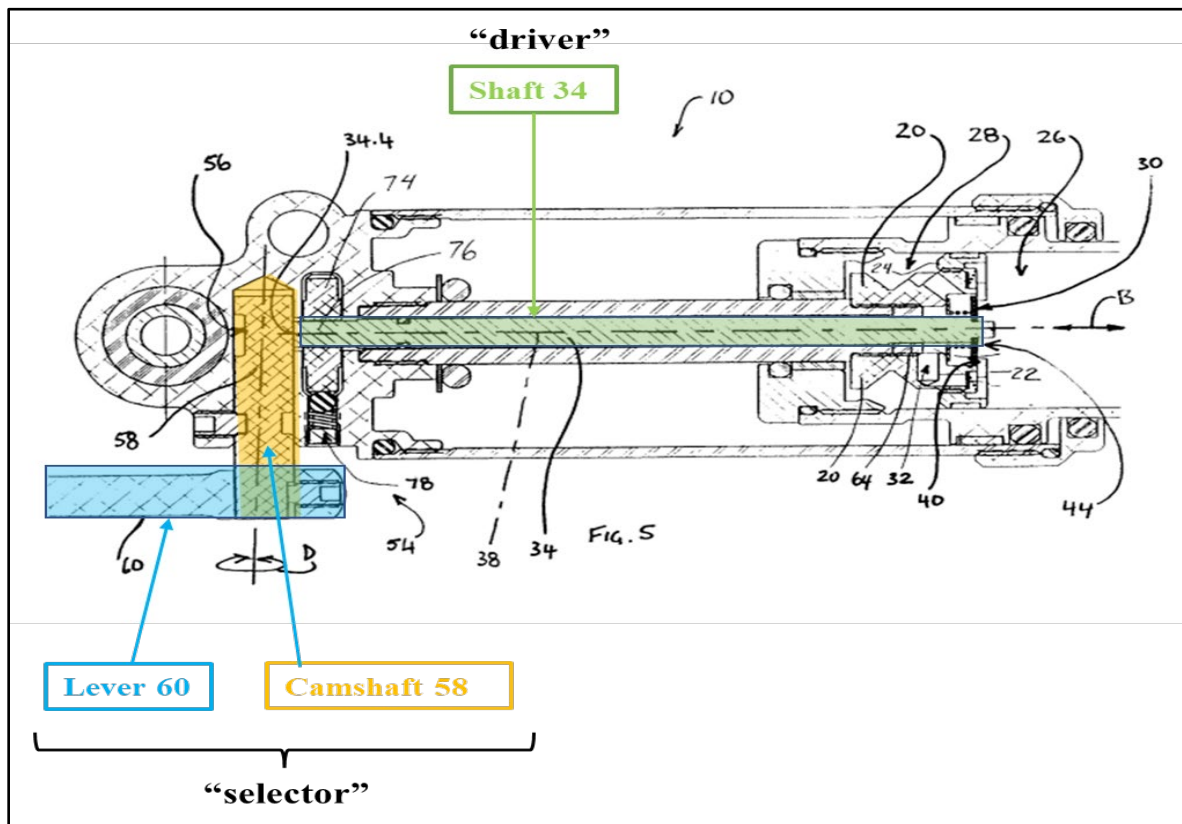
97. A skilled artisan would also have readily known how to implement a manual or motorized mechanism to axially move Fox’s camshaft 58 (modified to have JP’279’s tapered surface 44) along the camshaft’s longitudinal axis. *See* Ex. 1007, 5-6. In particular, a POSITA would have known to implement a mechanism such as Nagai’s stopper bolt 141 threaded into Fox’s camshaft housing to axially displace Fox’s camshaft 58, which would be similar to JP’279’s “adjuster assembly” (i.e., feed axle 50 engaged with slider 43). A POSITA would have been motivated to use Nagai’s stopper bolt 141 to axially move camshaft 58 to simplify and combine implementations of the elements of JP’279’s “adjuster assembly” and Nagai’s limiting mechanism into Fox’s suspension system to improve the compression damping adjustment mechanism of Fox.

98. The “adjuster assembly” of Fox, modified in view of JP’279 and Nagai to have JP’279’s tapered surface 44 and Nagai’s stopper bolt 141, varies the damping characteristics of Fox’s shock absorber 10 in the open compression damping position, i.e., when shaft 34 is in engagement with rotary cam surface 56 having tapered surface 44. Specifically, when shaft end 34.4 abuts the sloped surface 44, then any axial displacement of camshaft 58 varies the axial position of shaft 34 and thereby varies the contact pressure of shaft end 34.1 on restriction component 44, which in turn varies the damping characteristics of the open setting. Ex. 1005, 7:61-8:30; 5:47-53; Ex. 1007, 5-6. Moreover, adjustment of the compression damping characteristics in the open position is independent of the damping characteristics in the closed/lockout position, i.e., when shaft 34 is in engagement with the non-recessed cam surface of Fox’s camshaft 58, because fine-tuning of damping characteristics in the open position does not change any characteristics of the closed/lockout compression damping position.

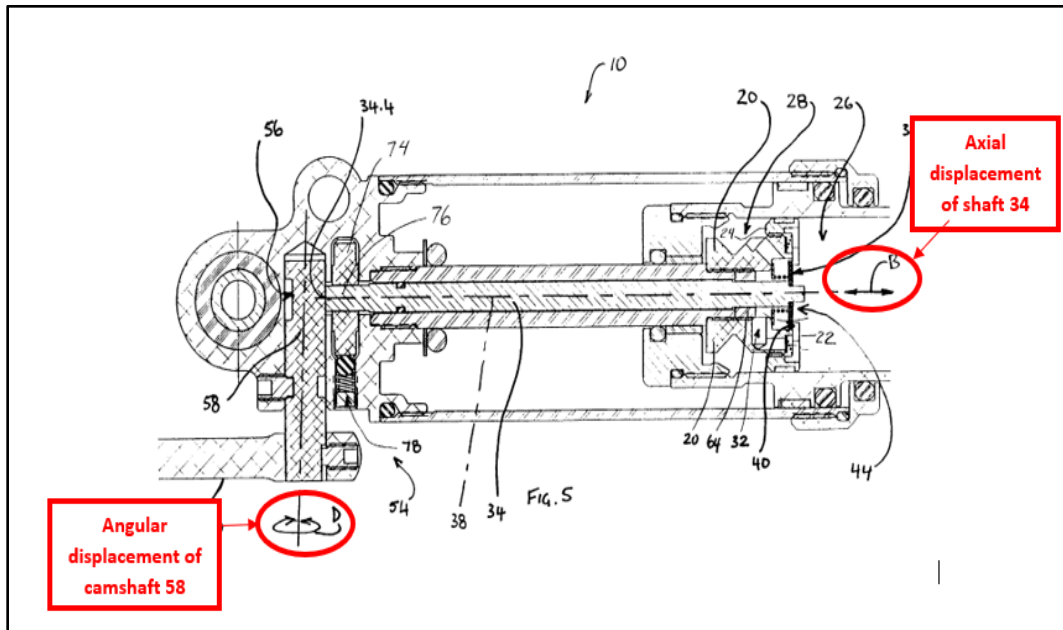
3. Claim 2 (“The actuator apparatus of claim 1 wherein the valve actuating assembly comprises: a driver movable to adjust the valve mechanism between various suspension settings; and a selector operatively connected to the driver and rotatable between the positions.”)

99. As discussed with reference to claim 1, Fox’s shock absorber 10 (the “suspension system”) comprises a shaft 34 and an actuator arrangement 54, which together form a “valve actuating assembly.” Shaft 34 functions as a “driver” that is

movable axially to adjust restriction component 44 (the “valve mechanism”) between an open and a closed/lockout position of compression damping. Ex. 1005, 7:61-8:2, 8:13-22, 8:31-34, 11:33-39. Actuator arrangement 54, which comprises camshaft 58 and lever 60, functions as a “selector” and can be rotated between the open and the closed/lockout compression damping positions to selectively adjust the axial position of shaft 34 along its axis 38 by operation of the lever (i.e., actuator arrangement 54 is a “selector operable connected to the driver”). Ex. 1005, 8:3-34.



Ex. 1005, Fig. 5 (annotations added).



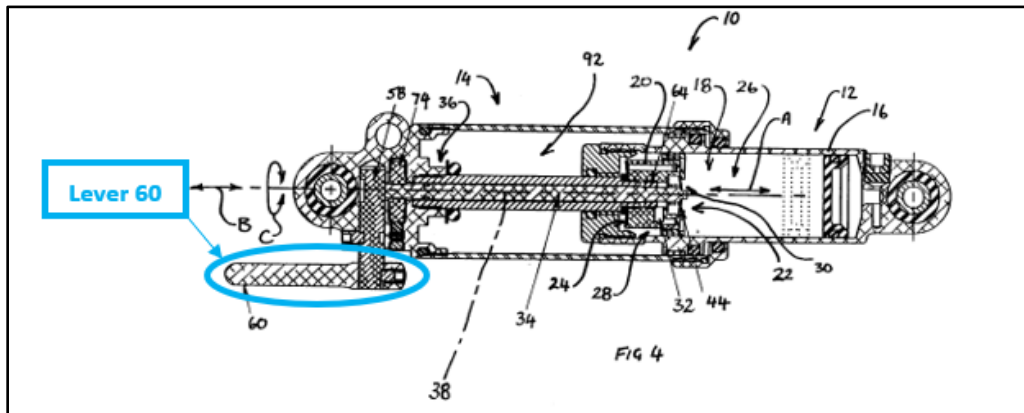
Ex. 1005, Fig. 5 (annotations added).

4. Claim 3

- a. **Claim term 3.1 (“The actuator apparatus of claim 2 wherein the selector comprises: a lever operable between the positions”)**

100. As discussed with reference to claim 2, actuator arrangement 54 (i.e., the “selector”) comprises a camshaft 58 and a lever 60 (the “lever”). Lever 60 is connected to camshaft 58. Ex. 1005, Figs 4-5, 8:22-25. Lever 60 is operable between the open and the closed/lockout compression damping positions, which angularly displaces camshaft 58 between the two compression damping positions. Ex. 1005, 8:3-30. Specifically, operation of lever 60 causes camshaft 58 to be rotated (angularly displaced) between the two compression damping positions, which then causes shaft 34 to be axially displaced along its longitudinal axis 38 to vary the

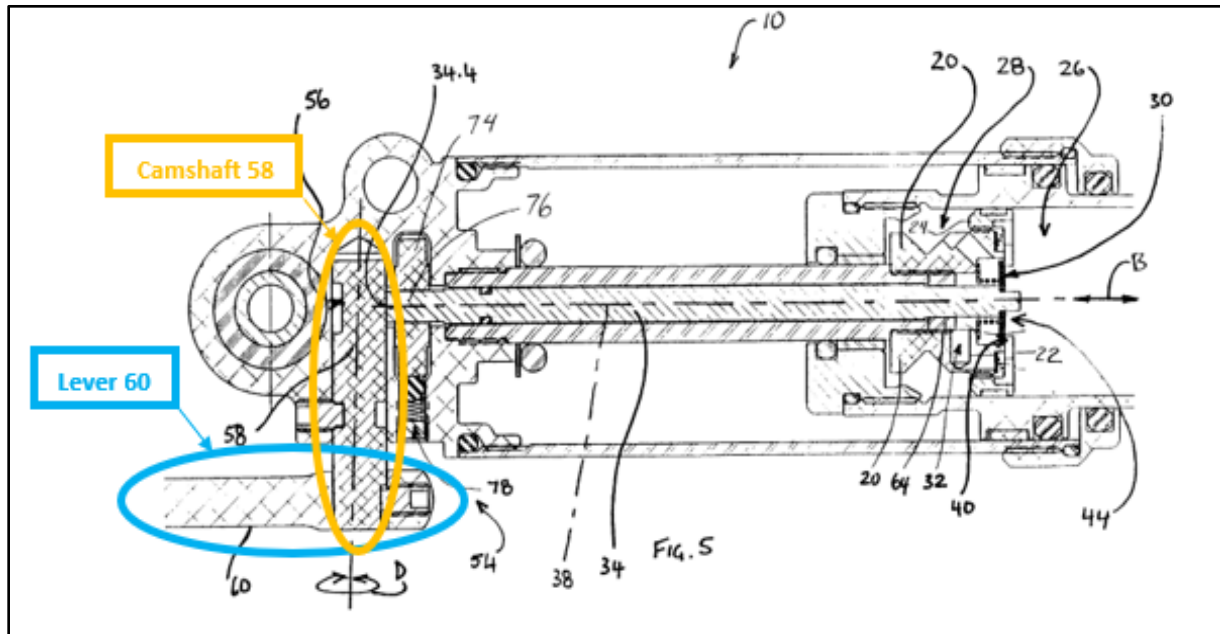
contact pressure on restriction component 44 (the “valve mechanism”), which then adjusts the compression damping characteristics of restriction component 44 to an open or a closed/lockout setting. Ex. 1005, 7:61-8:30.



Ex. 1005, Fig. 4 (annotation added).

- b. **Claim term 3.2 (“the camshaft operatively connected to the lever, and at least two cam surfaces corresponding to the positions of the lever, the cam surfaces configured to be engageable with the driver.”)**

101. Camshaft 58 (the “camshaft”) is operatively connected to lever 60 (the “lever”). Ex. 1005, Figs. 4-5, 8:22-25.

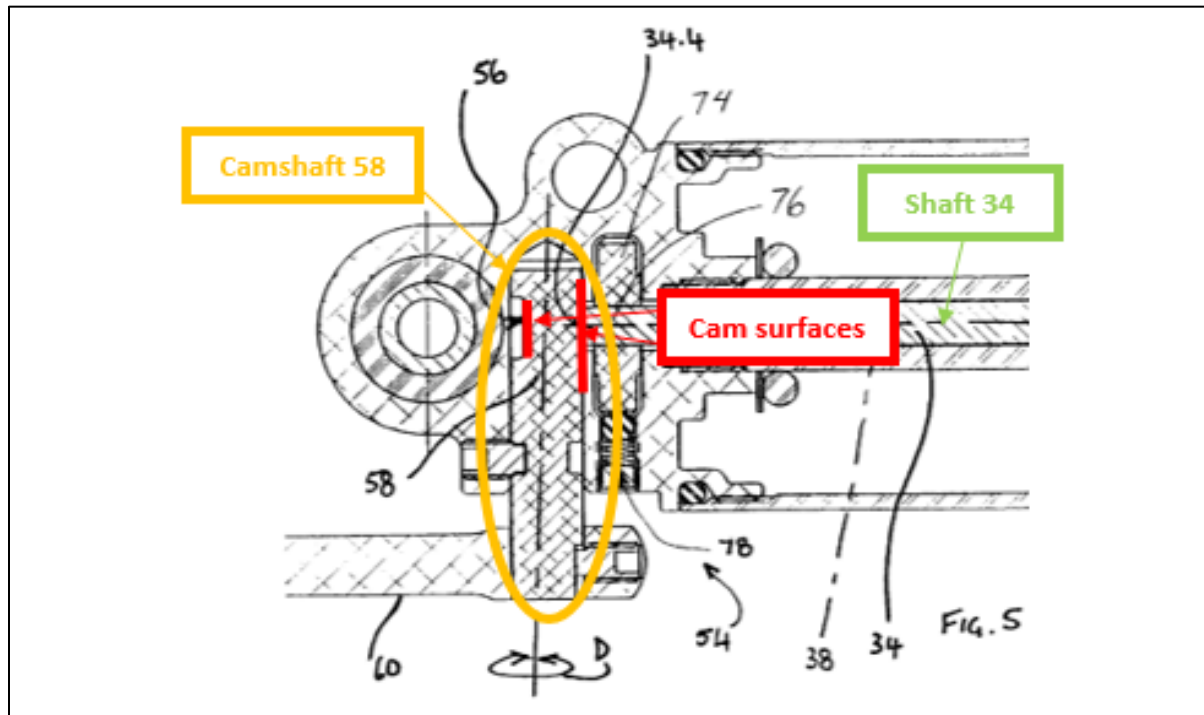


Ex. 1005, Fig. 5 (annotations added).

102. Camshaft 58 comprises at least two cam surfaces, a rotary cam surface 56 and a non-recessed cam surface, which correspond to the open and the closed/lockout compression damping positions of lever 60, respectively. These cam surfaces are configured to operatively engage with end 34.4 of shaft 34 (the “driver”).

Ex. 1005, 7:52-8:30. Specifically, when lever 60 is operated such that cam surface 56 of camshaft 58 abuts end 34.4 of shaft 34, then shaft 34 causes restriction component 44 to be in an open setting for compression damping.

Ex. 1005, 7:52-8:30. When lever 60 is operated such that a non-recessed portion of camshaft 58 abuts end 34.4 of shaft 34, as shown in Figure 4-6, then shaft 34 causes restriction component 44 to be in a closed/lockout setting for compression damping.



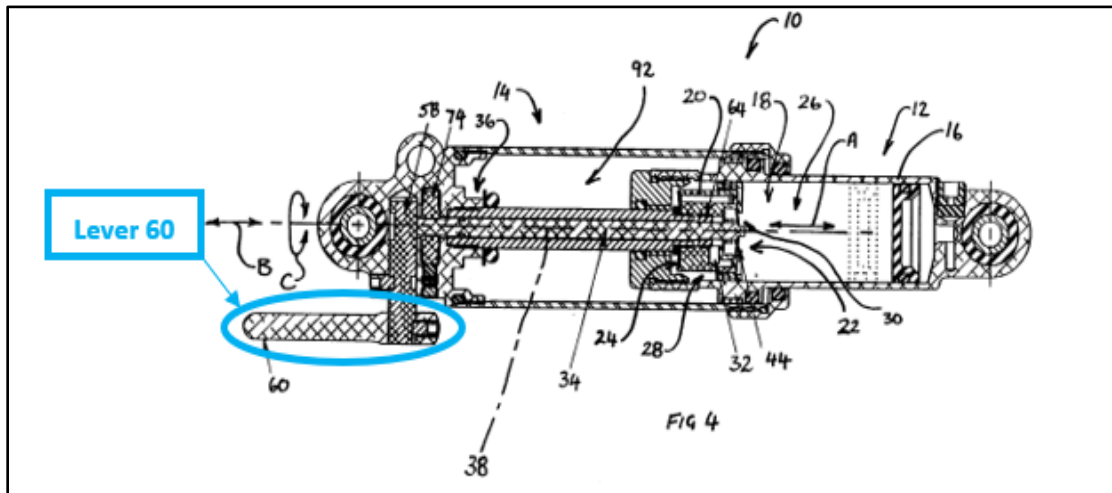
Ex. 1005, Fig. 5 (enlarged and annotations added).

5. Claim 7

- a. Claim term 7.1 (“The actuator apparatus of claim 2 wherein the selector comprises: a lever operable between the positions”)

103. As discussed with reference to claim 2, actuator arrangement 54 (i.e., the “selector”) comprises a camshaft 58 and a lever 60 (the “lever”). Lever 60 is operable between the open and the closed/lockout compression damping positions, which angularly displaces camshaft 58 between the two compression damping positions. Ex. 1005, 8:3-30. Specifically, operation of lever 60 causes camshaft 58 to be rotated (angularly displaced) between the two compression damping positions, which then causes shaft 34 to be axially displaced along its longitudinal axis 38 to vary the

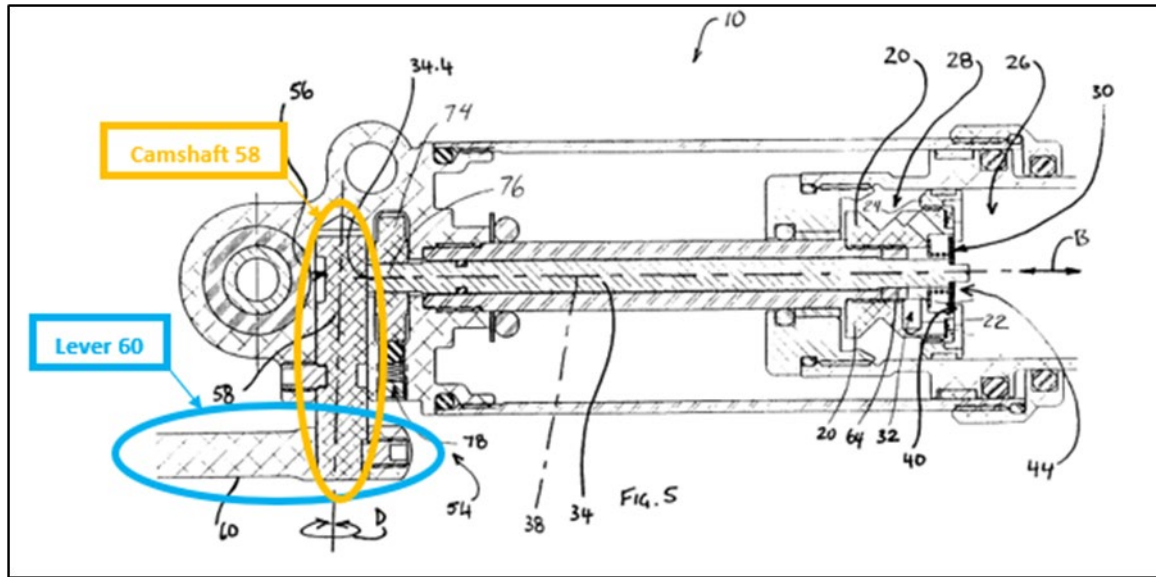
contact pressure on restriction component 44 (the “valve mechanism”), which then adjusts the compression damping characteristics of restriction component 44 to an open or a closed/lockout setting. Ex. 1005, 8:3-30.



Ex. 1005, Fig. 4 (annotation added).

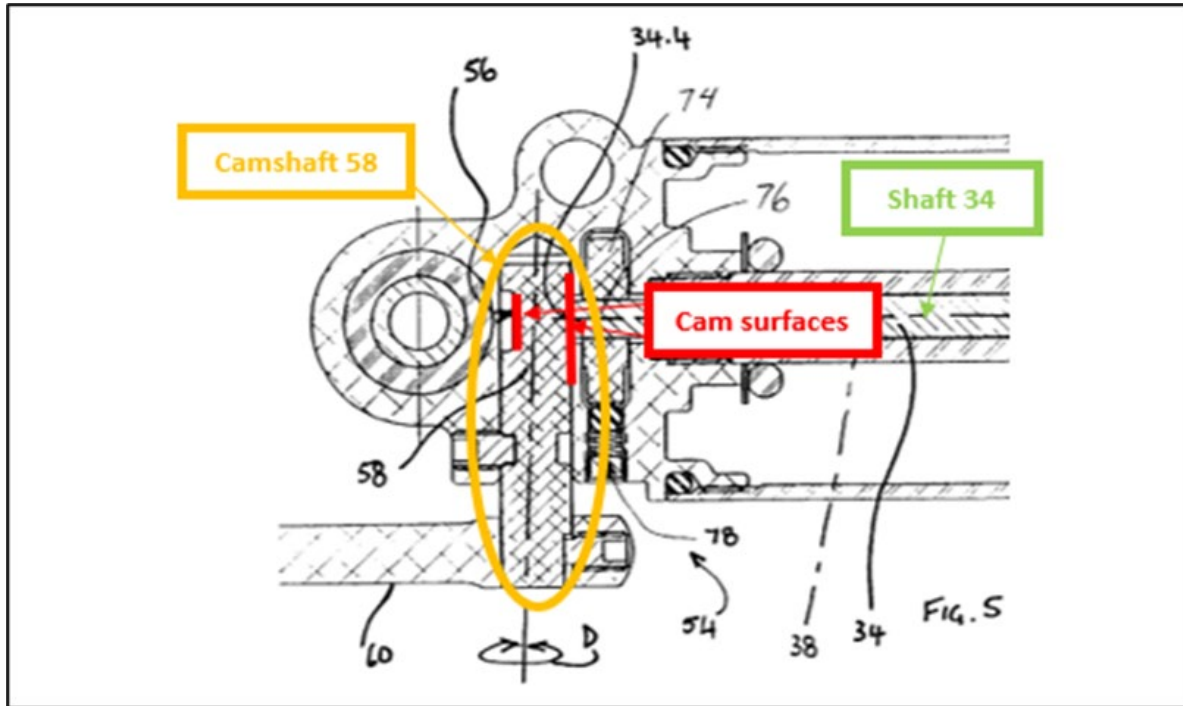
- b. **Claim term 7.2 (“the camshaft having at least two cam surfaces corresponding to the positions of the lever, the camshaft operatively connected to the lever”)**

104. Camshaft 58 (the “camshaft”) is operatively connected to lever 60 (the “lever”). Ex. 1005, Figs. 4-5, 8:22-25.



Ex. 1005, Fig. 5 (annotations added).

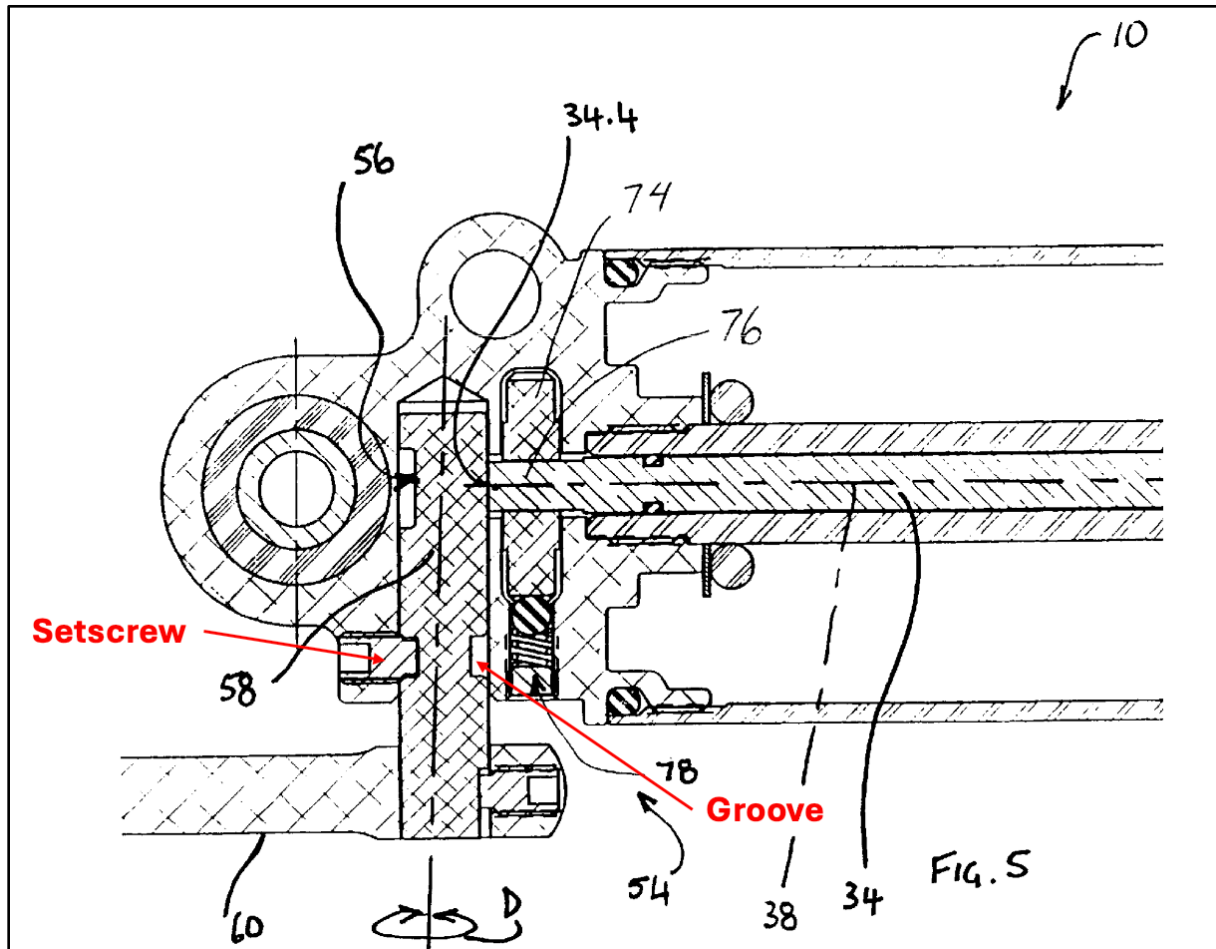
105. Camshaft 58 comprises at least two cam surfaces, a rotary cam surface 56 and a non-recessed cam surface, which correspond to the open and the closed/lockout compression damping positions of lever 60, respectively. These cam surfaces are configured to operatively engage with end 34.4 of shaft 34 (the “driver”). Ex. 1005, 7:52-8:30. Specifically, when lever 60 is operated such that cam surface 56 of camshaft 58 abuts end 34.4 of shaft 34, then shaft 34 causes restriction component 44 to be in an open setting for compression damping. Ex. 1005, 7:52-8:30. When lever 60 is operated such that a non-recessed portion of camshaft 58 abuts end 34.4 of shaft 34, as shown in Figure 4-6, then shaft 34 causes restriction component 44 to be in a closed/lockout setting for compression damping.



Ex. 1005, Fig. 5 (enlarged and annotations added).

- c. **Claim term 7.3 (“a stop element rotatable with the selector and configured to abut against the adjuster assembly to prevent over-rotation of the lever.”)**

106. Fox’s suspension system modified in view of JP’279 and Nagai includes Nagai’s stopper bolt 141 engaged with Fox’s camshaft 58 and camshaft housing and Nagai’s “stop element” (projection 135) on camshaft 158. Ex. 1008, 6:55-7:13, Figs. 7-8.



Ex. 1005, Fig. 5 (annotations added).

108. As discussed in Section VIII.B.1, a POSITA would have been motivated to combine the “stop element” disclosed in Nagai with Fox’s camshaft 58 (even though Fox discloses the setscrew and groove arrangement) to set an optimum range of rotation and prevent over-rotation of camshaft 58 beyond the optimum range. *See* Ex. 1005, Fig. 5. Because Nagai’s projection 135 is added to Fox’s camshaft 58, the “stop element” (i.e., projection 135) is rotatable with the “selector” (i.e., Fox’s camshaft 58 and lever 60). Further, projection 135 is configured to abut against stop

element 142 of Nagai's stopper bolt 141, which is part of the "adjuster assembly" (see claim term 1.2, above). Specifically, as part of the "adjuster assembly," Nagai's stopper bolt 141 could have been used to move Fox's camshaft 58 axially to finely adjust the damping characteristics of Fox's shock absorber 10 in the open setting for compression damping. A spring could have provided the return force, or stopper bolt 141 could have been threaded into the camshaft to axially move it just like JP'279's "adjuster assembly" (i.e., feed axle 50 engaged with slider 43).

109. Thus, Fox's shock absorber 10 modified in view of JP'279 and Nagai includes a "stop element" (Nagai's projection 135) rotatable with the "selector" (Fox's lever 60 and camshaft 58 having JP'279's tapered surface 44). The "stop element" is configured to abut against a portion of the "adjuster assembly" (Nagai's stopper bolt 141 having stop element 142) to set optimum limits and prevent over-rotation of the "lever" (lever 60).

6. Claim 8 ("The actuator apparatus of claim 7 wherein the cam surfaces are disposed substantially parallel to the camshaft axis.")

110. As shown in annotated Figure 5 of Fox below, the cam surfaces on camshaft 58, i.e., the rotary cam surface 56 and the non-recessed cam surface, are disposed substantially parallel to the longitudinal axis of camshaft 58.



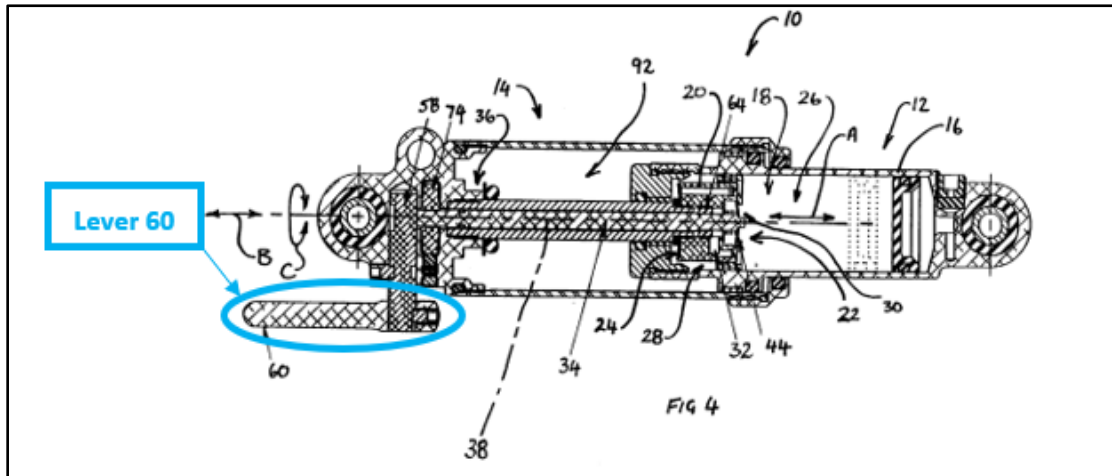
Ex. 1005, Fig. 5 (enlarged and annotations added).

7. Claim 10

- a. Claim term 10.1 (“The actuator apparatus of claim 2 wherein the selector comprises: a lever operable between the positions”)**

111. As discussed with reference to claim 2, Fox's actuator arrangement 54 (the "selector") comprises a camshaft 58 and a lever 60 (the "lever"). Lever 60 is operable between the open and the closed/lockout compression damping positions, which angularly displaces camshaft 58 between the two compression damping positions. Ex. 1005, Figs. 4-5, 8:3-30. Specifically, operation of lever 60 causes camshaft 58 to be rotated (angularly displaced) between the two compression damping positions,

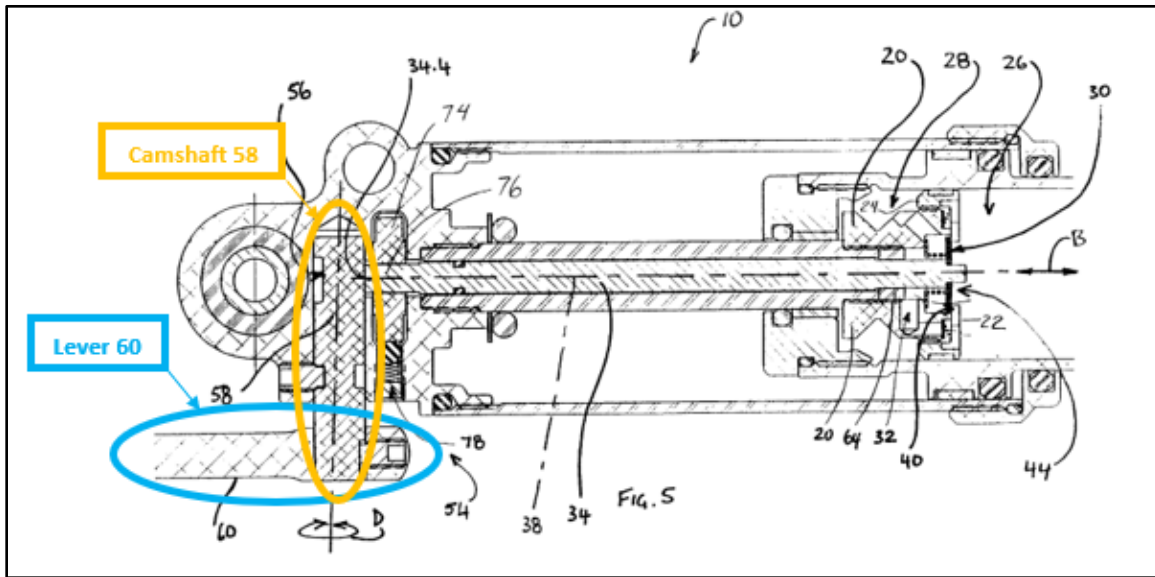
which then causes shaft 34 to be axially displaced along its longitudinal axis 38 to vary the contact pressure on restriction component 44 (the “valve mechanism”), which then adjusts the compression damping characteristics of restriction component 44 to an open setting or a closed/lockout setting. Ex. 1005, 8:3-30.



Ex. 1005, Fig. 4 (annotation added).

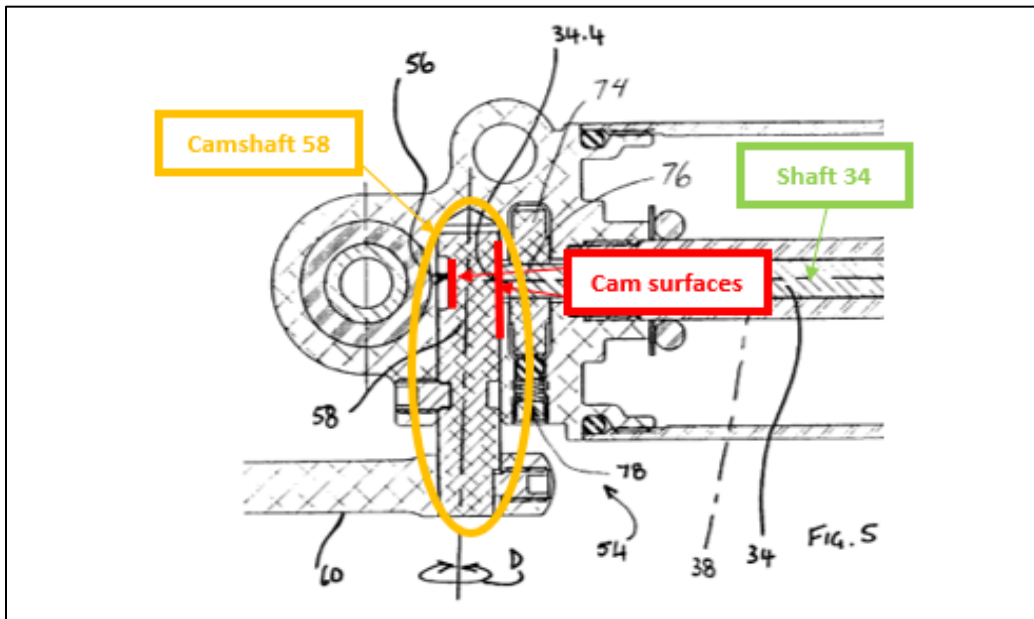
- b. **Claim term 10.2 (“the camshaft having a plurality of cam surfaces, at least one of said cam surfaces configured to be engageable with the driver, the cam surfaces corresponding to the positions of the lever, the cam surfaces disposed substantially parallel to the axis of the camshaft, the camshaft operatively connected to the lever.”)**

112. As discussed with reference to claim 2, lever 60 is operatively connected to camshaft 58. Ex. 1005, Figs. 4-5, 8:22-25. Camshaft 58 is angularly displaceable between the open and the closed/lockout compression damping positions by operation of lever 60. Ex. 1005, 8:3-30.



Ex. 1005, Fig. 5 (annotations added).

113. Camshaft 58 comprises at least two cam surfaces, a rotary cam surface 56 and a non-recessed cam surface, which correspond respectively to the open and the closed/lockout compression damping positions of lever 60, respectively. These cam surfaces are configured to operatively engage with end 34.4 of shaft 34 (the “driver”). Ex. 1005, 7:52-8:30. Specifically, when lever 60 is operated such that cam surface 56 of camshaft 58 abuts end 34.4 of shaft 34, then shaft 34 causes restriction component 44 to be in an open setting for compression damping. Ex. 1005, 7:52-8:30. When lever 60 is operated such that a non-recessed portion of camshaft 58 abuts end 34.4 of shaft 34, as shown in Figure 4-6, then shaft 34 causes restriction component 44 to be in a closed/lockout setting for compression damping.



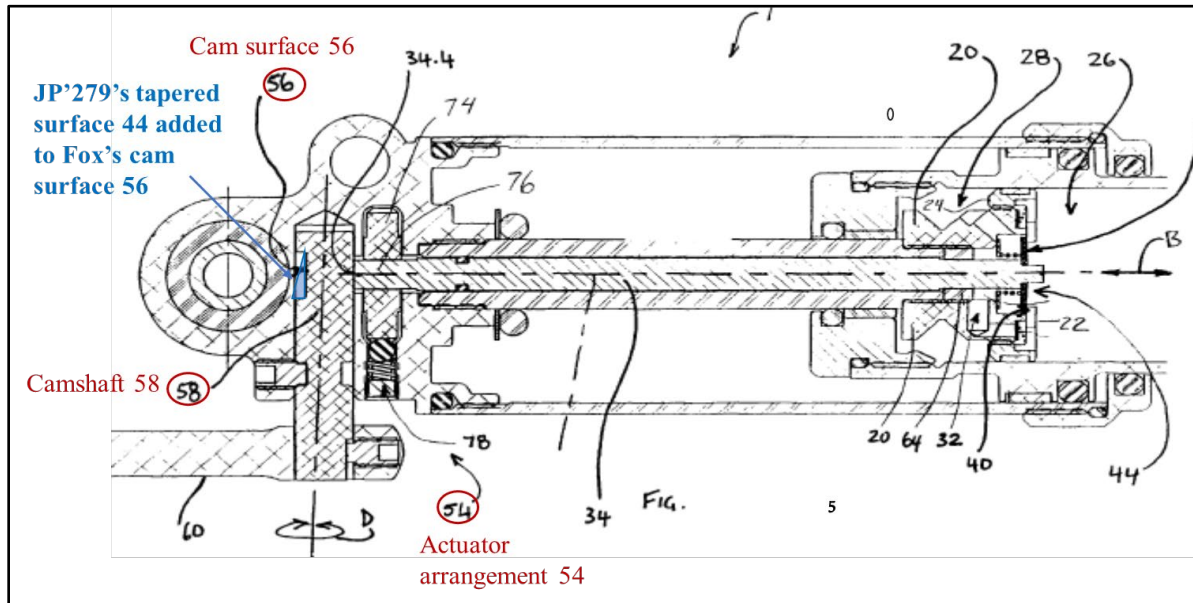
Ex. 1005, Fig. 5 (enlarged and annotations added).

114. As shown in annotated Figure 5 of Fox, above, the cam surfaces on camshaft 58, i.e., the rotary cam surface 56 and the non-recessed cam surface, are disposed substantially parallel to the longitudinal axis of camshaft 58.

8. Claim 11 (“The actuator apparatus of claim 10 wherein the adjuster assembly is operatively connected to the driver to position the driver relative to camshaft of the selector.”)

115. As discussed with reference to claim term 1.2, the “adjuster assembly” of Fox in view of JP’279 and Nagai comprises JP’279’s tapered surface 44 on Fox’s cam

surface 56 and Nagai's stopper bolt 141 to axially move Fox's camshaft 58.



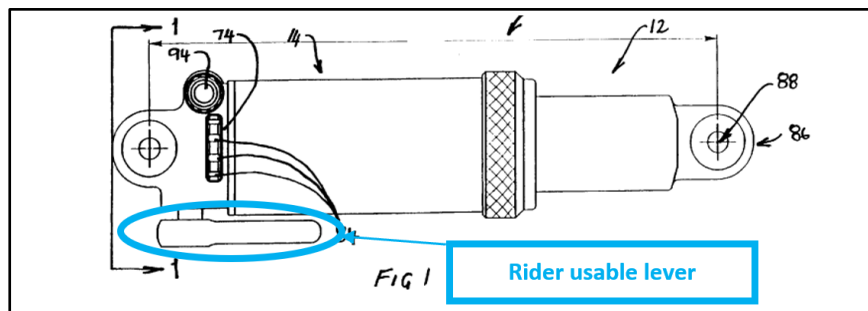
Ex. 1005, Fig. 5 (JP'279's tapered surface 44 added to Fox's camshaft 58).

116. As Fox's camshaft 58 is rotated by operation of lever 60, the cam surfaces on camshaft 58 engage with end 34.4 of shaft 34 (the "driver"). Ex. 1005, 7:52-8:30. Specifically, when lever 60 is operated such that tapered surface 44 on cam surface 56 abuts end 34.4 of shaft 34, then shaft 34 causes restriction component 44 to be in an open setting for compression damping. Ex. 1005, 7:52-8:30. When lever 60 is operated such that a non-recessed portion of camshaft 58 abuts end 34.4 of shaft 34, as shown in Figure 4-6, then shaft 34 causes restriction component 44 to be in a closed/lockout setting for compression damping. Further, operation of Nagai's stopper bolt 141 axially displaces camshaft 58 and changes the position at which shaft 34 engages with tapered surface 44. Thus,

tapered surface 44 and stopper bolt 141 of Fox's modified "adjuster assembly" are operatively connected to the "driver" (Fox's shaft 34) to position the "driver" relative to the camshaft of the "selector" (Fox's camshaft 58).

9. Claim 12 ("The actuator apparatus of claim 1 wherein the positions of the valve actuating assembly are rider-selectable positions.")

117. As discussed with reference to claim 3, camshaft 58 of the "valve actuating assembly" is angularly displaceable between the open and the closed/lockout compression damping positions by operation of lever 60. Ex. 1005, 8:3-30. Lever 60 enables a rider to select the damping settings because "the lever 60 is positioned outside the rest of the shock absorber 10 so as to enable a user selectively to adjust the axial position of the shaft 34 along its axis 38 by operation of the lever 60 outside the rest of the shock absorber 10." Ex. 1005, 8:25-30, Fig. 1. The axial position of shaft 34 changes the loading on resilient restriction component 44, and thereby how it responds to letting fluid (from pressure in the damping cylinder) to flow between the damping chambers and dissipate energy (dampen) in response to ride loads.



Ex. 1005, Fig. 1 (annotation added).

C. Ground 3: Claims 1-3, 7, 8, and 10-12 Are Rendered Obvious by Yi in View of JP'279 and Nagai

1. A POSITA would have been motivated to combine Yi, JP'279, and Nagai, and would have reasonably expected success in doing so

118. As discussed in Section VII.B, Yi discloses a shock absorber, specifically a shock absorber with adjustable damping characteristics for use in a bicycle. Ex. 1006, Title, Abstract, 2:66-3:6, Figs. 1-4 and 12. JP'279 also discloses a suspension system, specifically a hydraulic shock absorber. Ex. 1007, Title, 2, Fig. 1; *see also* Section VII.C. Nagai further discloses a suspension system, specifically a hydraulic damper. Ex. 1008, Fig. 5, 5:48-65; *see also* Section VII.D. Thus, Yi, JP'279, and Nagai are in the same technical field of suspension systems. Each of these references also teaches adjustment mechanisms for controlling compression damping characteristics of the suspension system. Ex. 1006, 1:7-8, 5:38-57; Ex. 1007, 1; Ex. 1008, 1:10-13. A POSITA would therefore have considered Yi, JP'279, and Nagai together when investigating adjustment mechanisms for controlling compression damping in a suspension system.

119. It would have been obvious to a POSITA to combine Yi's "valve actuating assembly" and elements of JP'279's "adjuster assembly," which comprises a slider 43 with a tapered surface 44, to allow the damping characteristics corresponding to at least one of the compression damping setting of Yi's "valve actuating assembly"

to be finely adjusted independently of the damping characteristics corresponding to another position of the “valve actuating assembly.” This is because a POSITA in November 2004 would have recognized that modification of Yi in view of JP’279 would provide an additional range of damping adjustments, specifically the “fine adjustment” offered by JP’279’s slider mechanism. Ex. 1007, 6. The solid model images I created above of tapered cylindrical surface cams illustrate how a POSITA would implement this combination to achieve finely tunable cam action.

120. Specifically, Yi notes that “conventional shock absorbers normally provide a limited range of damping effects and cannot be adjusted to provide a wider range of damping effects for different road conditions.” Ex. 1006, 1:13-16. Relatedly, JP’279 discloses capabilities of “fine adjustment.” Ex. 1007, 3 and 6. A POSITA would have understood, based on the disclosure of Yi, that fine adjustment of damping characteristics is desired because Yi states “the shock absorber of this invention can have various damping effects so as to adapt to different road conditions, thereby eliminating the drawback associated with the prior art. . . . [I]t is apparent that various modifications and variations can be made without departing from the spirit of the present invention.” Ex. 1006, 5:66-6:7.

121. Implementation of elements of JP’279’s adjuster assembly onto Yi’s shock absorber 6 would have been well within the skills of a POSITA in November 2004. Indeed, a skilled artisan would have simply needed to implement JP’279’s tapered

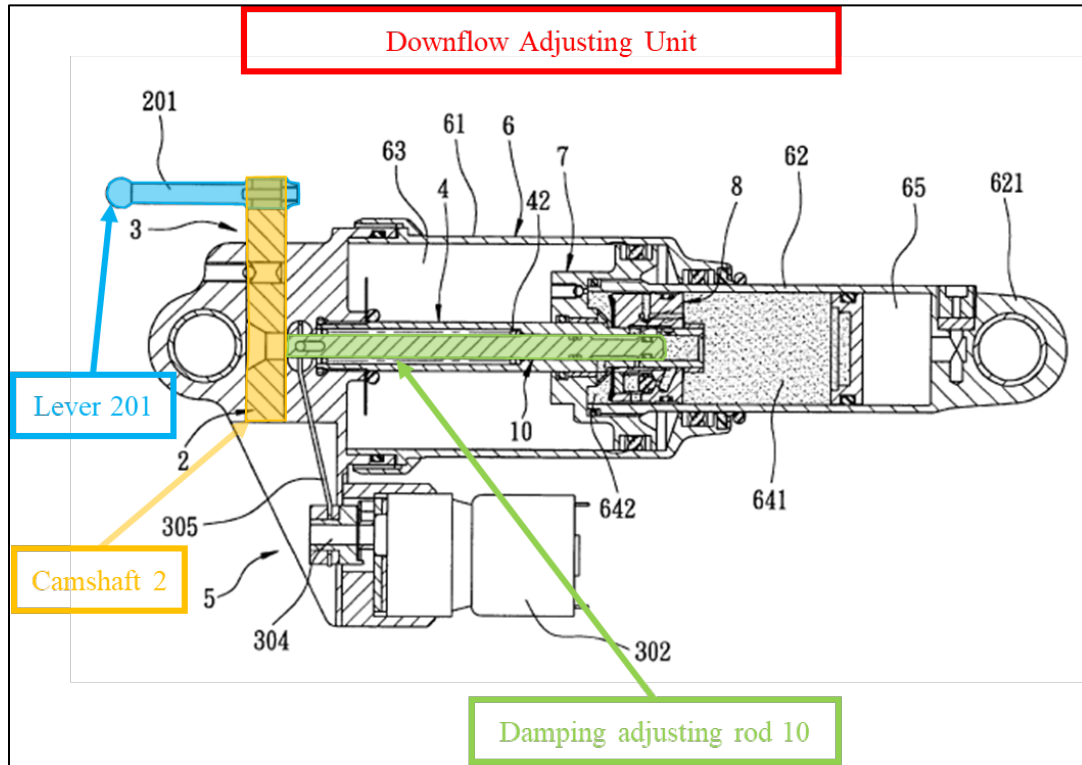
surface 44 on Yi's eccentric camshaft 2, for example, along a portion of the shaft that corresponds to the second axial position of Yi's damping adjusting rod 10, such that the position at which Yi's rod 10 engages with camshaft 2 may be varied axially (i.e., along the camshaft axis), and thereby finely adjust the medium-velocity flow characteristics of the damper fluid during a compression stroke. A POSITA would also have readily known how to axially move Yi's camshaft 2 (modified to have tapered surface 44) along the camshaft's longitudinal axis using a manual push-pull mechanism actuatable by a rider, or with a motorized mechanism as taught by JP'279. *See* Ex. 1007, 5-6. Indeed, a person skilled in the art would have known to use a mechanism such as Nagai's stopper bolt 141, which may be configured to engage with Yi's camshaft 2, and would have been used to advance and retract the camshaft along its longitudinal axis (as I have discussed above).

122. A POSITA would also have been motivated to include Nagai's limiting means, i.e., projection 35 and stopper 142, in Yi's suspension system to limit the maximum angular displacement of Yi's camshaft 2 (eccentric shaft) or to set the angular displacement to within an optimum range. As Nagai notes, incorporating a limiting means would ensure that "no inappropriate damping forces are generated by the damper assembly." Ex. 1008, 2:22-40. A POSITA would also understand from the disclosure of Nagai that including a limiting means would ensure "optimum damping forces." Ex. 1008, 2:22-40.

123. Further, modifying Yi's camshaft 2 to have a projection 135 configured to engage with Nagai's stopper 142 would have been well within the skills of a POSITA in November 2004. A POSITA would have readily known from the disclosures of Yi and Nagai that Nagai's stopper bolt 141 could have been easily integrated with Yi's camshaft 2, and that stopper bolt 141 would have served the dual purpose of (1) axially displacing Yi's camshaft 2 for fine-tuning the compression damping forces, and (2) setting the maximum or optimum damping forces. *See* Ex. 1008, 6:55-7:13. A POSITA would have been motivated to use Nagai's stopper bolt 141 to axially move camshaft 58 to simplify and combine implementations of the elements of JP'279's "adjuster assembly" and Nagai's limiting mechanism into Fox's suspension system to improve the compression damping adjustment mechanism of Fox.

124. In an exemplary embodiment of Yi's shock absorber modified in view of JP'279 and Nagai, Yi's camshaft 2 would include the tapered surface 44 of JP'279's slider 43 and the camshaft would be actuated axially by Nagai's stopper bolt 141. Rotation of Yi's handle 201 would operate Yi's down-flow adjusting unit 3 (shown below with annotations) to select between one of three axial positions of Yi's damping adjusting rod 10, which correspond to three compression damping settings. Ex. 1006, 5:38-57. Nagai's stopper bolt 141 would be used to axially displace Yi's camshaft 2, which would vary the position at which rod 10 would abut tapered

surface 44, thereby finely adjusting the damping characteristics at one of the three damping settings.



Ex. 1006, Fig. 12 (annotations added).

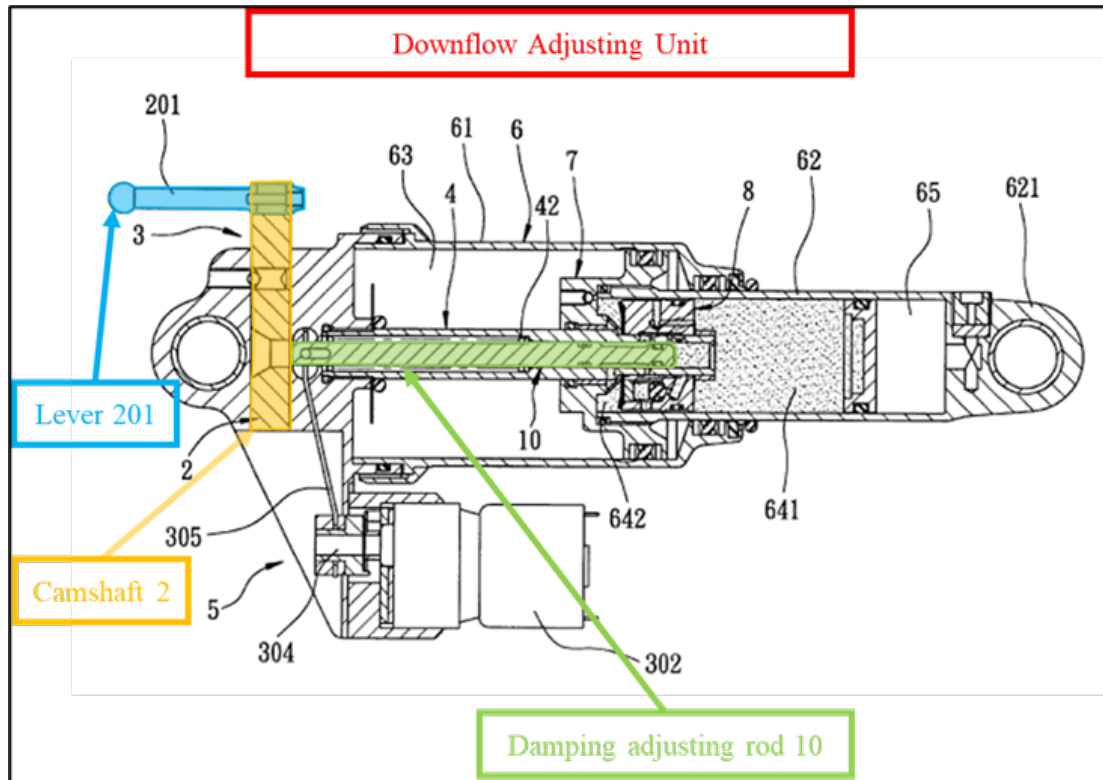
125. A POSITA would have understood that a combination of Yi, JP'279, and Nagai would have been obvious and desirable, and a POSITA would have reasonably expected success when modifying Yi's shock absorber with JP'279's adjuster assembly and Nagai's limiting means because the modifications described above are mere combinations of known prior art elements according to known methods to yield predictable results. Indeed, the modifications discussed above are simple mechanical adaptations and substitutions that are well described in the prior

art, and therefore, a POSITA would have readily expected success in making those modifications to yield the known benefits of fine-tuning the compression damping characteristics of Yi's suspension system and setting a maximum or optimum range of damping forces.

2. Independent Claim 1

a. Claim term 1.0 (“An actuator apparatus for controlling a valve mechanism of a suspension system, the actuator apparatus comprising:”)

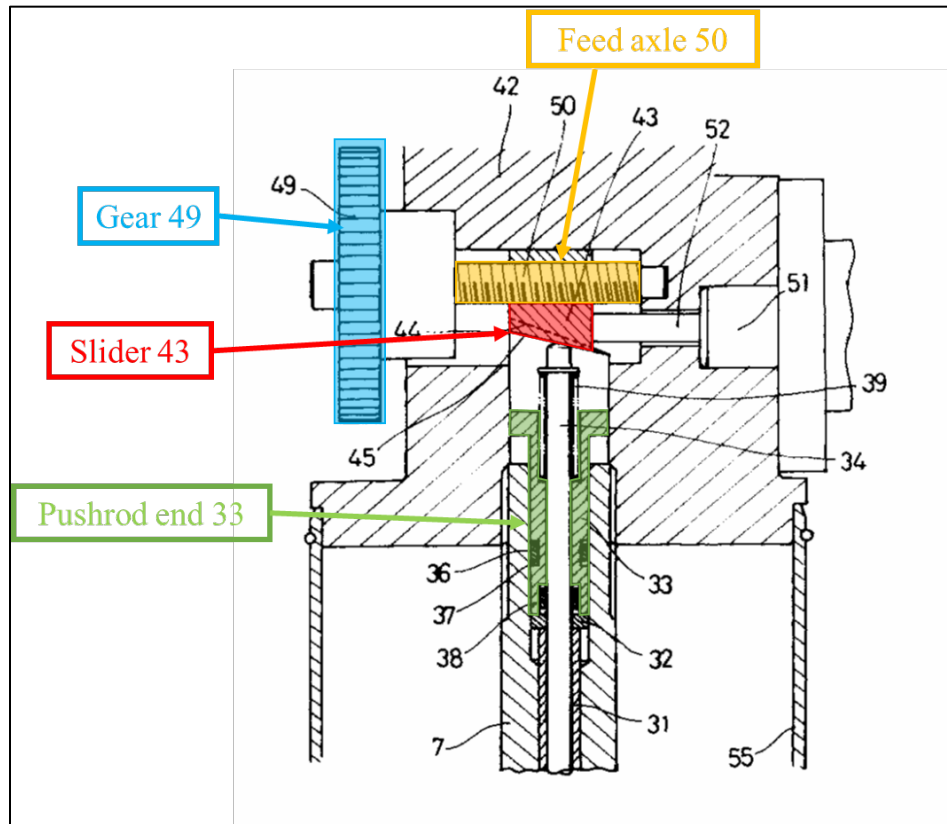
126. Yi discloses a shock absorber 6, which is a “suspension system.” Ex. 1006, Title, Abstract, 2:66-3:6, Figs. 1-4, 11, and 12. Yi further discloses an “actuator apparatus,” comprising a camshaft 2, damping adjusting rod 10, and handle 201 for controlling a “valve mechanism.” Ex. 1006, 5:38-46, 5:51-57. The “valve mechanism” of Yi comprises two valves (851, 831) associated with two down-flow channels (85, 87) that operate during a compression stroke. Ex. 1006, 3:34-65. Axial movement of damping adjustment rod 10 either: (1) adjusts (i.e., opens or closes) the medium-velocity damper-fluid flow through an opening 83 and down-flow channel 87 associated with valve 831, or (2) allows high-velocity damper-fluid flow through openings 83 and 84 and down-flow channel 87. Ex. 1006, 3:60-65, 4:18-49, 5:38-46.



Ex. 1006, Fig. 2 (annotations added).

127. JP'279 discloses a hydraulic shock absorber, which is a "suspension system."

Ex. 1007, Title, 1, 2. JP'279 further discloses an "adjuster assembly," comprising gear 49, feed axle 50, slider 43, and pushrod end 33, which facilitates fine adjustment of the compression damping characteristics of JP'279's shock absorber. Ex. 1007, 4.



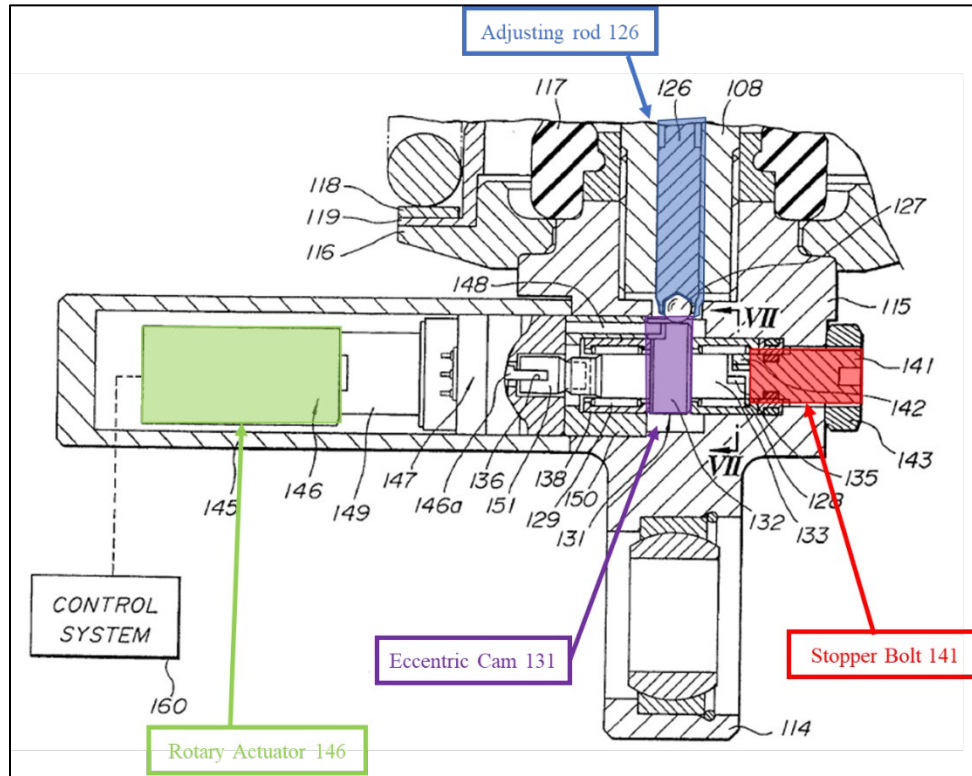
Ex. 1007, Fig. 4 (annotations added).

128. Nagai further discloses a damper assembly, which is a “suspension system.”

Ex. 1008, 5:48-65. Nagai’s damper assembly includes an “actuator apparatus” that comprises a rotary actuator 146, eccentric cam 131, and adjusting rod 126.

Ex. 1008, 6:32-46, 7:56-60. “When the rotary actuator 146 is energized, the eccentric cam 131 is rotated to axially move the adjusting rod 126 for thereby varying the cross-sectional area of the bypass oil passage 125. Therefore, the damping forces generated by the piston 110 can be adjusted by the adjusting rod 126.” Ex. 1008, 7:56-60. Nagai’s “actuator apparatus” also includes a

stopper bolt 141, which is configured to engage with cam 131 and limit angular displacement of the cam. Ex. 1008, 6:55-7:13.

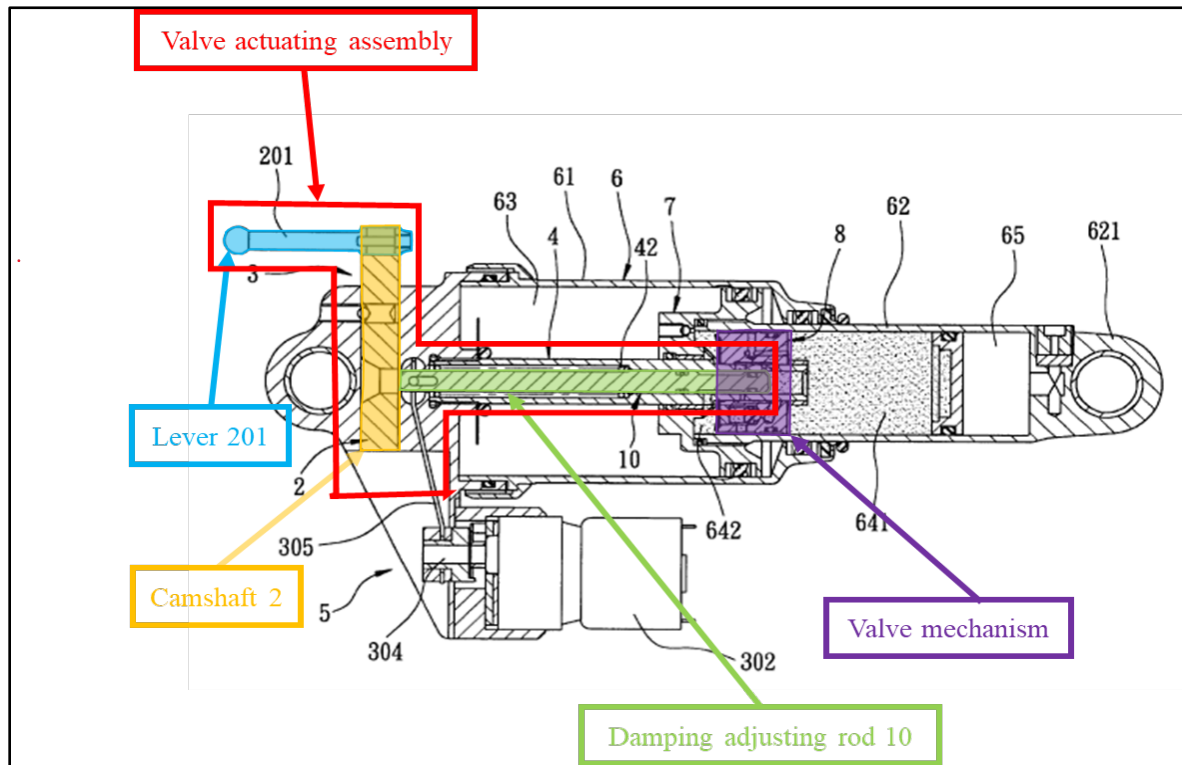


Ex. 1008, Fig. 6 (annotations added).

- b. **Claim term 1.1 (“a valve actuating assembly operatively connected to the valve mechanism, the valve actuating assembly including a camshaft rotatable between at least two positions to adjust the valve mechanism between various suspension settings”)**

129. Yi’s actuator apparatus includes a “valve actuating assembly” operatively connected to the “valve mechanism,” as shown below in annotated Fig. 12 of Yi. Ex. 1006, Fig. 12, 3:1-5:46. The “valve actuating assembly” includes a handle 201,

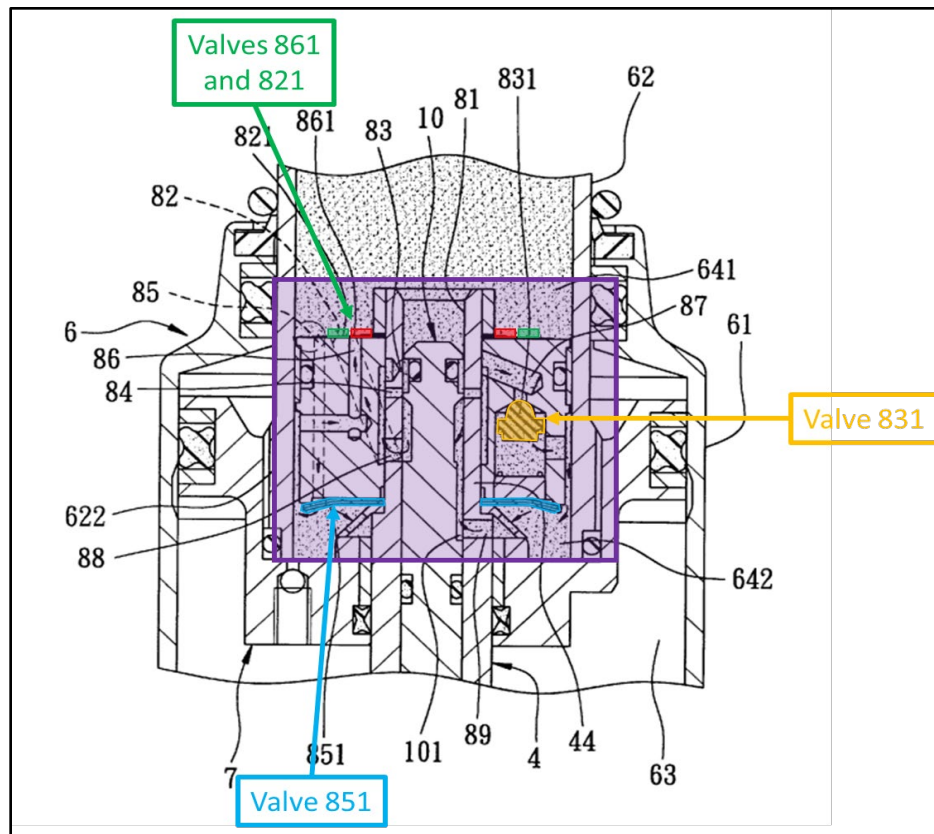
a camshaft (eccentric shaft 2) operable by rotating handle 201, and a damping adjusting rod 10 operatively engaged with camshaft 2. Ex. 1003, 5:51-57. Specifically, rotation (turning) of camshaft 2 moves damping adjusting rod 10 in an axial direction to one of the first, second, and third positions. Ex. 1006, 5:38-45.



Ex. 1006, Fig. 12 (annotations added).

130. Yi discloses a “valve mechanism,” as shown below in annotated Fig. 4 of Yi, which is operatively connected to the “valve actuating assembly.” Ex. 1006, Fig. 4, 3:1-4:57. Valve 851 is associated with a down-flow channel 85 and permits unrestricted low-velocity flow of damper fluid during a compression stroke. Ex. 1006, 3:48-65. Valve 831 is associated with a down-flow channel 87 and permits

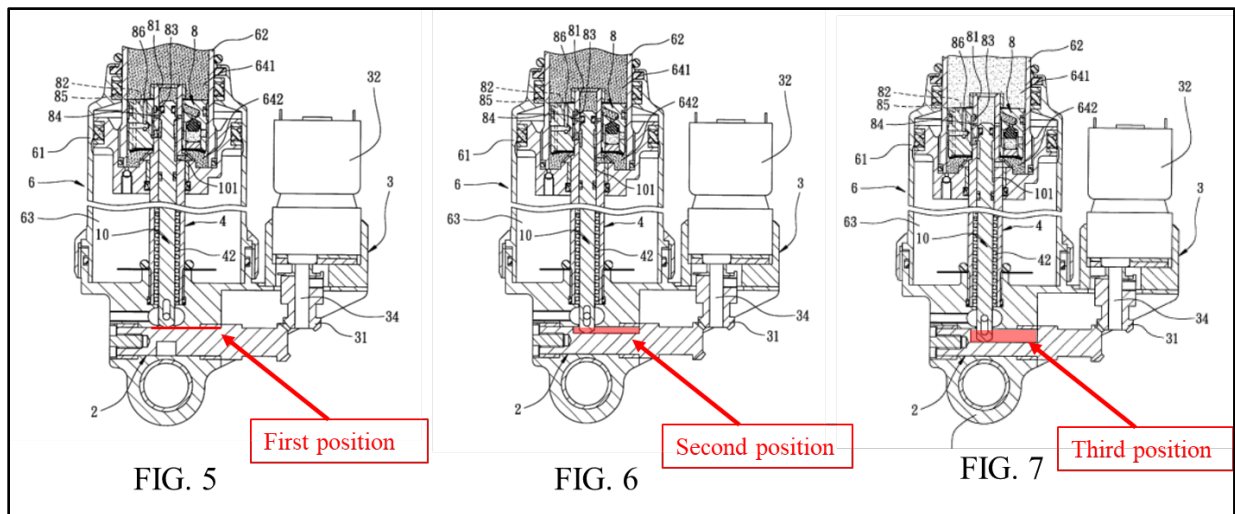
medium-velocity flow of damper fluid during compression depending on a position of damping adjusting rod 10. Ex. 1006, 3:60-65. Specifically, angular displacement (rotation) of camshaft 2 results in axial displacement of rod 10, which varies a position of rod 10 against openings 83 and 84 which are associated with down-flow channel 87 and valve 831, and thereby adjusts the flow velocity of damper fluid through channel 87 during a compression stroke and thus varies the compression damping characteristics of Yi's shock absorber 6. Ex. 1006, 3:60-65, 4:31-49.



Ex. 1006, Fig. 4 (annotations added).

131. Yi further discloses that camshaft 2 is rotatable between at least three compression damping positions to adjust the “valve mechanism” (specifically, Yi’s

valves 851 and 831) between three damping characteristics. Ex. 1006, 3:48-65, 5:38-45, Figs. 5-7. In the first setting associated with the first axial position of damping adjusting rod 10, only down-flow channel 85 and valve 851 are open and they permit unrestricted low-velocity flow of damper fluid during a compression stroke (in this position medium- and high-velocity flows are not permitted because openings 83 and 84 are closed). Ex. 1006, 3:48-59, 4:18-25, 4:40-42. In the second setting associated with a second axial position of rod 10, the rod moves away from an opening 83, so as to permit medium-velocity flow of damper fluid via a channel 87 associated with valve 831 during a compression stroke. Ex. 1006, 3:60-65, 4:25-30. And in the third setting associated with a third axial position of rod 10, the rod moves away from openings 83 and 84, so as to permit high-velocity flow of damper fluid via a channel 87 during a compression stroke. Ex. 1006, 4:39-49.



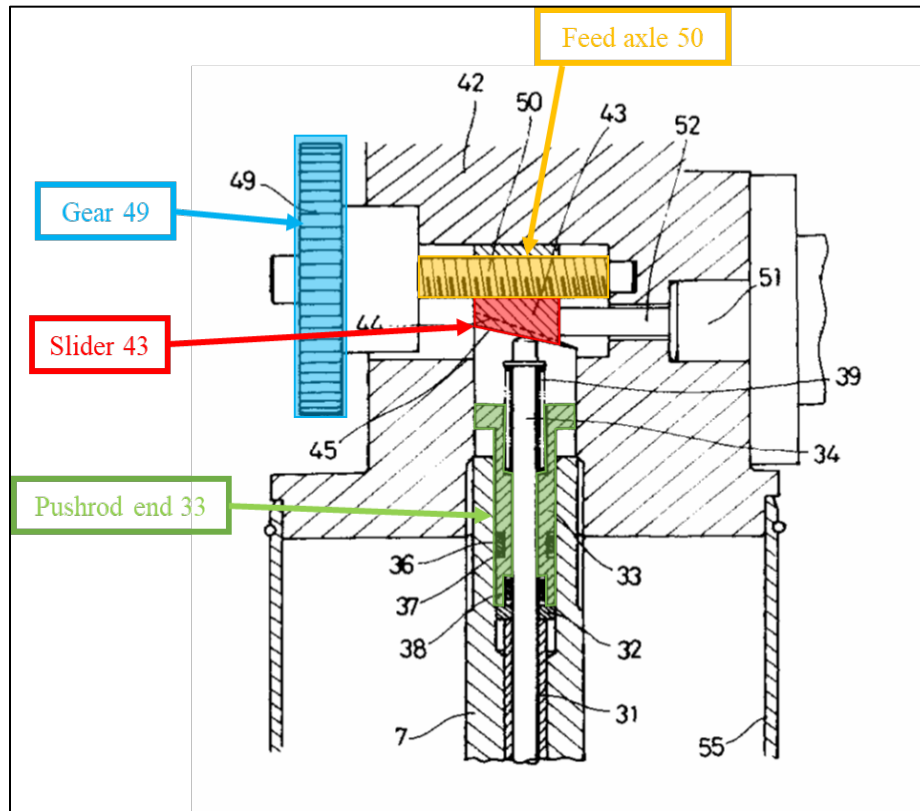
Ex. 1006, Figs. 5-7 (annotations added).

- c. **Claim term 1.2 (“an adjuster assembly operatively connected to the valve actuating assembly for adjusting the damping characteristics corresponding to at least one of the positions of the valve actuating assembly independently of the damping characteristics corresponding to another position of the valve actuating assembly.”)**

132. A POSITA would have been motivated to modify the suspension system of Yi to include an “adjuster assembly” that is separate from Yi’s “valve actuating assembly” (i.e., handle 201, camshaft 2, rod 10) to finely adjust the compression damping characteristics in either the second or third compression damping settings. Specifically, a person skilled in the art would have readily understood that although Yi’s shock absorber 6 allows adjustment of damping between three settings when damping adjusting rod 10 is in engagement with camshaft 2, an “adjuster assembly” as taught by JP’279 would allow fine-tuning of the damping characteristics beyond that possible in Yi’s shock absorber.

133. As previously described in Section VIII.B.2.c (Ground 2), the “adjuster assembly” of JP’279 includes a slider 43 with tapered surface 44 and a mechanism for axially displacing slider 43, including gear 49 and feed axle 50, as shown below.

Ex. 1007, 4-6, Fig. 4.



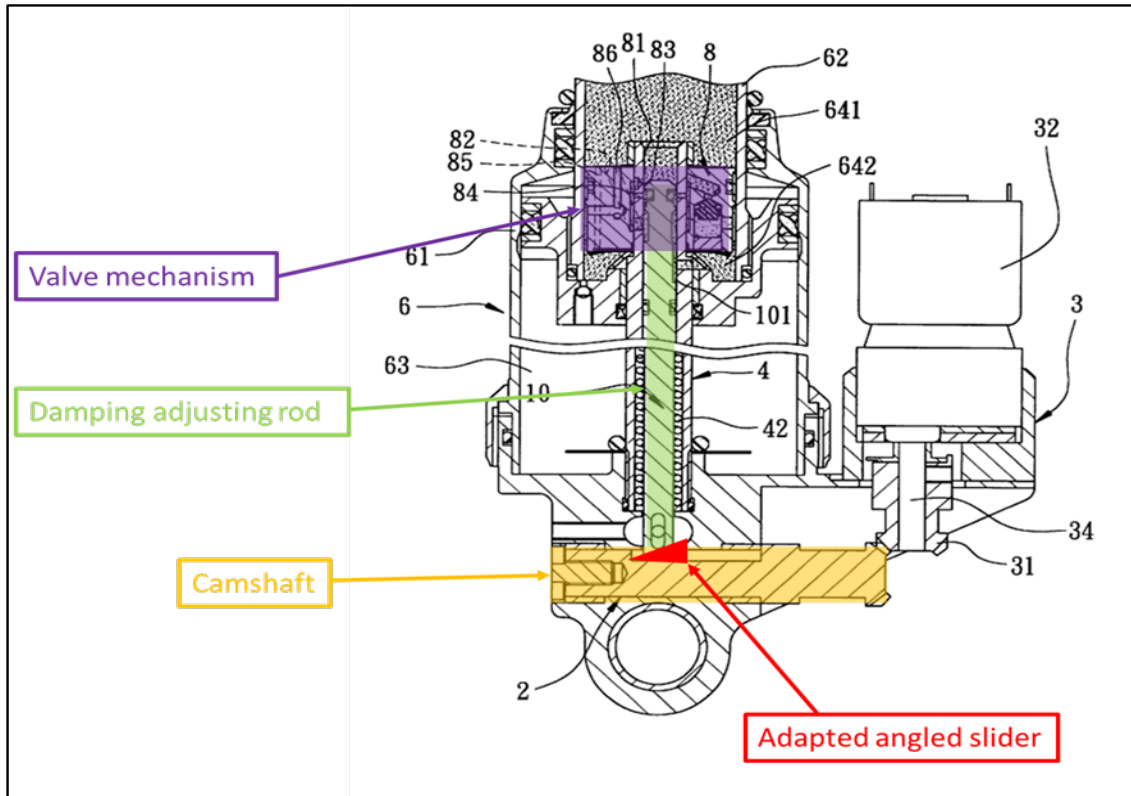
Ex. 1007, Fig. 4 (annotations added).

134. A POSITA would have found it obvious to implement elements of JP'279's "adjuster assembly" within Yi's actuating assembly to fine-tune the medium-velocity flow by adding tapered surface 44 within the cam surface of camshaft 2 that corresponds to the second compression setting (i.e., second axial position of rod 10).² A POSITA would have also readily known how to axially move Yi's camshaft

²A POSITA would also have readily known to fine-tune the high-velocity flow by adding tapered surface 44 within the cam surface of camshaft 2 that corresponds to

along a longitudinal axis using gear 49 and feed axle 50, as taught by JP'279, or by using an ancillary mechanism. *See* Ex. 1006, Figs. 5-6; Ex. 1007, Fig. 4. Indeed, a POSITA would have known to use a mechanism such as Nagai's stopper bolt 141 threaded into Yi's camshaft housing to axially displace Yi's camshaft 2. A POSITA would have been motivated to use Nagai's stopper bolt 141 to axially move camshaft 58 to simplify and combine implementations of the elements of JP'279's "adjuster assembly" and Nagai's limiting mechanism into Fox's suspension system to improve the compression damping adjustment mechanism of Fox.

the third compression setting (i.e., third axial position of rod 10). But for simplicity, only fine-tuning of the medium-velocity flow setting is discussed hereinafter because the Challenged Claims only require adjustment of at least one compression damping setting.



Ex. 1006, Fig. 6 (JP'279's tapered surface 44 added to Yi's camshaft 2 at the cam surface corresponding to the second compression damping setting).

135. The “adjuster assembly” of Yi modified in view of JP'279 and Nagai varies the damping characteristics of Yi's shock absorber 6 in the second setting of compression damping, i.e., when rod 10 is in the second axial position. Specifically, when connecting end 16 of Yi's rod 10 abuts JP'279's tapered surface 44, then any axial displacement of camshaft 2 varies the amount/degree of opening of opening 83 (associated with valve 831 and flow channel 87), and thereby varies the medium-velocity flow of damper fluid and accordingly the damping characteristics of the second damping setting. Ex. 1006, 3:60-65, 4:31-49. Moreover, adjustment of the

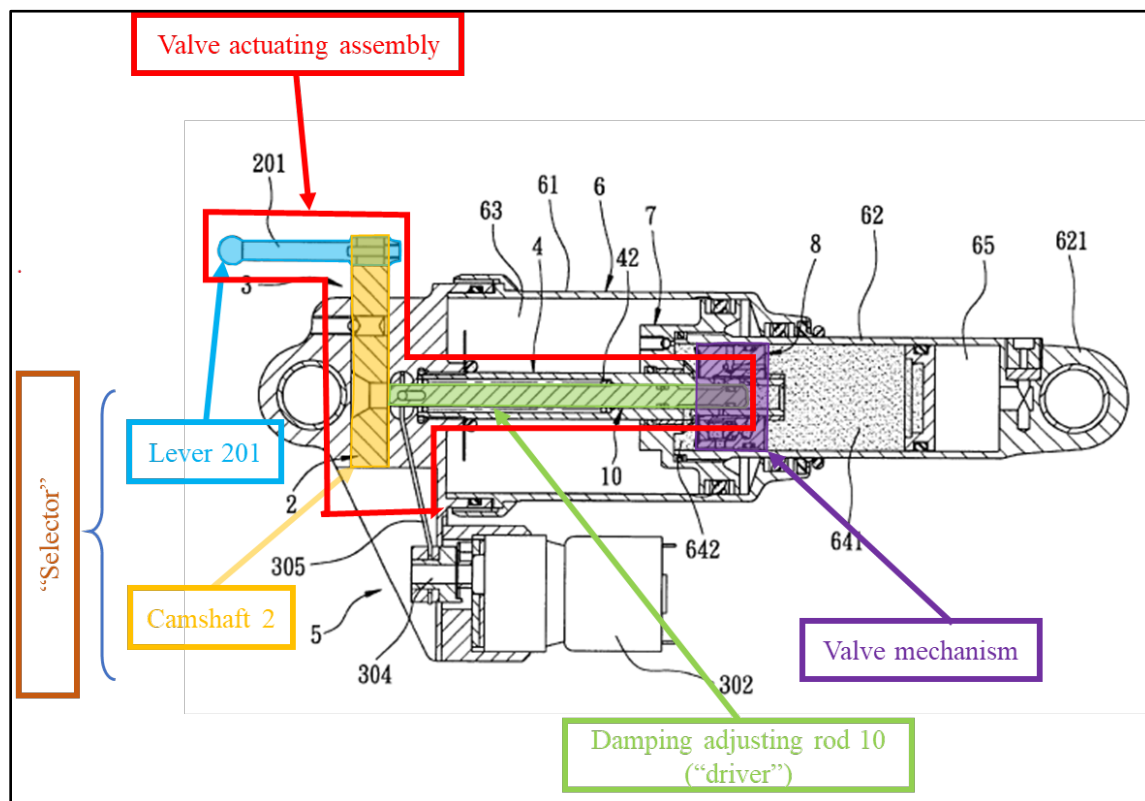
compression damping characteristics in the second axial position is independent of the damping characteristics in the first axial position of rod 10 (allowing unrestricted low-velocity flow) or the third axial position of the rod (allowing high-velocity flow of damper fluid). This is because fine-tuning of the degree of opening of opening 83 does not affect the low-velocity flow through channel 85 or cause high-velocity flow through opening 84. *See* Ex. 1006, 4:50-57.

3. Claim 2 (“The actuator apparatus of claim 1 wherein the valve actuating assembly comprises: a driver movable to adjust the valve mechanism between various suspension settings; and a selector operatively connected to the driver and rotatable between the positions.”)

136. As discussed with reference to claim 1, the “valve actuating assembly” of Yi’s shock absorber 6 (the “suspension system”) comprises a damping adjusting rod 10, a camshaft 2, and a handle 201 for turning camshaft 2. Rod 10 functions as a “driver” and is movable axially to a first, second, or third axial position corresponding to three settings of compression damping. Ex. 1006, Figs. 5-7, 4:18-49. The first axial position of the “driver” (damping adjusting rod 10) blocks the medium-velocity and high-velocity flows of damper fluid from third chamber 641 to second chamber 642 of cylinder 62 during a compression stroke (and only low-velocity flow is permitted); the second axial position allows medium-velocity flows of damper fluid from third chamber 641 to second chamber 642; and the third axial position allows high-velocity flow from third chamber 641 to second chamber 642. Ex. 1006,

Figs. 5-7, 4:18-49. The flow regulation of damper fluid, effected by the axial position of damping adjusting rod 10, adjusts the compression damping characteristics of Yi's shock absorber 6.

137. Yi further discloses a “selector” operatively connected to the “driver” (damping adjusting rod 10) and rotatable between the three damping positions. Specifically, Yi's camshaft 2 and handle 201 form the “selector.” The “selector” is operatively connected to the “driver” for axial displacement of the “driver” along its longitudinal axis in response to angular displacement (rotation) of camshaft 2.

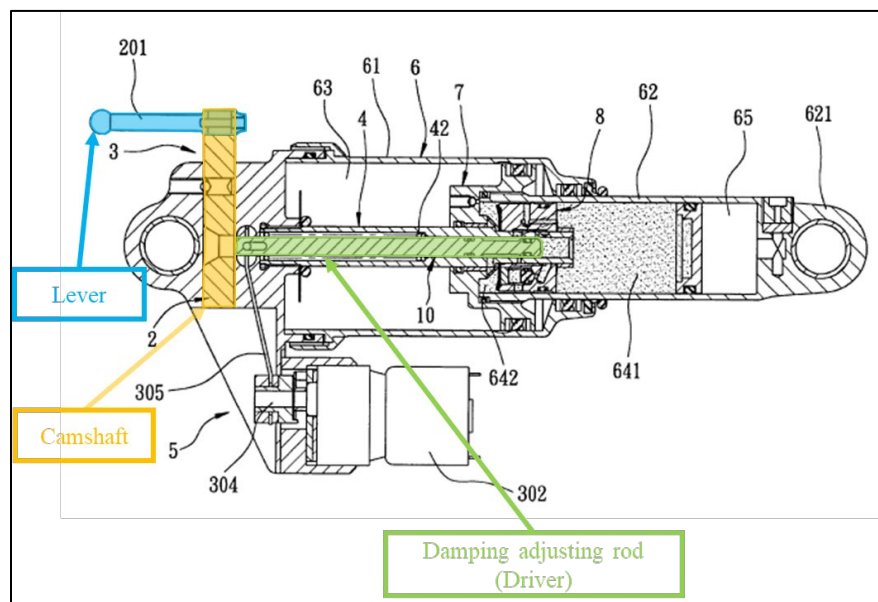


Ex. 1006, Fig. 12 (annotations added).

4. Claim 3

a. Claim term 3.1 (“The actuator apparatus of claim 2 wherein the selector comprises: a lever operable between the positions”)

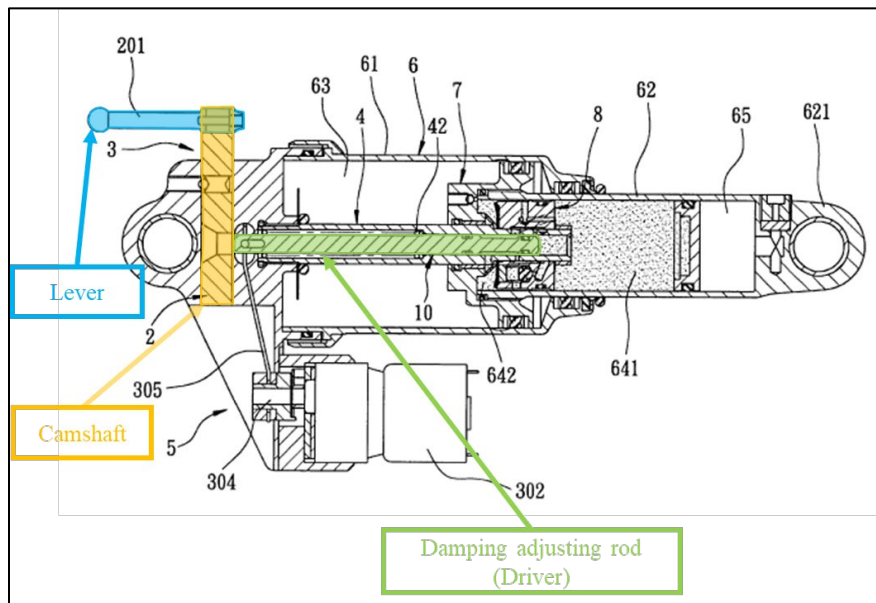
138. As discussed with reference to claim 2, Yi’s “selector” comprises a camshaft 2 and a handle 201 (the “lever”). Handle 201 is operable by a user to adjust the compression damping position and is operatively connected to camshaft 2. Ex. 1006, Fig. 12, 5:50-55. Specifically, operation of handle 201 causes camshaft 2 to be rotated (angularly displaced) between the three compression damping settings, which then causes the “driver” (damping adjusting rod 10) to be axially displaced along its longitudinal axis, thereby adjusting the compression damping characteristics of Yi’s shock absorber 6.



Ex. 1006, Fig. 12 (annotations added).

- b. **Claim term 3.2 (“the camshaft operatively connected to the lever, and at least two cam surfaces corresponding to the positions of the lever, the cam surfaces configured to be engageable with the driver.”)**

139. Yi’s camshaft (eccentric shaft 2) is operatively connected to the “lever” (handle 201). Ex. 1006, Fig. 12, 5:51-57.



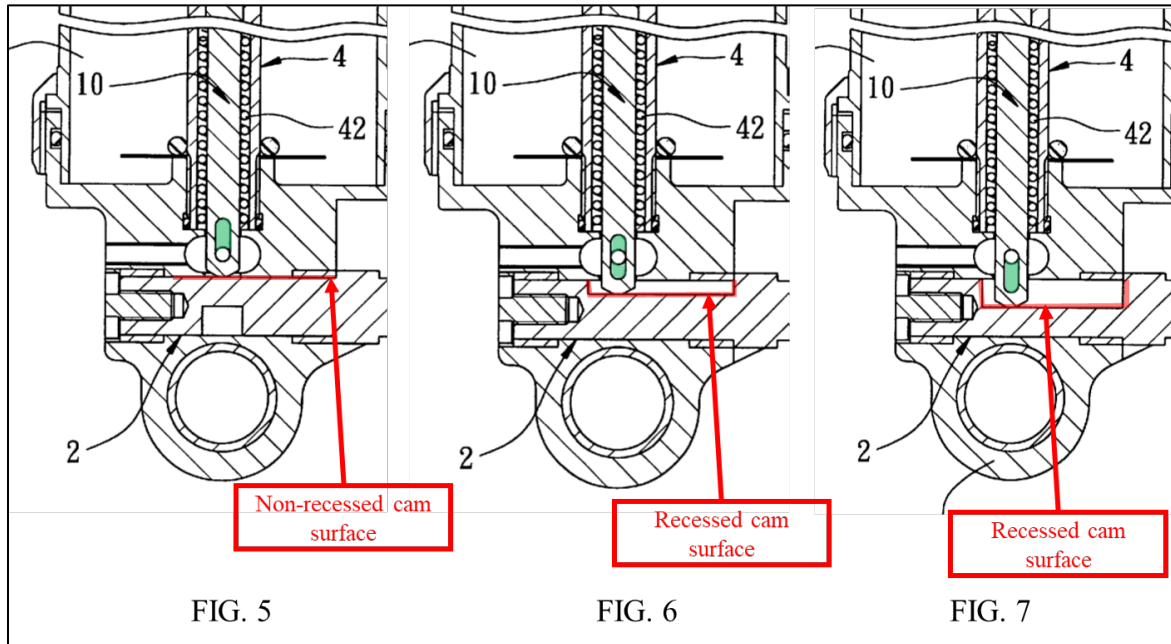
Ex. 1006, Fig. 12 (annotations added).

140. Yi further discloses camshaft 2 has at least three cam surfaces corresponding to three positions of the “lever” (handle 201) and the three axial positions of the “driver” (damping adjusting rod 10). Ex. 1006, Figs. 5-7, 4:18-49. For illustration, see the solid model I created and showed previously. These cam surfaces are configured to operatively engage with connecting end 16 of damping adjusting rod 10 (the “driver”). Ex. 1006, 5:38-42. In Yi’s shock absorber,

rotation of camshaft 2 causes movement of damping adjusting rod 10 in the axial direction. Ex. 1006, 5:42-44. This is enabled by the at least three cam surfaces of camshaft 2, as illustrated below in annotated Figs. 5-7 of Yi. In the first axial position (shown in Fig. 5 below), the connecting end of damping adjusting rod 10 abuts a non-recessed cam surface of camshaft 2 such that medium and high-velocity flow of damper fluid from third chamber 641 to second chamber 642 via a down-flow channel 87 is not permitted during a compression stroke. Ex. 1006, 4:18-25. In the second axial position (shown in Fig. 6 below), the connecting end of damping adjusting rod 10 is pushed against a slightly recessed cam surface of camshaft 2 such that the medium-velocity flow of the damper fluid from third chamber 641 to second chamber 642 via down-flow channel 87 is permitted during the compression stroke. Ex. 1006, 4:25-30. In the third axial position (shown in Fig. 7 below), the connecting end of damping adjusting rod 10 is pushed against a significantly recessed cam surface of camshaft 2 such that high-velocity flow of the damper fluid from third chamber 641 to second chamber 642 via down-flow channel 87 is permitted during the compression stroke. Ex. 1006, 4:31-49.

141. Yi also discloses that camshaft 2 of the down-flow adjusting unit 3 is operated via a handle 201. Ex. 1006, 5:52-57. A POSITA would have understood that Yi's handle 201 (the "lever"), configured to turn camshaft 2, allows a user to choose between damping positions corresponding to a non-recessed cam surface, a slightly

recessed cam surface, and a significantly recessed cam surface of camshaft 2, thereby adjusting the damping characteristics.



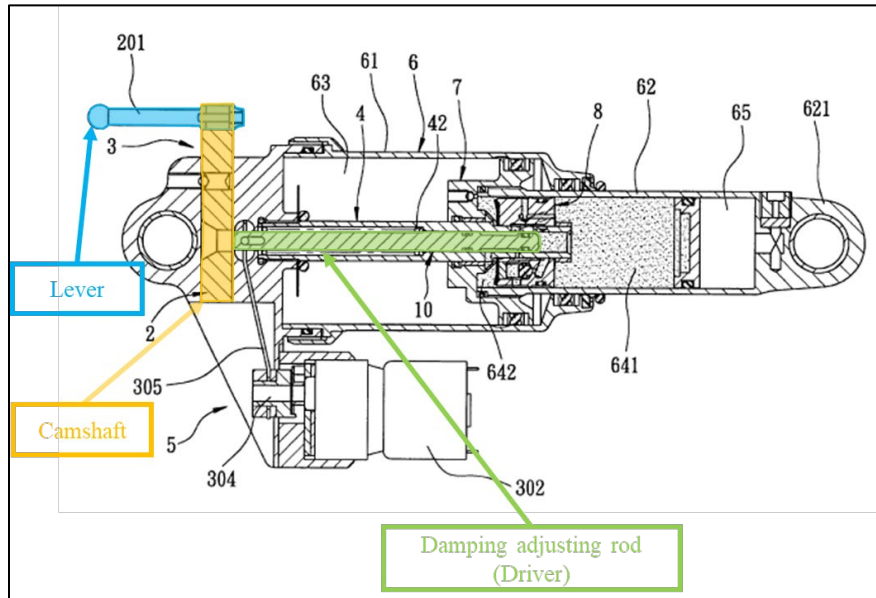
Ex. 1006, Figs. 5-7 (enlarged and annotations added).

5. Claim 7

- a. **Claim term 7.1 (“The actuator apparatus of claim 2 wherein the selector comprises: a lever operable between the positions”)**

142. As discussed with reference to claim 2 and claim term 3.1, Yi’s “selector” comprises a camshaft 2 and a handle 201 (the “lever”). Handle 201 is operable by a user to adjust the compression damping positions and is operatively connected to camshaft 2. Ex. 1006, Fig. 12, 5:50-55. Specifically, operation of handle 201 causes camshaft 2 to be rotated (angularly displaced) between the three compression damping positions, which then causes the “driver” (damping adjusting rod 10) to be

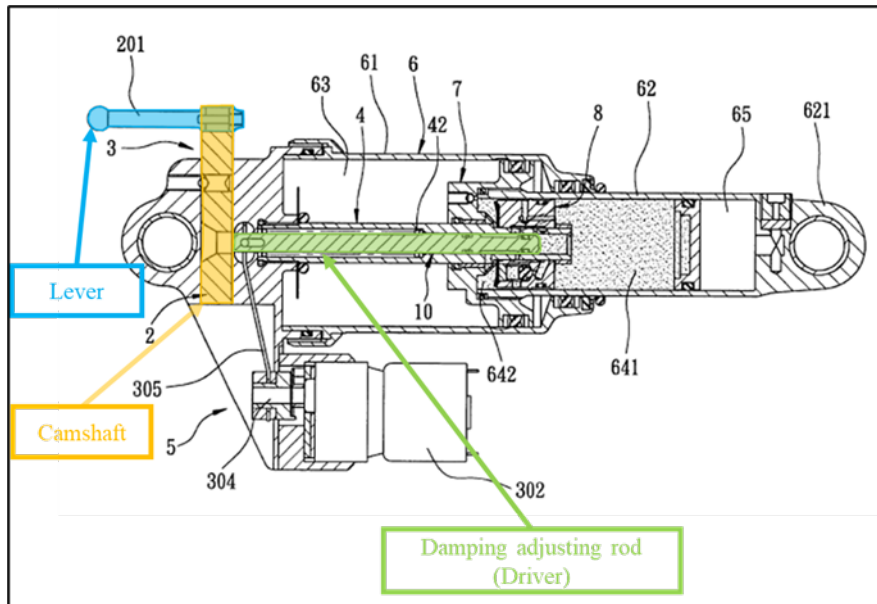
axially displaced along its longitudinal axis, thereby adjusting the compression damping characteristics of Yi's shock absorber 6.



Ex. 1006, Fig. 12 (annotations added).

- b. **Claim term 7.2 (“the camshaft having at least two cam surfaces corresponding to the positions of the lever, the camshaft operatively connected to the lever”)**

143. Yi's camshaft (eccentric shaft 2) is operatively connected to the “lever” (handle 201). Ex. 1006, Fig. 12.

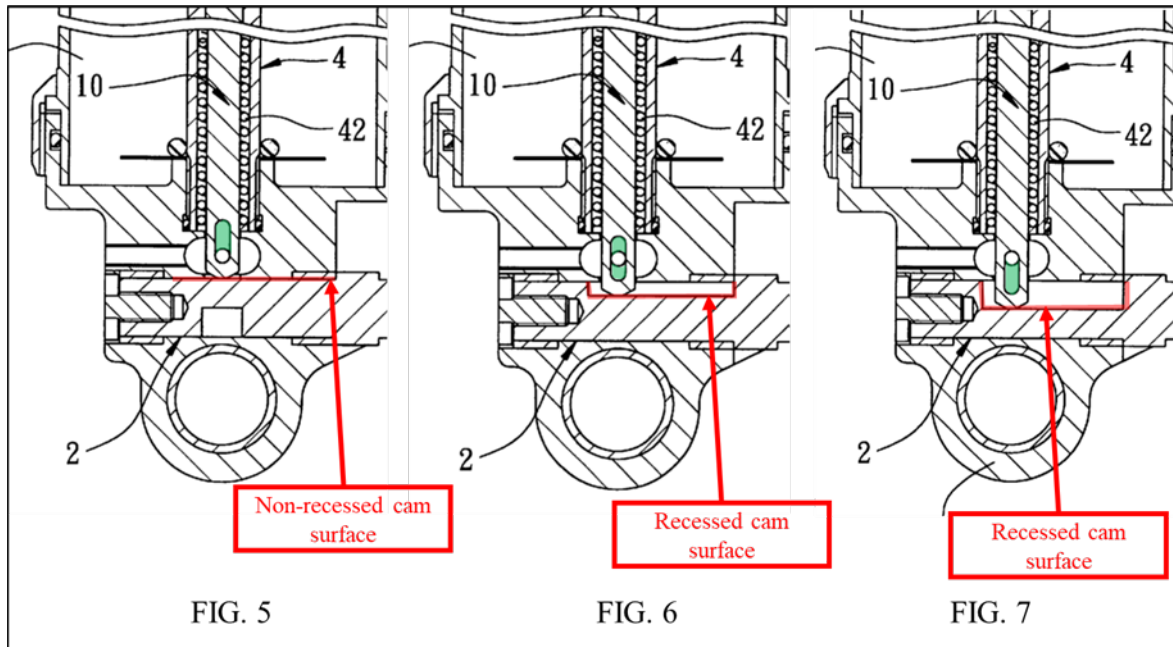


Ex. 1006, Fig. 12 (annotations added).

144. Yi further discloses camshaft 2 has at least three cam surfaces corresponding to three positions of the “lever” (handle 201) and the three axial positions of the “driver” (damping adjusting rod 10). Ex. 1006, Figs. 5-7, 4:18-49. These cam surfaces are configured to operatively engage with connecting end 16 of damping adjusting rod 10 (the “driver”). Ex. 1006, 5:38-42. In Yi’s shock absorber, rotation of camshaft 2 causes movement of damping adjusting rod 10 in the axial direction. Ex. 1006, 5:42-44. This is enabled by the at least three cam surfaces of camshaft 2, as illustrated below in annotated Figs. 5-7 of Yi. In the first axial position (shown in Fig. 5 below), the connecting end of damping adjusting rod 10 abuts a non-recessed cam surface of camshaft 2 such that medium and high-velocity flow of damper fluid from third chamber 641 to second chamber 642 via a down-flow channel 87 is not

permitted during a compression stroke. Ex. 1006, 4:18-25. In the second axial position (shown in Fig. 6 below), the connecting end of damping adjusting rod 10 is pushed against a slightly recessed cam surface of camshaft 2 such that the medium-velocity flow of the damper fluid from third chamber 641 to second chamber 642 via down-flow channel 87 is permitted during the compression stroke. Ex. 1006, 4:26-31. In the third axial position (shown in Fig. 7 below), the connecting end of damping adjusting rod 10 is pushed against a significantly recessed cam surface of camshaft 2 such that high-velocity flow of the damper fluid from third chamber 641 to second chamber 642 via down-flow channel 87 is permitted during the compression stroke. Ex. 1006, 4:32-49.

145. Yi also discloses that camshaft 2 of the down-flow adjusting unit 3 is operated via a handle 201. Ex. 1006, 5:54-55. A POSITA would have understood that Yi's handle 201 (the "lever"), configured to turn camshaft 2, allows a user to choose between damping characteristics corresponding to a non-recessed cam surface, a slightly recessed cam surface, and a significantly recessed cam surface of camshaft 2, thereby adjusting the damping characteristics.



Ex. 1006, Figs. 5-7 (enlarged and annotations added).

- c. **Claim term 7.3 (“a stop element rotatable with the selector and configured to abut against the adjuster assembly to prevent over-rotation of the lever.”)**

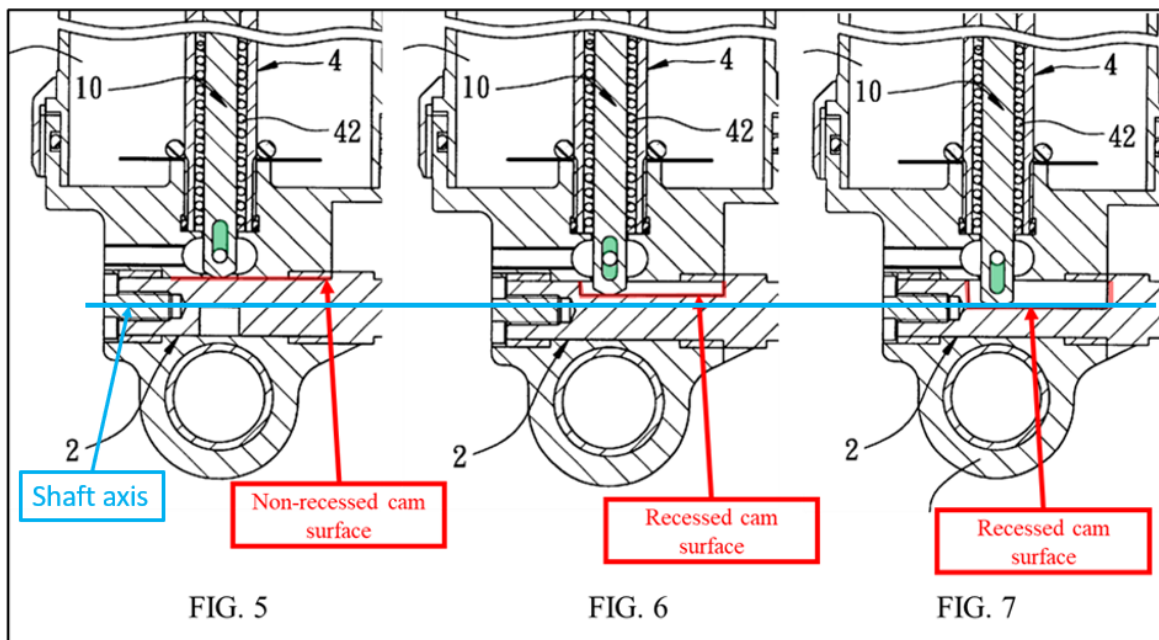
146. Yi combined with JP’279 and Nagai includes Nagai’s stopper bolt 141 engaged with Yi’s camshaft 2 and camshaft housing and Nagai’s “stop element,” i.e., projection 135, on camshaft 2. Ex. 1008, 6:55-7:1, Figs. 6-8.

147. As discussed in Section VIII.C.1, a POSITA would have been motivated to combine the “stop element” disclosed in Nagai with Yi’s camshaft 2 to set an optimum range of rotation and prevent over-rotation of camshaft 2. *See* Ex. 1006, Fig. 2. Because Nagai’s projection 135 is added to Yi’s camshaft 2, the “stop

element” (i.e., projection 135) is rotatable with the “selector” (i.e., when camshaft 2 is rotated by lever 201). Further, the projection 135 is configured to abut against stop element 142 of Nagai’s stopper bolt 141, which is part of the “adjuster assembly” (*see* claim term 1.2 above). Therefore, Yi’s shock absorber 6, modified in view of JP’279 and Nagai, includes a “stop element” (projection 135) rotatable with Yi’s “selector” (camshaft 2) and configured to abut against the “adjuster assembly” (stopper bolt 141 having stop element 142) to prevent over-rotation of camshaft 2 and lever 201.

6. Claim 8 (“The actuator apparatus of claim 7 wherein the cam surfaces are disposed substantially parallel to the camshaft axis.”)

148. As shown in the enlarged and annotated Figures 5-7 of Yi below, each of the recessed and the non-recessed cam surfaces on camshaft 2 are disposed substantially parallel to the longitudinal axis of camshaft 2.

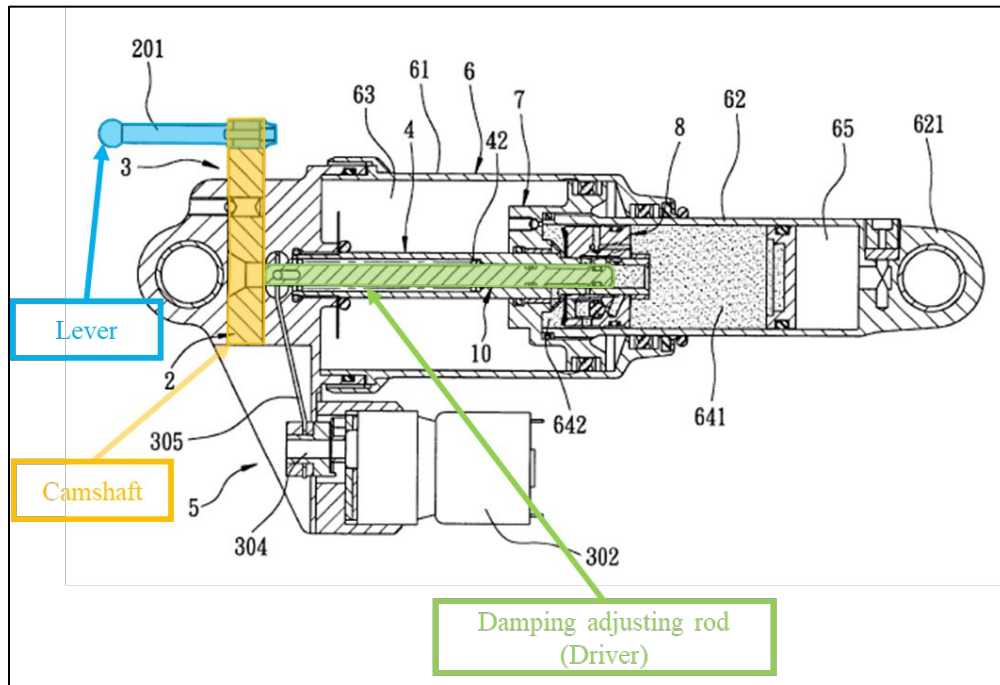


Ex. 1006, Figs. 5-7 (enlarged and annotated).

7. Claim 10

- a. Claim term 10.1 (“The actuator apparatus of claim 2 wherein the selector comprises: a lever operable between the positions”)**

149. As discussed with reference to claim 2 and claim terms 3.1 and 7.1, Yi’s “selector” comprises a camshaft 2 and a handle 201 (the “lever”). Handle 201 is operable by a user to adjust the compression damping positions and is operatively connected to camshaft 2. Ex. 1006, Fig. 12, 5:50-55. Specifically, operation of handle 201 causes camshaft 2 to be rotated (angularly displaced) between the three compression damping positions, which then causes the “driver” (damping adjusting rod 10) to be axially displaced along its longitudinal axis, thereby adjusting the compression damping characteristics of Yi’s shock absorber 6.



Ex. 1006, Fig. 12 (annotations added).

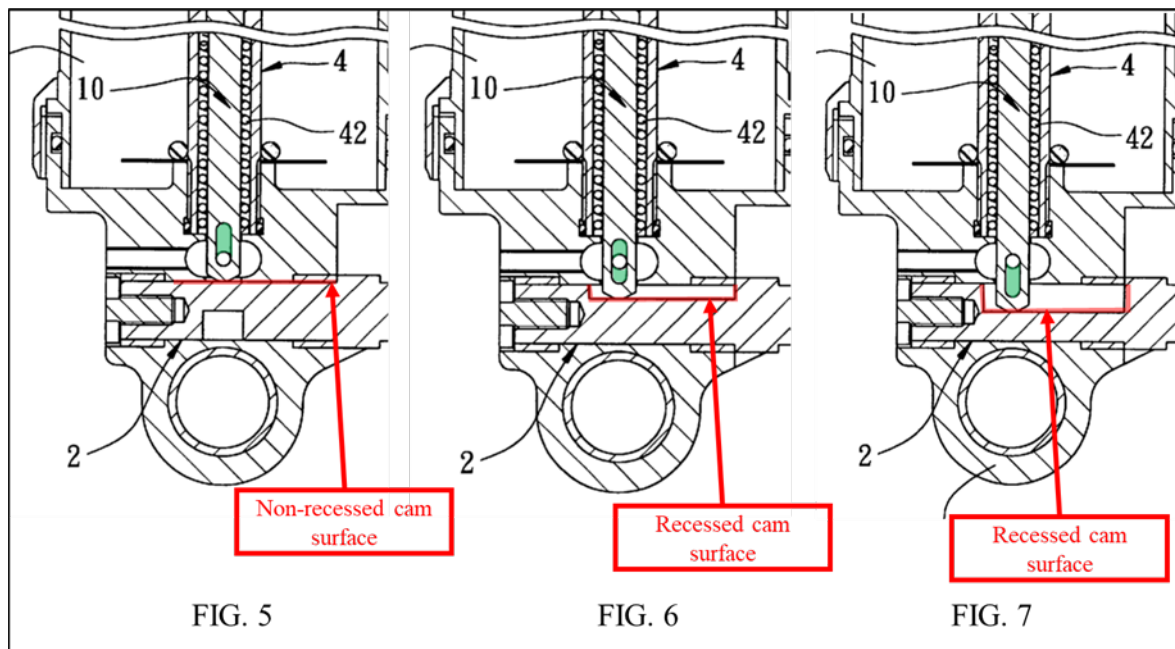
- b. **Claim term 10.2 (“the camshaft having a plurality of cam surfaces, at least one of said cam surfaces configured to be engageable with the driver, the cam surfaces corresponding to the positions of the lever, the cam surfaces disposed substantially parallel to the axis of the camshaft, the camshaft operatively connected to the lever.”)**

150. As discussed with reference to claim 2, Yi’s camshaft (eccentric shaft 2) and lever (handle 201) form the “selector,” which is operatively connected to damping adjusting rod 10 (the “driver”) for axial displacement of the “driver” along its longitudinal axis. Ex. 1006, Fig. 12. Specifically, handle 201 is operatively connected to camshaft 2, which itself is operatively engaged with a connecting end

16 of damping adjusting rod 10. Ex. 1006, 5:38-46, 5:52-57. Camshaft 2 is angularly displaceable between three positions by operation of handle 201. Ex. 1006, Figs. 5-7, 4:18-49. Specifically, operation of handle 201 causes camshaft 2 to be rotated (angularly displaced), which then causes damping adjusting rod 10 to be axially displaced along its longitudinal axis to one of three positions, thereby adjusting the compression damping characteristics of shock absorber 6. *See* Ex. 1006, 4:18-49.

151. Yi further discloses that camshaft 2 has at least three cam surfaces—a non-recessed cam surface, a slightly recessed cam surface, and a significantly recessed cam surface—which correspond to three compression damping positions of the “lever” (handle 201). Ex. 1006, Figs. 5-7, 4:18-49. These cam surfaces are configured to operatively engage with connecting end 16 of damping adjusting rod 10 (the “driver”). Ex. 1006, 5:38-42. In Yi’s shock absorber, angular displacement (rotation) of camshaft 2 causes axial movement of damping adjusting rod 10 in the axial direction. Ex. 1006, 5:42-44. This is enabled by the at least three cam surfaces on camshaft 2, as illustrated below in annotated Figures 5-7 of Yi. In the first axial position (shown in Fig. 5 below), the connecting end of damping adjusting rod 10 abuts a non-recessed cam surface of camshaft 2 such that the medium-velocity flow of the damper fluid from third chamber 641 to second chamber 642 via a down-flow channel 87 is not permitted during a compression stroke. Ex. 1006, 4:18-25. In the second axial position (shown in Fig. 6 below), the

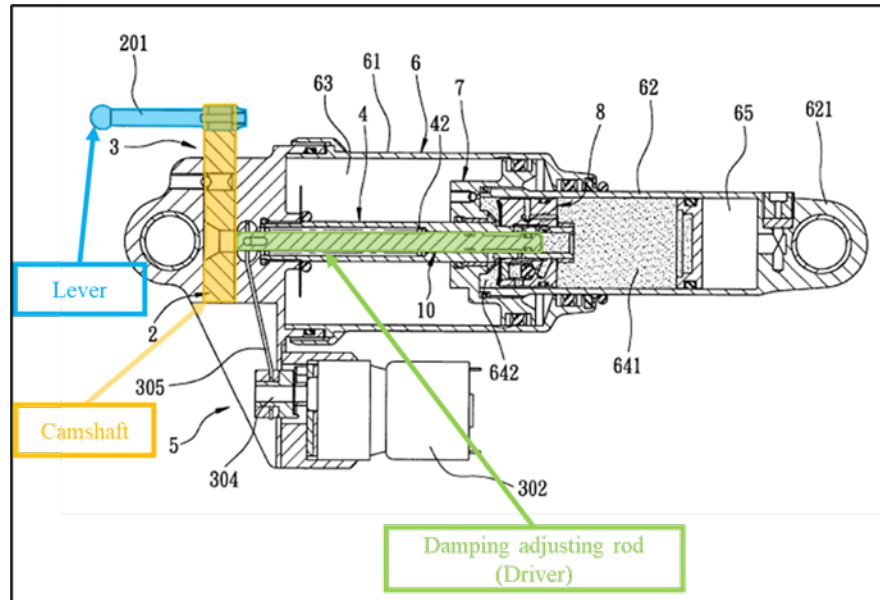
connecting end of damping adjusting rod 10 abuts a slightly recessed cam surface of camshaft 2 such that the medium-velocity flow of the damper fluid from third chamber 641 to second chamber 642 is permitted during a compression stroke. Ex. 1006, 4:25-30. In the third axial position (shown in Fig. 7 below), the connecting end of damping adjusting rod 10 abuts a significantly recessed cam surface of camshaft 2 such that high-velocity flow of the damper fluid from third chamber 641 to second chamber 642 via down-flow channel 87 is permitted during the compression stroke. Ex. 1006, 4:31-49.



Ex. 1006, Figs. 5-7 (enlarged and annotated).

152. As discussed with reference to claim 8, the cam surfaces on camshaft 2 are disposed substantially parallel to the longitudinal axis of camshaft 2.

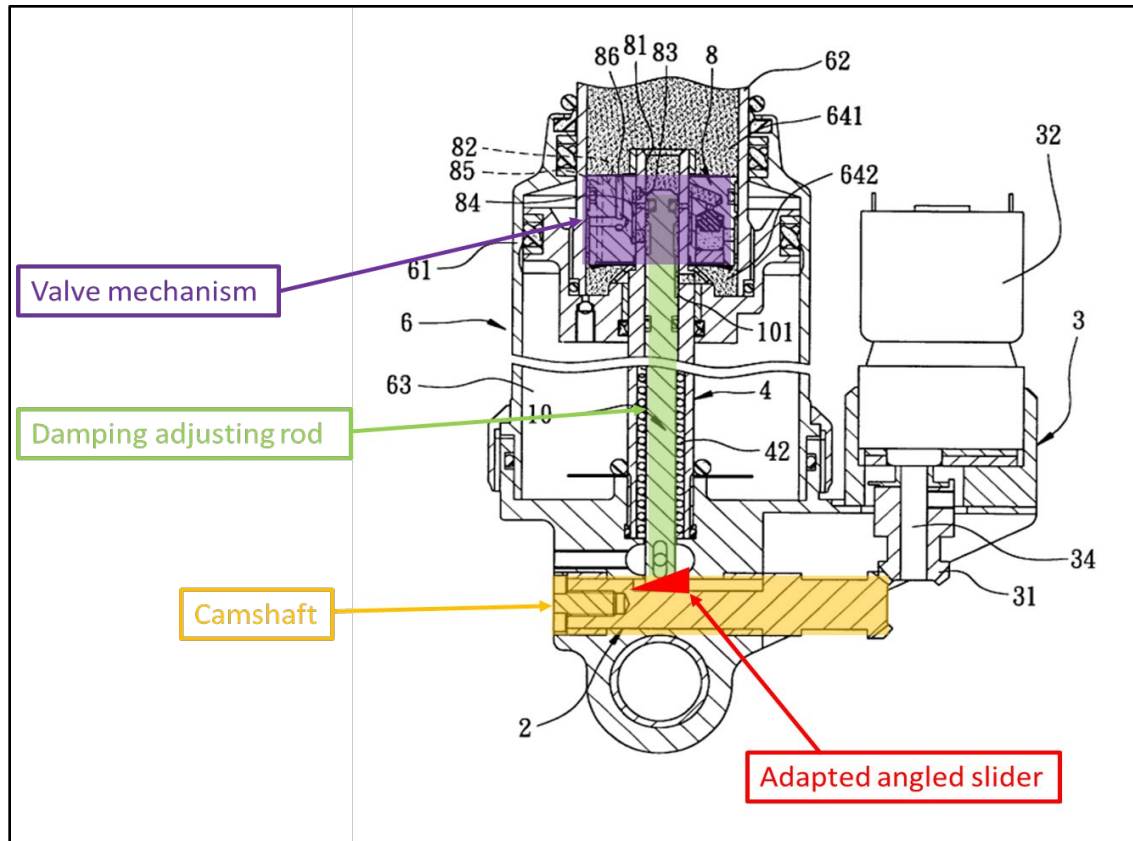
153. Camshaft 2 is operatively connected to handle 201 (the “lever”). Ex. 1006,
Fig. 12.



Ex. 1006, Fig. 12 (annotations added).

8. Claim 11 (“The actuator apparatus of claim 10 wherein the adjuster assembly is operatively connected to the driver to position the driver relative to camshaft of the selector.”)

154. As discussed with reference to claim term 1.2, the “adjuster assembly” of Yi in view of JP’279 and Nagai comprises JP’279’s tapered surface 44 on Yi’s slightly recessed cam surface, as shown below. I also presented, above, a solid model image of rotational cam surfaces with additional axial taper for cam action by rotation and/or axial displacement of the camshaft.



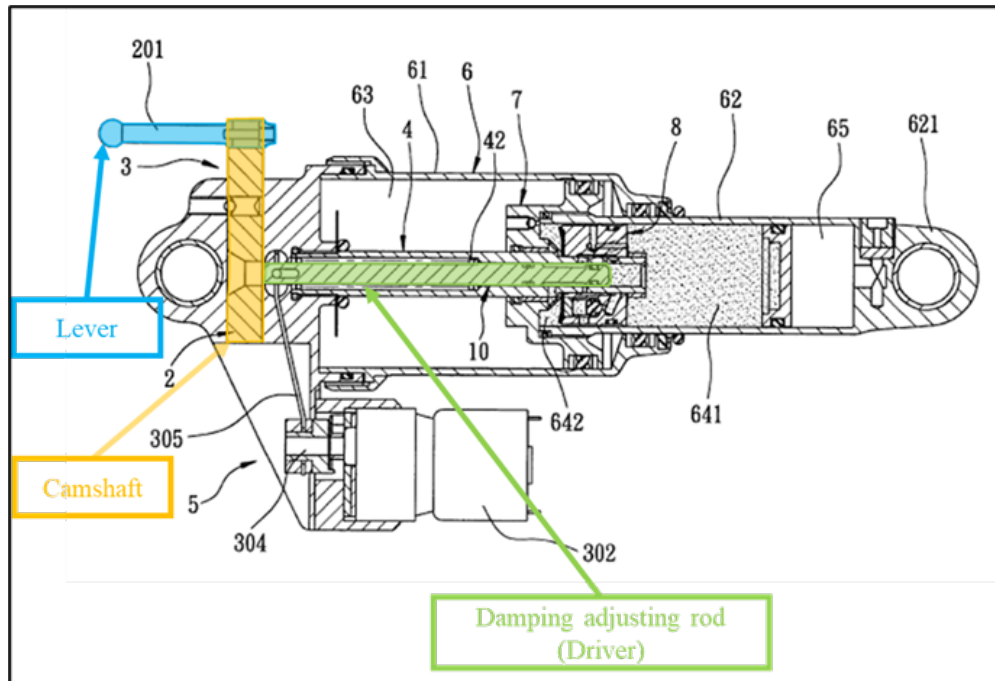
Ex. 1006, Fig. 6 (JP'279's tapered surface 44 added to Yi's camshaft 2 at the cam surface corresponding to the second compression damping setting).

155. As Yi's camshaft 2 is rotated by operation of handle 201, the cam surfaces on camshaft 2 engage with connecting end 16 of damping adjusting rod 10 (the "driver"). Ex. 1006, 5:52-57. Specifically, when handle 201 is operated such that tapered surface 44 on the slightly recessed cam surface abuts connecting end 16 of damping adjusting rod 10, then rod 10 causes opening 83 (associated with valve 831 and down-flow channel 87) to be in an open position for medium-velocity flow of damper fluid. Ex. 1006, 3:60-65, 4:18-30. Further, operation of Nagai's stopper bolt 141 axially displaces camshaft 2 and changes the position at which rod 10 engages

with tapered surface 44. Thus, tapered surface 44 and stopper bolt 141 of Yi's modified "adjuster assembly" are operatively connected to the "driver" (i.e., Yi's damping adjusting rod 10) to position the "driver" relative to Yi's camshaft 2 which is part of the "selector."

9. Claim 12 ("The actuator apparatus of claim 1 wherein the positions of the valve actuating assembly are rider-selectable positions.")

156. As discussed with reference to claim 3, camshaft 2 of Yi's "valve actuating assembly" is angularly displaceable between the three compression damping positions by operation of a handle 201 (the "lever"). Ex. 1006, 5:38-45, 5:53-57. The "lever" enables a rider to select the damping positions because it is positioned outside the rest of the shock absorber 6 so as to enable a user to selectively adjust the axial position of damping adjusting rod 10 by operation of the "lever." *See* Ex. 1006, Fig. 12. Specifically, a POSITA would have understood that Yi's handle 201 (the "lever") is configured to be user-adjustable to allow a user to choose between the compression damping settings corresponding to a non-recessed cam surface, a slightly recessed cam surface, and a significantly recessed cam surface of Yi's camshaft 2, thereby adjusting the damping characteristics.



Ex. 1006, Fig. 12 (annotations added).

IX. CONCLUSION

157. For the reasons explained in detail above, every element of the Challenged Claims of the '207 patent is disclosed by Fox, Fox in view of JP'279 and Nagai, and Yi in view of JP'279 and Nagai. Moreover, it would have been obvious to a person skilled in the art to combine the teachings of Fox or Yi with those of JP'279 and Nagai to arrive at the purported invention recited in the '207 patent. A person skilled in the art would have been motivated to make the modifications and/or combinations, doing so would have required only routine engineering skill and knowledge, as I have demonstrated above, and the modifications and/or combinations would have yielded predictable results.

158. Moreover, I am not aware of any secondary indicia of non-obviousness tied to the claimed invention that would alter my opinion that the Challenged Claims would have been obvious to a person skilled in the art at the time of the purported invention.

159. I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct, that all statements made herein of my knowledge are true, and that all statements made on information and belief are believed to be true, and 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.

Respectfully submitted,

A handwritten signature in black ink, consisting of a series of loops and a long horizontal stroke extending to the right.

Dated: January 29, 2024

By: _____
Alexander H. Slocum, Ph.D.

EXHIBIT A

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

School of Engineering Faculty Personnel Record

Date: 1 December 2022 Full Name: Alexander H. Slocum
Department: Mechanical Engineering

1. Date of Birth: on file

2. Citizenship: U.S.

<u>School</u>	<u>Degree</u>	<u>Date</u>
M.I.T.	S.B., M.E	June 1982
M.I.T.	S.M., M.E	Jan. 1983
M.I.T.	Ph.D., M.E.	June 1985

4. Title of Thesis for Most Advanced Degree:
Sensor System Design to Determine Position and Orientation of Articulated Structures

5. Principle Field of Interest:
Precision Engineering

6. Name and Rank of Other Department Faculty in the Same Field:
David Trumper, Professor
Martin Culpepper, Professor
Sangbae Kim, Associate Professor
Amos Winter, Associate Professor

7. Name and Rank of Faculty in Other Departments in Same Field:
Jeff Lang, Professor, Electrical Engineering

Non-MIT Experience:		<u>Beginning</u>	<u>End</u>
<u>Employer</u>	<u>Position</u>		
NIST	Mechanical Engineer	June 1982	Sept. 1986
Cranfield Inst. Tech.	Visiting Professor	Oct. 1989	Oct. 1990

9. History of M.I.T. Appointments:

<u>Rank:</u>	<u>Beginning</u>	<u>End</u>
Assistant Professor (CE)	Sept. 1985	July 1989
Assistant Professor (ME)	July 1991	July 1992
Associate Professor (ME)	July 1992	July 1995
Associate Professor (ME, tenured)	July 1995	July 1998
Professor	July 1998	?

10. Department and Institute Committees, Other Assigned Duties:

<u>Activity</u>	<u>Beginning</u>	<u>End</u>
Inst. Comm. on Design in UG Education	Feb. 1987	June 1988
Inst. UG Admissions Folder Reader	Jan. 1987	Present
Inst. Committee on the Hobby Shop	July 1989	June 1997
Chairman, Inst. Committee -- Hobby Shop	June 1997	Present
Dept. Committee on Graduate Curricula	Oct. 1992	June 2004
Dept. Support Staff Cost Committee	Mar. 1994	May 1994
Pi Tau Sigma Faculty Advisor	May 1994	Jan. 2002
Dept. Faculty Search Committee	Jan. 1995	June 1995
Leader, OME 2nd Summer Design Program	Jan. 1996	Jan. 2008
MIT Educational Council	June 1996	Present
ME Strategic Planning Committee	Sept. 1996	June 1998
ME Design Faculty Search Committee	Jan. 1997	June 1998
Designated Course Professors Committee	Sept. 1997	June 2004
ME Design Faculty Search Committee	Jan. 1998	Nov. 1998
Space Committee	Jan. 2000	Sept. 2003
CalTech/MIT Voting Commission	Jan. 2001	June 2001
ME Council	Jan 2004	June 2005
Director: Experimental Study Group	Sept. 2004	June 2012
Research Administration Improvement Initiative	July. 2005	
co-chair of the Class of 1982 Reunion Gift Fund	Spring 2007	
Energy Education Task Force	Dec. 2008	June 2012
Institute Committee on Student Life	Aug. 2009	June 2012
Energy Minor Oversight Committee	Feb. 2009	June 2012
Daper Advisory Board	Aug. 2009	June 2016
Institute Committee on Student Life, Chair	June 2010	June 2012
Department Awards Committee	Spring 2011	June 2018
ME Design Faculty Search Committee	Fall 2017	June 2018
Institute Committee on Intellectual Property	Fall 2019	Fall 2022

11. Professional Service:

<u>Activity</u>	<u>Dates</u>
Office of Secretary of Defense, Foreign Strategic Trade	June 1990-June 2005
Department of Justice, Bearing Tariffs	Jan.1992-Dec.1992
NIST, Technology Assessment	June 1986-Aug. 1997
International Scientific Committee of the European Union Society for Precision Engineering and Nanotechnology	Feb. 2004-present
Session Chair "Education" 4th. Intl. Conf. Advanced Engineering Design, Glasgow, Scotland,	Sept. 5-8, 2004
Vice Chair, ASME Design Education Committee	2005
Associate Editor ASME Jou. Mechanical Design	2007-2012
Department of Energy: BP Gulf Oil Spill response team	May 2010-Sept. 2010
Assistant Director for Advanced Manufacturing, Executive Office of the White House	June 2013- May 2014

12. Awards or Honors Received:

1. U.S. DoC Development of an Advanced Robot Gripper Feb. 1984
2. U.S. DoC Outstanding Performance Rating Mar. 1985
3. SME Outstanding Contribution to FMS Feb. 1986
4. U.S. DoC Outstanding Performance Rating Mar. 1986
5. U.S. DoC Outstanding Performance Rating Mar. 1986
6. U.S. DoC Development of Robotic Micromanipulator June 1986
7. U.S. DoC Robot End Effector Patent July 1986
8. U.S. DoC Robotic Micromanipulator Patent July 1986
9. SME Outstanding Contribution to Robotics Aug. 1986
10. U.S. DoC Bronze Medal Award for Federal Service Dec. 1986
11. NSF Presidential Young Investigator June 1987
12. Royal Society Visiting Scholar Fellowship Aug. 1988
13. Oak Ridge Offsite Research Fellowship Aug. 1988
14. SME Earl E. Walker Outstanding Young Manufacturing Engineer Award, June 1993
15. ASCE 1994 Thomas Fitch Rowland Prize
16. 1994 R&D 100 Award, one of 100 best new technical products of the year (ShearDamper™)
17. 1994 International Machine Tool Show “Best of Show” award for development of Weldon Machine Tool’s 1632 Gold Cylindrical Grinder (it used Slocum’s hydrostatic bearings and ShearDamper technology).
18. 1994 R&D 100 Award, one of 100 best new technical products of the year (HydroGuide™)
19. 1995 R&D 100 Award, one of 100 best new technical products of the year (HydroSpindle™)
20. 1996 R&D 100 Award, one of 100 best new technical products of the year (TurboTool™ Ultra-High Speed Spindle)
21. SME 1997 SME Frederick W. Taylor Research Medal
22. 1997 R&D 100 Award -one of 100 best new technical products of the yr. (Machining Variation Analysis)
23. 1997 R&D 100 Award-- one of 100 best new technical products of the yr. (ShieldBeam™ Contactor)
24. 1997 R&D 100 Award, one of 100 best new technical products of the yr. (Kinematic Docking System)
25. 1998 R&D 100 Award, one of 100 best new technical products of the yr. (Q-Tool™)
26. Who’s Who in America Science and Engineering
27. Martin Luther King Jr. Leadership Award, January 1999.
28. MacVicar Faculty Fellow, January 1999.
29. 1999 R&D 100 Award, one of 100 best new technical products of the yr. (Quasi Kinematic Coupling for Engine Assembly)
30. Massachusetts Professor of the Year Award, November 2000
31. ASME Leonardo da Vinci Award, 2004
32. 100K Competición Winner (2007, Team Robopsy)
33. ASME Machine Design Award, 2008
34. 2008 R&D 100 Award, one of 100 best new technical products of the yr. (Saber Furnace)
35. 2009 R&D 100 Award, one of 100 best new technical products of the yr. (Micro-ESR with Active Spectrum, Inc).
36. 2010 Arthur Smith Faculty Achievement Award
37. Best Paper Award: O. Yaglioglu, R Martens, A. Cao, A. H. Slocum, “Compliant Carbon Nanotube-Metal Contact Structures”, Proc. of 57th IEEE Holm Conference on Electrical Contacts, 2011
38. 2014 ASME Thar Energy Award
39. 2014 Association of Manufacturing Technology Charlie Carter Award
40. 2015 Best Paper Award: J.M. Kluger, T.P. Sapsis, and A.H. Slocum, Combined offshore wind-wave-storage system power and cost predictions, NAWEA Symposium, Blacksburg, VA, June 8, 2015.

41. 2016 Best Paper Award: M.N. Haji, C. Delmy, J. Gonzalez, A.H. Slocum , “Uranium Extraction from Seawater Using Adsorbent Shell Enclosures Via a Symbiotic Offshore Wind Turbine Device”, ISOPE-2016 Best Student Paper Award, Twenty-sixth (2016) International Offshore and Polar Engineering Conference, Rhodes, Greece, June 26 – July 1, 2016.
 42. 2017 Member National Academy of Engineering
 43. 2017 Capers and Marion MacDonald Award for Excellence in Mentoring and Advising
 44. 2018 ASME Ruth and Joel Spira Outstanding Design Educator Award
 45. 2020 Elected Fellow of the American Society for Precision Engineering (inaugural year of the Fellows program).
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158. US10906285, Wardle; Brian L., Hart; Anastasios John, Garcia; Enrique J., Slocum; Alexander H., "Nanostructure-reinforced composite articles and methods", 02/02/2021
159. US10925655 Alexander Slocum, James Connor Jr., Jacob Mooney, Nicholas Wing-Ping Kwok | "Bone Reduction Forceps", 02/23/2021
160. US10926418 Lu Lu; Xiaodong, Tang; Peter, Slocum; Alexander H., Chen; Rui, "Robotic devices and methods for fabrication, use and control of same", 02/23/2021
161. US 10974298 Smith; Eric D., Takata; Rosalind K., Slocum; Alexander H., Nayfeh; Samir A., "Tapered structure construction", April 13, 2021
162. US10,988,279, Alexander Slocum, Debra Thurston-Slocum, "Package Maker", April 27, 2021
163. US11,065,036, DiBiasio; Christopher, Durand; Keith, Hopkins; Jonathan, Traina; Zach, Slocum; Alexander, Nayfeh; Samir, del Nido; Pedro J., Vasilyev; Nikolay V., "Instrument port for minimally invasive cardiac surgery", 07/20/2021
164. US11,111,141 Jonathan Slocum, Alexander Slocum, "Storing Activated Aluminum", Sept. 7, 2021.
165. US11121437, Bazzarella; Ricardo, Slocum; Alexander H., Doherty; Tristan, Cross, III; James C., "Electrochemical cells and methods of manufacturing the same", 09/14/2021
166. US 11161579, Slocum; Alexander H., Slocum; Jonathan T., "Systems, modules, and submersible vehicles for collecting material from a seafloor", 09/23/2021

167. US11130557, Slocum; Alexander H., Slocum; Jonathan T., "Controlling lifting gas in inflatable structures", 9/28/2021
168. US11148947, Slocum; Jonathan T., Slocum; Alexander H., "Controlling hydrogen production from water-reactive aluminum", 10/19/2021
169. US11148840, Slocum; Jonathan T., Slocum; Alexander H., "Method of packaging water-reactive aluminum", 10/19/2021
170. US11,268,180 Slocum; Jonathan T., Slocum; Alexander H., "Structure inflation using activated aluminum", 3/8/2022
171. US11312466 Slocum; Jonathan T., Slocum; Alexander H., "Inflatable structure deployment", 4/26/2022
172. US11318437 Slocum; Jonathan T., Slocum; Alexander H., "Controlling contamination in hydrogen production from water-reactive aluminum" 5/3/2022
173. US11332366 Slocum; Jonathan T., Slocum; Alexander H., "Controlling reactivity of water-reactive aluminum" 05/17/2022
174. US11373549 Johnson, Hilary; Slocum Alexander, "Braille writing device", June 28, 2022

15. Professional Registration: None.

16. Major New Products, Processes, Designs, or Systems:

- SEMI E57 - Specification for Kinematic Couplings Used to Align and Support 300 mm Wafer Carriers. I proposed to SEMI/Sematech a new standard for locating 300 mm wafer cassettes, and then led the formulation and implementation of the standard, which is now in use by all companies for 300 mm semiconductor wafer cassettes and interfaces.
- OMAX Jet Machining Center (many different models). See: www.omax.com.
- Weldon 1632 Gold Grinder, International Machine Tool Show (IMTS: "Best of Show" award for development Weldon Machine Tool's 1632 Gold Cylindrical Grinder (it used Slocum's hydrostatic bearings and ShearDamper technology), Sept. 1994.
- ShieldBeam Contactor, manufactured by Teradyne, which won an R&D 100 Award for one of 100 best new technical products of the year, June 1997.
- K-Dock Kinematic Docking System, manufactured by Teradyne, which won an R&D 100 Award for one of 100 best new technical products of the year, June 1997.
- Executive Producer for inner-city kids' rap group Mental Block, their first CD entitled, "IF".
- Kinetrix, Inc. (a new startup I helped create) Apollo Semiconductor Device Sorter and Galileo Semiconductor Device Handler.
- Created web sites and programs for the Urban Design Corp (www.urbandesigncorp.org), and Paths-to-Peace (www.pathstopeace.org) to help teach kids to design and create and to promote better understanding between cultures.
- Advised 2nd Summer students as UROPs to pursue patenting their device "Ergonomic Cleaning Apparatus with Multiple Scrubbing Surfaces," US Patent # 5,915,869, June 1999.
- Worked with Overbeck Corp. of Long Island, NY to create the LT Grinding machine, which was featured as a cover article: "Get a Preload of This," American Machinist, December 2002.
- Executive Producer for "Journey of The Lost Souls" by Marc Graham (book of poems and rap CD).
- Dial Soap "Quest for the Best" consumer product search finalist for "Massagasoap".
- Massachusetts State Archives: Encasements for Documents of Freedom (cases to provide 20 years O₂ free enclosures to enable public viewing of original documents: Commonwealth of MA Charter of 1629, Charter of 1692, original copies provided to the 13 colonies of: US Declaration of Independence, Constitution, and Bill of Rights, all with combined value >\$80 million).
- OOSEH massaging balls (see www.roll2run.com)
- OOSEH finger splint

17. Teaching Experience:

<u>Term</u>	<u>Subject Number</u>	<u>Title</u>	<u>Role</u>
ST 1986	1.965	Special Studies in Civil Engineering	Lect. in Charge
FT 1986	1.964	Design for Construction Automation*	Lect. in Charge
ST 1987	1.13	Design for Construction Automation*	Lect. in Charge
FT 1987	1.08	Introduction to Robotics*	Lect. in Charge
FT 1987	1.502A	Freshman Seminar "Design of Machine Systems"	Lect. in Charge
ST 1988	1.13	Design for Construction Automation*	Lect. in Charge
FT 1988	2.70	Introduction to Design	Recitation
FT 1988	1.S04	Fr Freshman Seminar "Precision Machine Design"	Lect. in Charge
ST 1989	2.996	Precision Machine Design*	Lect. in Charge
FT 1991	2A08	Freshman Seminar: Precision Machine Design*	Lect. in Charge
FT 1991	2.731	Advanced Engineering Design	Co-lecturer
ST 1992	2.732	Advanced Engineering Design	Co-lecturer
ST 1992	2.840	Precision Machine Design*	Lect. in Charge
FT 1992	2A08	Freshman Seminar: Precision Machine Design*	Lect. in Charge
FT 1992	2.731	Advanced Engineering Design	Co-lecturer
ST 1993	2.732	Advanced Engineering Design	Co-lecturer
ST 1993	2.75	Precision Machine Design*	Lect. in Charge
FT 1993	2A08	Freshman Seminar: Precision Machine Design*	Lect. in Charge
FT 1993	2.72	Machine Elements	Co-lecturer
ST 1994	2.75	Precision Machine Design*	Lect. in Charge
FT 1994	2A08	Freshman Seminar: Precision Machine Design*	Lect. in Charge
FT 1994	2.73	Design	Co-Lect. in Charge
ST 1995	2.70	Introduction to Design	Lect. in Charge
FT 1995	2A08	Freshman Seminar: Design of Toys & Games*	Lect. in Charge
FT 1995	2.75	Precision Machine Design*	Lect. in Charge
IAP 1996	2.971	2nd Summer Intro. to Design*	Lect. in Charge
ST 1996	2.70	Introduction to Design	Lect. in Charge
FT 1996	2A08	Freshman Seminar: Design of Toys & Games*	Lect. in Charge
FT 1996	2.75	Precision Machine Design*	Lect. in Charge
IAP 1997	2.971	2nd Summer Intro. to Design*	Lect. in Charge
ST 1997	2.007	Design & Mfg I*	Lect. in Charge
IAP 1998	2.971	2nd Summer Intro. to Design*	Lect. in Charge
ST 1998	2.75	Precision Machine Design*	Lect. in Charge
ST 1998	2.007	Design & Mfg I*	Lect. in Charge
FT 1998	2.009	Product Design Section Instructor	
IAP 1999	2.971	2nd Summer Intro. to Design*	Lect. in Charge
ST 1999	2.007	Design & Mfg I*	Lect. in Charge
IAP 2000	2.971	2nd Summer Intro. to Design*	Lect. in Charge
ST 2000	2.007	Design & Mfg I*	Lect. in Charge
ST 2000	2.75	Precision Machine Design*	Lect. in Charge
IAP 2001	2.971	2nd Summer Intro. to Design*	Lect. in Charge
ST 2001	2.007	Design & Mfg I*	Lect. in Charge
FT 2001	2.75	Precision Machine Design*	Lect. in Charge
FT 2001	2.997	(J with 6.963 Medical Innovation)	Co-Lect. in Charge
IAP 2002	2.971	2nd Summer Intro. to Design*	Lect. in Charge
IAP 2002	2.996	Paths to peace*	Lect. in Charge
ST 2002	2.007	Design & Mfg I*	Lect. in Charge
FT 2002	2.996	Paths to peace*	Lect. in Charge
IAP 2003	2.971	2nd Summer Intro. to Design*	Lect. in Charge
ST 2003	2.007	Design & Mfg I*	Lect. in Charge
FT 2003	SP247	8.01 Physics with Sports*	Lect. in Charge
FT 2003	2.75	Precision Machine Design*	Lect. in Charge
IAP 2004	2.971	2nd Summer Intro. to Design*	Lect. in Charge

ST 2004	2.007	Design & Mfg I*	Lect. in Charge
FT 2004	SP247	8.01 Physics with Sports*	Lect. in Charge
FT 2004	2.75	Precision Machine Design*	Lect. in Charge
IAP 2005	2.971	2nd Summer Intro. to Design*	Lect. in Charge
ST 2005	2.007	Design & Mfg I*	Lect. in Charge
FT 2005	2.75	Precision Machine Design*	Lect. in Charge
ST 2006	2.007	Design & Mfg I*	Lect. in Charge
FT 2006	2.75	Precision Machine Design*	Lect. in Charge
ST 2007	2.007	Design & Mfg I*	Lect. in Charge
ST 2008	2.007	Design & Mfg I*	Lect. in Charge
FT 2008	2.75/2.750	Precision Machine Design*	Lect. in Charge
ST 2009	2.752/2.753	Developing Mechanical Products*	Lect. in Charge
FT 2009	2.75/2.750	Precision Machine Design*	Lect. in Charge
FT2009	2.A38	Freshman Advisor Seminar*	Lect. in Charge
ST 2010	2.752/2.753	Developing Mechanical Products*	Lect. in Charge
FT 2010	2.75/2.750	Precision Machine Design*	Lect. in Charge
FT2010	2.A38	Freshman Advisor Seminar*	Lect. in Charge
ST 2011	2.752/2.753	Developing Mechanical Products*	Lect. in Charge
FT 2011	2.75/2.750	Precision Machine Design*	Lect. in Charge
ST 2012	2.752/2.753	Developing Mechanical Products*	Lect. in Charge
FT 2012	2.75/2.750	Precision Machine Design*	Lect. in Charge
ST 2013	2.752/2.753	Developing Mechanical Products*	Lect. in Charge
FT 2014	2.75/6.525, 2.750/6.025J	Design of Medical Devices	Co-Lect. In Charge
ST 2014	2.752/2.753	Developing Mechanical Products*	Lect. in Charge
FT 2015	2.75/6.525, 2.750/6.025J	Design of Medical Devices	Co-Lect. In Charge
ST 2016	2.752/2.753	Developing Mechanical Products*	Lect. in Charge
ST 2016	2.70/2.77	FUNdaMENTALS of Precision Product Design *	Lect. in Charge
FT 2016	2.75/6.525, 2.750/6.025J	Design of Medical Devices*	Co-Lect. In Charge
ST 2017	2.70/2.77	FUNdaMENTALS of Precision Product Design *	Lect. in Charge
FT 2017	2.75/6.525, 2.750/6.025J	Design of Medical Devices*	Co-Lect. In Charge
ST 2018	2.70/2.77	FUNdaMENTALS of Precision Product Design *	Lect. in Charge
FT 2018	2.75/6.525, 2.750/6.025J	Design of Medical Devices*	Co-Lect. In Charge
ST 2019	2.70/2.77	FUNdaMENTALS of Precision Product Design *	Lect. in Charge
FT 2019	2.75/6.525, 2.750/6.025J	Design of Medical Devices*	Co-Lect. In Charge
ST 2020	2.70/2.77	FUNdaMENTALS of Precision Product Design *	Lect. in Charge
FT 2020	2.75/6.525, 2.750/6.025J	Design of Medical Devices*	Co-Lect. In Charge
ST 2021	2.70/2.77	FUNdaMENTALS of Precision Product Design *	Lect. in Charge

* Indicates subject developed by Slocum

Publications of Alexander H. Slocum

18. Books:

- 1) Slocum, A. H., Precision Machine Design, © 1995, Society of Manufacturing Engineers, Dearborn, MI. (first published by Prentice Hall in 1992).
- 2) Handbook of Human-centered Design (Japanese), Section 7.3.
- 3) Slocum, A. H., FUNdaMENTALS of Design, and accompanying lecture videos and notes available on-line for free at (<http://pergatory.mit.edu/2.007/resources/FUNdaMENTALS.html>).
- 4) Ito, T., Ichikawa, T., Hanumara, N. C., Slocum, A. H., "Teaching Creativity in Design Through Project-Based Learning in a Collaborative Distributed Educational Setting," Chapter from Cloud-Based Design and Manufacturing (CBDMM) , D. Schaefer (ed.) available on-line at (http://link.springer.com/chapter/10.1007/978-3-319-07398-9_9), Springer International Publishing Switzerland, 2014, pp. 231-282.

19. Papers in Refereed Journals:

- 1) McClintock, F. A., Slocum, A. H., "Predicting Fully Plastic Mode II Crack Growth from an Asymmetric Weld Defect," International Jrl. of Fracture Vol. 27, 1985, pp 49-62.
- 2) Slocum, A. H., "Design to Limit Thermal Effects on Linear Motion Bearing Components," Int. Jrl. Machine Tool Design, Vol. 27, No. 2, 1987, pp 239-245.
- 3) Slocum, A. H., Greenspan, L., Peris, J.P., "Design and Implementation of a Five Axis Robotic Micro-manipulator," Int. Jrl. Machine Tool Design, Vol. 28, No. 2, 1988, pp 131-141.
- 4) Slocum, A. H., "Development of a Six Degree-of-Freedom Position and Orientation Sensing Device: Design Theory and Testing," Int. Jrl. Machine Tool Design, Vol. 28, No. 2, 1988, pp 131-139.
- 5) Slocum, A. H. "Kinematic Couplings for Precision Fixturing - Part I - Formulation of Design Parameters," Jou. Int. Soc. of Precision Engineering and Nanotechnology, Vol. 10, No. 2, April 1988, pp 85-91.
- 6) Slocum, A. H. and Donmez, A., "Kinematic Couplings for Precision Fixturing - Part II - Experimental Determination of Repeatability and Stiffness," Jou. Int. Soc. of Precision Engineering and Nanotechnology, Vol. 10, No. 3, July 1988, pp 115-122.
- 7) *Slocum, A. H. and Schena, B., "Blockbot: A Robot to Automate Construction of Cement Block Walls," Robotics, Vol. 4, 1988, pp 111-129.
- 8) *Slocum, A. H. and Ziegler, A., "An Automated Shear Stud Welding System," Jrl. Robotics and Autonomous Systems, Vol. 6, 1990, pp 367-382.
- 9) Slocum, A. H. "Design of Three-Groove Kinematic Couplings," Jou. Int. Soc. of Precision Engineering and Nanotechnology, Vol. 14, No. 2, April 1992, pp 67-76.
- 10) *Battles, A.E., Linder, B. M., Chang, K.W., Slocum, A.H., "The Design of a Precision Bilaminar Resonating Transducer Assembly Tool", Jou. Int. Soc. of Precision Engineering and Nanotechnology, Vol. 15, No. 4, Oct. 1993, pp 248-257.
- 11) *Everett, J. G., and Slocum, A. H. "CRANIUM: Device for Improving Crane Safety and Productivity," ASCE Jrl. Construction Engineering and Management, 1994, 119 (1), pp 1-17. Received the ASCE 1994 Thomas Fitch Rowland Prize.
- 12) *Smith, M.H., Annaswamy, A.M., Slocum, A.H., "Adaptive Control Strategies for a Precision Machine Tool Axis," Precision Engineering, Vol. 17, No. 3, 1995, pp. 192-206.
- 13) *Slocum, A. H., Marsh, E.R., Douglas H. Smith, "A New Damper Design for Machine Tools and Components: "The Replicated Internal Viscous Damper," Precision Eng., Vol. 16, No. 3, June. 1994, pp 174-183.

- 14) *Slocum, A.H., Scagnetti, P.E., Kane, N.R., Brünner, C., "Design of Self Compensated Water-Hydrostatic Bearings", Jou. Int. Soc. of Precision Engineering and Nanotechnology, Vol. 17, No. 3, 1995, pp 173-185.
- 15) *Hale, L.C., Slocum, A.H., "Design of Anti-Backlash Transmissions for Precision Position Control Systems", Jou. Int. Soc. of Precision Engineering and Nanotechnology, Vol. 16, No. 4, Oct. 1994, pp. 244-258.
- 16) *Van Doren, M. and Slocum, A. "Design and Implementation of a Precision Material Handling Robot Control System," International Journal of Machine Tools and Manufacture, Vol. 35, Issue 7, 1995, Pages 1003-1014, [https://doi.org/10.1016/0890-6955\(94\)00043-J](https://doi.org/10.1016/0890-6955(94)00043-J).
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- 18) Schmiechen, P., Slocum, A.H., "Analysis of Kinematic Systems: a Generalized Approach", Jou. Int. Soc. of Precision Engineering and Nanotechnology, Vol. 19, No. 1, July 1996, pp. 11-18.
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- 20) *Kotilainen, M., Slocum, A. "Manufacturing of Cast Monolithic Hydrostatic Journal Bearings", Jou. Int. Soc. of Precision Engineering and Nanotechnology, Vol. 25 (2001), pp. 235-244.
- 21) *Hale, L. and Slocum, A, "Optimal design techniques for Kinematic Couplings", Jou. Int. Soc. of Precision Engineering and Nanotechnology, April 2001, vol. 24, number 2, pp. 114-127.
- 22) *Balasubramaniam, M., Dunn, H., Golaski, E., Son, S., Sriram, K., Slocum, A., "An Anti Backlash Two-Part Shaft Coupling with Interlocking Elastically Averaged Teeth", Precis Eng., Volume 26, July 2002, No. 3 pp. 314-330, 2002.
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- 26) *Slocum, A., Basaran, M., Cortesi, R., Hart, A.J., "Linear Motion Carriage with Bearings Preloaded by Inclined Iron Core Linear Electric Motor", Jou. Int. Soc. of Precision Engineering and Nanotechnology, 27 (2003) 382-394.
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- 54) *Graham, M, Slocum, A, Moreno Sanchez R., "Teaching high school students and college freshman product development by Deterministic Design with PREP", ASME Journal of Mechanical Design (Special Issue on Design Engineering Education), July 2007, Vol. 129, pp 677-681, [DOI: 10.1115/1.2722334].
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- 141) J.E. Petrzalka, D.M. Chatzigeorgiou, M.C. Menon, M.E. Lustrino, C.J. Stefanov-Wagner, A.H. Slocum, S.K. Agarwal, 2001, An Articulating Tool For Endoscopic Screw Delivery, Proc. of the 2010 Design of Medical Devices Conference, April 13-15, 2010, Minneapolis, MN, USA.
- 142) S.J. Anderson, J.C. Zimmermann, E.F. Houston, K.M. Farino, N.D. Begg, , Design of an Endoscopic Lens Shielding Device for use in Laparoscopic Procedures, Proc. of the 2010

Design of Medical Devices Conference, Minneapolis, MN, USA, Mar. 13-15, DMD2010-3849.

- 143) M. Read, R. Martens, J. Lang, and A. Slocum, "The Effects of Contact Radius and Scrub on Thin Film Contacts," Proc. of 56th IEEE Holm Conference on Electrical Contacts, Charleston, 2010.
- 144) D.S. Codd, A.H. Slocum, "Direct Absorption Volumetric Molten Salt Receiver With Integral Storage", Proceedings of ASME 2011 5th International Conference on Energy Sustainability & 9th Fuel Cell Science, Engineering and Technology Conference, ESFuelCell2011, August 7-10, 2011, Washington, DC, USA
- 145) *G. Rothenhöfer, A. Slocum, M. Paone, X. Lu, A. Yui, "Elements for the Design of Next Generation, High Stiffness and High Accuracy Precision Machines", 2011 euspen annual mtg, Como, Italy
- 146) *A. Slocum, R. Campbell, S. Ziegehgaen, W. Miskoe, D. V. Lorenzo Ippolito, N. De Blasio, "Design, Fabrication, and Testing of a Modular Concentrated Solar Power Trough System", 2011 euspen annual mtg, Como, Italy
- 147) O. Yaglioglu, R. Martens, A. Cao, A. H. Slocum, "Compliant Carbon Nanotube-Metal Contact Structures", Proc. of 57th IEEE Holm Conference on Electrical Contacts, 2011
- 148) D.S. Codd and A.H. Slocum, "Direct absorption volumetric molten salt receiver with integral storage," in ASME 5th International Conference on Energy Sustainability, ESFuelCell2011, August 7-10, 2011, Washington, DC, 2011.
- 149) Walsh, C., Slocum, A.H., "Design of a Telerobot for Percutaneous Instrument Distal Tip Repositioning", 33rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC'11), Boston, MA, USA on August 30 - September 3, 2011.
- 150) Zurovcik, D., Slocum, A.H., "Development of Simplified Negative Pressure Wound Therapy Device for Low-Resource Settings", 2011 IEEE Global Humanitarian Technology Conference.
- 151) Graves C., Slocum, A.H., Gupta, R., Walsh, C., "Towards a Compact Robotically Steerable Thermal Ablation Probe ", submitted to 2012 IEEE International Conference on Robotics and Automation, May 14-18, 2012, RiverCentre, Saint Paul, Minnesota, USA
- 152) Slocum, A.H, Wong, A.R., "Hydrostatics on a Halfshell", 2011 ASPE annual meeting, Denver, CO.
- 153) Petrzela, J.E., Chatzigeorgiou, D.M., Menon, M.C., Lustrino, M.E., Stefanov-Wagner, C.J., Slocum, A.H., and Agarwal, S.K., "An Articulating Tool for Endoscopic Screw Delivery," Proceedings of the 2010 Design of Medical Devices Conference, Minneapolis, MN, 2010.
- 154) Agarwal, S.K., Petrzela, J.E., Menon, M.C., Stefanov-Wagner, C.J., Chatzigeorgiou, D.M., Lustrino, M.E., and Slocum, A.H. "Thoracoscopic Stabilization of the Chest Wall," Proceedings of the New England Surgical Society Annual Meeting, 2010.
- 155) Ito, T, Ichikawa, T., Hanumara, H., Slocum, A.H., "Expectation Management In A Global Collaboration Project Using Deterministic Design Approach", Proceedings of the ASME 2012 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference IDETC/CIE 2012, August 12-15, 2012, Chicago, IL
- 156) T. Koiwai, A. Honda, G. Okahata, T. Kitajima, A. Yui, S. Okuyama, H. Kobayashi, A. Slocum, "Development of Grinding Machine for 450mm Wafer - 1st report: Specification and Fundamental Performance of The Grinding Machine", JSME 9th Manufacturing & Machine tool Conference, Akita prefecture October 26-27 2012
- 157) A. Honda, A. Yui, T. Koiwai, S. Okuyama, G. Okahata, H. Kobayashi, T. Kitajima, A. Slocum, "Development of Grinding Machine for 450mm Wafer - 2nd Report: Numerical Analysis of Static Stiffness and Load Capacity of Water Hydrostatic Table", JSME 9th Manufacturing & Machine tool Conference, Akita prefecture October 26-27 2012
- 158) A. H. Slocum, M. A. Chiu, E. D. Hobbs, G. Rothenhöfer, A.Yui, "Kinematic and Elastically Averaged Joints: Connecting the Past, Present and Future", IUSPEN, Tokyo Japan, March 13, 14, 2013

- 159) A. Yui, A. Honda, S. Okuyama, T. Kitajima, G. Okahata, H. Saito, A. H. Slocum, "Development of a vertical-spindle rotary surface grinding machine for large scale silicon-wafers –Machine specifications and performance of rotary work table–", Proceedings of the 13th euspen International Conference, Berlin, May 2013
- 160) F.E. Rojas and Slocum, A.H., "Continuous Feed of an Occluding Medium into a Flow Stream," presented at ASPE Annual Meeting, St. Paul, MN, USA, October 21-25, 2013.
- 161) A.H. Slocum, "Addressing Big Challenges with Precision Symbiotic Systems Thinking," presented at ASPE Annual Meeting, St. Paul, MN, USA, October 21-25, 2013.
- 162) S.A. Lopez, et al., "Design Prototyping, and Evaluation of a Collapsible Device for Single-Operator Sheathing of Ultrasound Probes," Mechanical Sciences Guest Editorial, ms-2013-13, Special Issue, Design of Medical Devices: Creative Solutions by Young Researchers.
- 163) A.H. Slocum, "Symbiotic Offshore Energy Harvesting and Storage Systems," Proceedings of 2014 Offshore Energy & Storage Symposium, Windsor, Ontario, Canada, UWCAES Society, July 10-11, 2014.
- 164) M. N. Haji, C. Vitry, A. H. Slocum, "Design of a Symbiotic System to Extract Uranium from Seawater," Seawater Uranium Recovery Program Meeting, Oak Ridge, TN, January 12-13, 2015.
- 165) J.M. Kluger, T.P. Sapsis, and A.H. Slocum, "First order power estimation of a floating oscillating water column encircling an offshore wind turbine," NEEC Annual Meeting, NSWC Carderock, West Bethesda, VA. April, 2015.
- 166) J.M. Kluger, T.P. Sapsis, and A.H. Slocum, Combined offshore wind-wave-storage system power and cost predictions, NAWEA Symposium, Blacksburg, VA, June 8, 2015.
- 167) M. N. Haji, C. Delmy, J. Gonzalez, A. H. Slocum, "Design of a Symbiotic System to Extract Uranium from Seawater," Seawater Uranium Recovery Program Meeting, College Park, MD, August 6-7, 2015.
- 168) M. N. Haji, C. Delmy, J. Gonzalez, A. H. Slocum, "Extraction of Uranium from Seawater: Design and Testing of a Symbiotic System," NAKFI Advancing Nuclear Technologies Mid-Cycle Grant Meeting, Chicago, IL, July 9, 2015.
- 169) M. N. Haji, C. Vitry, and A. H. Slocum, "Decoupling the functional requirements of an adsorbent for harvesting uranium from seawater through the use of shell enclosures," In *Proceedings of the 2015 ANS Winter Meeting and Nuclear Technology Expo*, Washington, DC, November 8-12, 2015
- 170) F. Rojas, A. Slocum, "A BOP Back-Up System: The Hampering Active Wellbore Kit (HAWK)" □SPE Workshop: Downhole Tools, Tuesday, October 20th, 2015, Galveston, TX
- 171) M. E. Flicker Byers, M. N. Haji, E. A. Schneider, and A. H. Slocum, "A Higher Fidelity Cost Analysis of Wind and Uranium from Seawater Acquisition SymBiotic Infrastructure", In *Proceedings of the 2016 ANS Winter Meeting and Nuclear Technology Expo*, Las Vegas, NV, November 6-10, 2016.
- 172) M. N. Haji, C. Delmy, J. Gonzalez, A. H. Slocum, "Uranium extraction from seawater using adsorbent shell enclosures via a symbiotic offshore wind turbine device", *Proc. Twenty-sixth (2016) International Ocean and Polar Engineering Conference*, Rhodes, Greece, June 26-July 1, 2016 (Best Paper Award)
- 173) J.M. Kluger, T.P. Sapsis, and A.H. Slocum, "A reduced-order, statistical linearization approach for estimating nonlinear floating wind turbine response statistics," *Proceedings of the International Society of Offshore and Polar Engineers Conference*, Rhodes, pp. 8 (2016).
- 174) M. N. Haji, A. H. Slocum, "Design of a Symbiotic Device to Harvest Uranium from Seawater through the use of Shell Enclosures", In *Proceedings of the 2016 ANS Winter Meeting and Nuclear Technology Expo*, Las Vegas, NV, November 6-10, 2016.
- 175) J.M. Kluger, A.H. Slocum, T.P. Sapsis, "A first-order dynamics and cost comparison of wave energy converters combined with floating wind turbines," *Proceedings of the International Society of Offshore and Polar Engineers Conference*, San Francisco, CA, pp. 9 (2017).

- 176) A.H. Slocum, M. N. Haji, J.M. Kluger, T.P. Sapsis, "Mechanics and materials in the design of symbiotic offshore energy harvesting systems", 7th Intl Conf. Progress in Mechanics and Materials in Design, Albufeira Portugal, 11-15 June 2017.
- 177) M. N. Haji, M. E. Flicker Byers, E. A. Schneider, and A. H. Slocum, "Cost Analysis of Wind and Uranium from Seawater Acquisition symBiotic Infrastructure using Shell Enclosures", In Proceedings of the 2017 ANS Meeting, San Francisco, CA, June 11-15, 2017.
- 178) M. N. Haji, J. Drysdale, K. Buesseler, and A. H. Slocum, "Ocean Testing of a Symbiotic Device to Harvest Uranium from Seawater through the Use of Shell Enclosures", In Proceedings of the Twenty-seventh (2017) International Ocean and Polar Engineering Conference, San Francisco, CA, June 25-30, 2017.
- 179) T. Hamer, L. Zhou, V. Perez, A. Gil, D. Trumper, A.H. Slocum, N. Calvet, "Implementation of Thermal-Insulating and-Mixing Elements in a Concentrated Solar Power on Demand System", SOLAR PACES Conf, Sept. 2017, Santiago, Chile.
- 180) A. Slocum, Ronald Campbell, M. Giglio, A. Bernasconi, S. Cardamone, N. Parow, "Large monolithic curved panels and cylindrical torque tubes for concentrated solar power parabolic trough systems", euspen annual mtg, Venice, Italy, 2018
- 181) L. Gray, A. Slocum, "Cable Train: In-Situ Manufacturing of Trackside Underground Cable HVDC Transmission Systems", CIGRE US National Committee [http : //www.cigre.org](http://www.cigre.org) 2018 Grid of the Future Symposium Nov. 2018.
- 182) A.C. Duenner, A.H. Slocum, "Framework for Error Budgeting in Precision Machine Design" Proceedings - ASPE 2018 Annual Meeting. Las Vegas, NV; 2018.
- 183) M. Verma et. Al., "Development Of A Long-Acting Direct-Acting Antiviral System For Hepatitis C Virus Treatment In A Swine Model", 2020 DDW (Digestive Diseases Weekly) conference.
- 184) Johnson, H. A., Simon, K. P., and Slocum, A. H., 2020, "Improving the Design Life Cycle Efficiency of Wastewater Treatment Plant Inflow Pumps," Proceedings of Applied Energy Symposium: MIT A+B, ICAE, p. 5. <http://www.energy-proceedings.org/improving-the-design-life-cycle-efficiency-of-wastewater-treatment-plant-inflow-pumps/>
- 185) J. Oeding, S. Bockman, H. Chiu, C. Hua, J. Connor, A. Slocum, "Design of a Multi-Degree-of-Freedom Traction and Stabilization Device for Open Reduction and Internal Fixation of Distal Radius Fractures", BIOMED 2021; V001T13A007doi:<https://doi.org/10.1115/DMD2021-1047>
- 186) Doron, P., Karni, J., & Slocum, A. (2019), "A Generalized Approach for Selecting Solar Energy System Configurations for a Wide Range of Applications", MRS Energy & Sustainability, 6, E#. doi:10.1557/mre.2019.10
- 187) Gessel, D., Slocum, A., "Lifespan Analysis of Utility Scale Energy Storage Options", euspen special interest group mtg, 13-14 Oct. 2021.
- 188)

*Outgrowth of supervised student research.

21. Other Major Publications:

- 1) Slocum, A. H., (Executive Producer) for inner-city kids' rap group Mental Block, their first CD entitled "IF".
- 2) Slocum, A. H., (Executive Editor) for Marc Graham's book of poems and images entitled "JoTLS" (Journey of The Lost Souls) www.jotls.com.

22. Invited Lectures:

1. April 1986, "Flexible Automated Fixturing Systems," SME Conf. on Jigs and Fixtures, Cincinnati, OH.
2. Dec. 1986, "A Five Axis Robotic Micromanipulator," ASME Winter Annual Meeting, Anaheim, California.
3. Dec. 1986 "A Servo-Controlled Pneumatic Double Gripper with Changeable Fingers," ASME Winter Annual Meeting, Anaheim, CA.
4. Sept. 1989, *Precision Machine Design*, Short course for the American Society for Precision Engineering Annual Meeting in Monterey, CA.
5. Sept. 1990, *Precision Machine Design*, Short course for the American Society for Precision Engineering Annual Meeting in Rochester, NY.
6. Oct. 1991, *Precision Linear Motion Bearing Design*, Short course for the American Society for Precision Engineering Meeting in Santa Fe, NM.
7. Oct. 1991, *Error Budgeting and Machine Modeling*, Short course for the American Society for Precision Engineering Meeting in Santa Fe, NM.
8. Oct. 1992, *Actuators for Precision Machines*, Short course for the American Society for Precision Engineering Meeting in Orlando, FL.
9. Oct. 1992, *Applications of Ceramic Materials in Precision Machines*, Short course for the American Society for Precision Engineering Meeting in Orlando, FL.
10. Nov. 1993, *Actuators for Precision Machines*, Short course for the American Society for Precision Engineering Meeting in Seattle, WA.
11. Nov. 1993, *Applications of Ceramic Materials in Precision Machines*, Short course for the American Society for Precision Engineering Meeting in Seattle, WA.
12. Nov. 1993, *Design of Damping Systems for High Precision Machines*, Short course for the American Society for Precision Engineering Meeting in Seattle, WA.
13. Nov. 1994, *Actuators for Precision Machines*, Short course for the American Society for Precision Engineering Meeting in Cincinnati, OH.
14. Nov. 1995, *Actuators for Precision Machines*, Short course for the American Society for Precision Engineering Meeting in Phoenix, AZ.
15. Oct, 2000, *Getting Students Psyched about Engineering and Science*, Robofesta Conf., Osaka, Japan
16. Nov. 2000, *Advances in Machine Tool Design*, ASME Winter Annual Meeting, Orlando, FL
17. July 2001, *Advances in Machine Elements*, keynote address, 10 International Conference on Precision Engineering, Yokohama, Japan.
18. Nov. 2002, *Mechanics of Designing Precision Machines*, Harvard University, Division of Engineering and Applied Science Dept. seminar
19. April. 2003, *The Nanogate*, Harvard University, Division of Engineering and Applied Science Dept. seminar
20. June 2003, *Characterization and Fabrication of the NanoGate for Nanoscale Fluidics, Wireless Communications, and ?*, NSF Workshop on Nanoscale Mechanical Engineering, Arlington, VA Nov. 2002
21. Nov. 2003, *Advances in Precision Machine Design*, keynote speaker, Mechatronics, Automation and Control Symposium of the COBEM 2003 Sao Paulo Brazil
22. Nov. 20, 2003, "Fundamentals of MEMS machines", Invited lecture, University of Florida
23. March 22, 2004, "Fundamentals of Precision Machine Design", invited lecture, Brigham Young University
24. March 22, 2004, "Applying Macro Machine Design Experience to Dinky Designs", invited lecture, Brigham Young University
25. May 17, 2004, "Fundamentals of Precision Machine Design", invited lecture, Ohio State University
26. June 2, 2004, "Magnetically Preloaded Friction Drive System", Invited keynote speaker, European Union Society for Precision Engineering & Nanotechnology annual meeting.
27. Sept. 6, 2004, "A design Environment to Teach Students about Optimal Transmission Ratios", 4th. Intl. Conf. Advanced Engineering Design, Glasgow, Scotland, Sept. 5-8, 2004.
28. Sept 14, 2006, "Design of Small Precision Machines", ICOMM Univ. of Illinois UC, keynote address

29. Oct. 16, 2007, "Water Hydrostatic Bearings for Precision Machine Tools and Industrial Machinery", invited talk, ASPE Annual Mtg
30. April 14, 2008 "A Fantasy Vision of how as a Giant Bio Nano Team We All Zoom Forward to Infinity and Beyond," 2008 Bio-Nano Manufacturing Grand Challenges for 2020 Workshop, Arlington, VA
31. Oct 21, 2010 "Precision Machines for Renewable Energy Harvesting and Storage", First IFToMM Asian Conference on Mechanism and Machine Science, Taipei, Taiwan
32. March 13-14, 2013 "Kinematic and Elastically Averaged Joints: Connecting the Past, Present and Future", IUSPEN, Tokyo Japan
33. July 10-11, 2014 "Symbiotic Offshore Energy Harvesting and Storage Systems," Offshore Energy & Storage Symposium, invited talk, UWCAES Society, Windsor, Ontario, Canada
34. July 25, 2014 "Big hydrostatic bearings for ships and offshore wind machines", invited keynote speech, Japan Society for Precision Engineering annual meeting, Komatsu Japan.
35. Nov 2014, "Symbiotic Systems for The Future of Energy, Water, and Food", Atlantic Council Energy and Economic Summit, Istanbul
36. March 24, 2015, "The Future of Energy, Generation, Demand & Supply", PEWA, Johannesburg, South Africa
37. Oct. 29, 2015, "Symbiotic Systems for The Future of Energy, Water, and Food", Dartmouth College, Visionaries in Technology Distinguished Lecture
38. Feb 16, 2016, "Symbiotic Systems for The Future of Energy, Water, and Food", Weizmann Institute of Science
39. June 2, 2016, "A Bright Future for Energy & the World", Frankfurter Allgemeine Forum, Berlin Germany.
40. Volo Foundation/ ClimateCorrec4on, "Symbiotic Systems for The Future of Energy, Water, and Food", Oct 11, Orlando, FL.
41. Dec. 11.2018, "Vision Speech: A Bright Future for Energy & the World", Future Energies Science Match 4 December 2018, Kiel Germany

Theses Supervised by Alexander H. Slocum

	<u>Total</u>	<u>Completed</u>	<u>In Progress</u>
S.B.	127	127	0
S.M.	85	84	1
Engineers	1	1	0
Doctoral Supervisor:	59	57	2
Doctoral Reader (committee member):	44	44	0

S.B. Theses:

1. Robinson, Darryl K., "Design of a Prototype Fastening System for the Trackbot Automated Construction Robot," May 1986.
2. Kang, Jiin, "Design of a Track Positioning Mechanism for an Interior Wall Construction Robot," June 1986.
3. Paulson, Bruce A., "Design of a Materials Handling System to Automate Interior Wall Construction," June 1986.
4. Thackston, III, George W., "Design of an Automatically Guided Vehicle for Use in Automated Drywall Construction," June 1986.
5. Gladwin, S. C., "Design and Assembly of a Construction Robot Subsystem to Fasten Drywall to Studs," June 1986.
6. Shiller, Andrew, "Kinematic Analysis of A Precision Slide," June 1987.
7. Gregory, Arthur, "Vacuum Gripper Design for Automated Assembly," June 1987.
8. Wurman, Peter, "Anechoic Chamber Design and Acoustical Analysis of Room 1-051," June 1987.
9. Heatzig, Eric, "Scaffbot-A Servo Controlled Scaffolding Device," June 1987.
10. Huang, Stanley, "Design and Implementation of a Software Controller for a Wall Building Robot," June 1987, (Electrical Engineering and Computer Science).
11. Barrientos, Miguel, "Tools for Developing Countries," June 1993.
12. Mateo, Evan, "Semiconductor Wafer Gripper," June 1994.
13. Phillips, Alton, "Electrostatic Air Cleaner," June 1994.
14. Breinlinger, Keith J., "A Handbook to show 2.007 Students How to Better Utilize the Materials in the 2.007 Kit," February 1996
15. Percer, Adrian C., "2.007 Briggs and Stratton Lawnmower Engine Exercise," June 1996
16. Estan, Basak, "Modeling Methods Using Computer Aided Design," June 1996.
17. Goldstein, Evan D., "The Design Process as Employed in the Introduction to Design Class at MIT," June 2006.
18. Hicks, Robert J., "A Proposal for the 2.007 Book: Instrument to Design," February 1997
19. Youngbear, Kathy, "Optimization of Cross-Sectional Configuration of an Extruded Plastic Truss," June 1997.
20. Richkus, Rebecca, "Performance Limiters in the Clamping Mechanism of Injection Molding Machine," June 1997.
21. Schmidt-Lang, Michael P., "The Design of a Simple Wind Tunnel Test Stand for Measuring Lift to Drag Ratio," June 1997.
22. Pellegrini, Brian J., "Guide to the Design Process through the MIT 2.70 Contest," June 1997.
23. Melvin, Jason W., "Design of a Kinematic Coupling for Machine Tool Fixturing," June 1997.
24. Lehman, David M., "The Design Process: MIT 2.70 Contest," June 1997.
25. Burn III, Robert D., "Simulator Chair Design: Ergonomics and Vibration," June 1997.
26. Shah, Raj, "Creation of a Website for the Purposes of Archiving Course-Related Material," June 1997.
27. Allen, Holly, "Multimedia as a Teaching Tool in 2.007," June 1998.
28. Miller, John, "Design of an Anti-Backlash Transmission for Position Control Applications," June 1998.
29. Butville, Michael, "Driveshaft Design for a Dynamometer Utilizing Rotary Motion Flexural Bearings," June, 1998.
30. Durant, Lawrence C., "Administration of the Urban Design Corp. and the Implementation of Design in Hip Hop Production," February 1999.
31. Prieto, Rodrigo, "2.007 Contest Design and Machine Design," June 1999.

32. Cooperman, Seth J., "The History, Mechanics, and Psychology of Magic," June 1999.
33. Cortesi, Roger S., "Designing a Mechanical Engineering Contest," June 1999.
34. Sprunt, Alexander D., "A Three Axis CNC Router Design," February 2000.
35. Davis, Wallace B., "Design and Cost Optimization of a Cast Concrete Constrained Layer Vibration Damper," September 2000.
36. Loisel, Phillip J., "Thermal Stability of Kinematically Coupled Microscope Stack Structure," June 2001.
37. Moon, Daniel K., "Flexure Based Mounts for Sensitive Payloads: A Management and Engineering Stack Study (Course 2B)," June 2001.
38. Harper, Christopher, "Redesign of Industrial Pin Joint Test Apparatus," June 2001.
39. Chouinard, Natalie, "Design Process of a 2.007 Design and Manufacturing Contest Table," June 2001.
40. Arguelles, David, "Design and Manufacture of a BattleBot," June 2001.
41. Sanchez, Manuel A., "Plantez Business Plan and Preliminary Research," June 2001.
42. Kisai, Darul "Mechanical Design of Chassis and Drivetrain for an Autonomous Mobile Robot," June 2001.
43. Montgomery, Sean J., "An Analysis of the Dynamics of the 2001 2.007 Contest Table with an Overview of its Application to Table Design Choice," June 2001.
44. Harper, Kelly, "Redesign of Industrial Pin Joint Test Apparatus," June 2001.
45. Shur, Maiya, "Design and Manufacturing of a Device Prototype for Performing Combined Ultrasound and X-Ray Mammography," June 2002.
46. Bernstein, Oren, "Wireless Touch Pads for Competitive Swimming," June 2002.
47. Bravard, Marjory A., "Design and Implementation of an Electrical System for a Combined Ultrasound and X-ray Mammography Breast Imaging Device," June 2002.
48. Ferguson, Kevin M., "Design and Fabrication of the Testing Apparatus for the Characterization of the Z-axis Flexure in the MIT-PERG/UIUC-LFD High-Precision Microscope Project," June 2002.
49. Praster, Stephanie M., "Prototype Development of Linear Actuator System to Enable Breast Ultrasound," September 2002.
50. Roberts, Michael H., "Approximation of Air Bearings as Linear Point Springs: Verification of an Analytical Model for a New Five-Axis Machine Tool," June 2002.
51. Bloomsburgh, John G., "Sealing and Heat Transfer Analysis of Gas Flow through Alumina Tubes in a Tube Furnace," June 2003.
52. Jacobs, Alex T., "Development of a Right-Angle Gearbox Design Module for Use in Undergraduate Mechanical Design Curriculum," June 2003.
53. Varady, Eric J., "Design and Manufacture of the 2003 2.007 Wireless Control Boxes," February 2004.
54. Browne, Courtney, "Design of a 2.007 machine with All-Terrain Suspension," June 2004.
55. Read, Melissa, "Designing a Better Hair Straightener," June 2004.
56. Kahn, Christopher, "Solution for Modular Die-Level Anodic Bonder," June 2004.
57. James, Richard, "Design of an Aluminum Differential Housing and Driveline Component for High Performance Application Abstract," June 2004.
58. Figueroa, Victor A., "Designing a Mechanism to Cleave Silicon Wafers," September 2004.
59. Mukaddam, Kabir, "Design of a Silicon Wafer Fracturing Instrument," February 2005.
60. Gomez III, Nicasio, "PCV Valve Flutter: Vibration Characterization through Pressure and Flow," June 2005.
61. Held, David, "Modeling and Control of a Silicon Substrate Heater for Carbon Nanotube Growth Experiments," June 2005.
62. Fonder, Gregory Paul, "The Back Stroke Buddy," June 2005.
63. Bonas, Calvin, "Re-Usability of Plastics," June 2005.
64. Jonnalagadda, Aparna S., "Passive Microfluidic Interconnects," June 2005.
65. Shu, Yuan, "Tabletop Robot to Aid in Arm Rehabilitation of Stroke Patients," June 2005.
66. Su, Benjamin W., "Wheelchair Exercise Roller Product Design," June 2005.
67. Johnson, Philip Tyler, "Development and Design of an Adjustable Elastic Support System for Ensuring Safety While Learning Physical Skills," June 2005.

68. Nelson, Alexandra T., "Press Fit Design: Force and Torque Testing of Steel Dowel Pins in Brass and Nylon Samples," June 2005.
69. Trangle, Etan S., "SmartBat: A Baseball Swing Analysis and Training Product," June 2005.
70. Smith, Benjamin D., "HandSkates: An Apparatus for physically Intelligent Exercise," June 2005.
71. McKenney, Kyle S., "The Design and Development of Aquatic Exercise Shoe Flags," June 2005.
72. Hatton, Ross L, "Plant Design for Deterministic Control of STEMs and Tape-Springs," June 2005.
73. Breinlinger, Joshua E., "Design and Construction of a Linear Induction Powered LEGO Roller Coaster," June 2006
74. Fuertes, Amilcar, "Read and Do with the Animaroos," June 2006.
75. Shull, Craig M., "Fundamentals of the 2.007 Design Process," June 2006.
76. Lin, Wey-Jiun, "Product Realization of the 2.007 Control Box," June 2006.
77. Yang, Tiffany, "The Wall-Mill: The Design of a Flexible Machine for the In-Situe Architectural Machining of Surfaces," June 2006.
78. Tsai, Helan, "Swimming Fins for Strengthening the Inner Quadriceps Muscle," June 2007.
79. Juan Herrera, "Wall Miller," June 2007.
80. Colton, Shane, "Energy harvesting power electronics," June 2008.
81. Bosworth, Will, "Adjustable Kinematic Coupling," June 2008.
82. Schroll, Gregory, "Gyroscope Actuated Spherical Robot," June 2008.
83. Treadway, Shane, "Climbing knot fixture," June 2008.
84. Harrington, Jeremy, "Steerable Catheter," June 2009.
85. Paxton, Adam, "Air Window over Salt Reciever," June 2009.
86. Gil Amrita, "Multi Loop Heat Exchanger for Molten Salts," June 2009.
87. Koniski , Cyril, "Precision 4-Bar linkages," June 2009.
88. Nikandrou, Paul, " Dynamic Valuation Model For Wind Development In Regard to Land Value, Proximity to Transmission Lines, and Capacity Factor," June 2009.
89. Houston, Emily, "Design of an Endoscope Lens Shielding Device for Use in Laparoscopic Procedures," June 2010.
90. Lampe, Evan M, "Design of an Endoscope Lens Shielding Device for Use in Laparoscopic Procedures," June 2010.
91. Schantz, Jarred L, "Design of an Endoscope Lens Shielding Device for Use in Laparoscopic Procedures," June 2010.
92. Adames, Adrian, "Design Considerations of a 15KW Heat Exchanger for the CSPonD Project"
93. Chen, Xuefeng, "Instrument Guide for MRI-guided Percutaneous Interventions," June 2010.
94. Ding, Hao, "Characterization of a Pre-curved Stylet Distal Tip Manipulation Mechanism for use in Volume Targeting," June 2010.
95. Esmail, Adnan M, "Cannabis Sativa: An Optimization Study for ROI," June 2010.
96. Powelson, Stephen K, "Developing a Low-Cost Ventilator," June 2010.
97. Rodriguez Alvarado, Juan F, "Validation of a Numerical Model for the Analysis of Thermal-Fluid Behavior in a Solar Concentrator Vessel," June 2010.
98. Racz, Rastislav , "Design of Bicycle Testing Rig," June 2010.
99. Adames, Adrian A., Design considerations of a 15kW heat exchanger for the CSPonD Project," June 2010.
100. Cervantes , Thomas Michael, "Analysis and Design of an Adjustable Bone Plate for Mandibular Fixation," June 2011.
101. Correll, Eric Owen, "Design of a rapid, continuous, small-scale device for creating dry powders from concentrated suspensions containing active pharmaceutical ingredients," June 2011.
102. O'Rourke, Conor Rakis, "Mechanical Development of the Mounting and Actuation System of a Parabolic Solar Trough," June 2011.
103. Westwood, Mitchell, "Creation and Validation of a Numerical Model for the Analysis of Bending Patterns of a Flexural Laparoscopic Grasper," June 2011.
104. Hawthorne, Stephan, "Device for the Mechanization of Corneal Transplants," June 2011.
105. Marten-Ellis Graves, Carmen, "Drive Train Improvements and Performance Evaluation of a Robotically Steered Needle," June 2011
106. Reyda, Caitlin J., "Design of a Pressure Sensing Laparoscopic Grasper," June 2011.
107. Rees, Jennifer A., "Modeling the Solar Thermal Receiver for the CSPonD Project," June 2011.

108. Dündar, Gökhan, "Design and manufacture study of Ocean Renewable Energy Storage (ORES) prototype," June 2012.
109. Erickson, Andrew T., "Design and optimization of actuation mechanisms for rapid skin closure device," June 2012.
110. Khalifa, Sammy Mohsen, "Mechanics of jammed media used as a structural element," June 2012.
111. Mason IV, Alexander M., "Design, measurement, and analysis of oxygenated fluid pump system," June 2012.
112. Peña, Kristen Helen, "Characterization of an oxygen suspension used for intravenous infusion," June 2012.
113. Piazzarolo, Bruno Aiala, "Design optimization of oxygenated fluid pump," June 2012.
114. Jarboe, Jason Neal, "A Method for Infrared Temperature Measurements of Thin Im Materials with a Low, Unknown and/or Variable emissivity at Low Temperatures," June 2013.
115. Popovic, Katarina, "Design and Analysis of Hydraulically Driven Actuation System for a Parabolic Solar Trough," June 2013.
116. Carrillo, Juan Felipe, "Mechanical Development of an Actuation System for a Parabolic Solar Trough Collector," June 2013.
117. Flowers, Susan Caroline, "Design of a Laparoscopic Simulation Device for Testing and Training," June 2014.
118. Abiose, Kabir, "Improving The Concentrated Solar Power Plant Through Connecting The Modular Parabolic Solar Trough", June 2016.
119. Cao, Cyndia, "Exploration of Configurations of Wave Energy Converters to Mechanically Drive a Seawater Uranium Harvester", June 2017
120. Delmy, Cédric, "Making Haiti "The Pearl of the Antilles" again: What Can Be Done?" June 2018
121. Brown, Austin, "Axially Compliant Grinding Spindle for Robotic Grinding", June 2018
122. Gray, Luke, "Cable Train: A Platform for In-Situ Manufacturing of Underground Cable", June 2018
123. Bratten, Richard, "Cost Analysis and Profitability of the Cable Train: A Mobile Platform for Manufacturing Underground Cable Systems", June 2018
124. Leathrum, Travis, "Modular Auger Design to Prevent Clogging in Suction", June 2019
125. Wettermark, Susan Daly, "Modeling Flow Characteristics of a Low Specific-Speed Centrifugal Pump with Different Volute Shapes", June 2019
126. Le, Serena, "Design of a Load-Lock System for the Lyophilization of Unit-Dose Pharmaceuticals in a Continuous Manufacturing Machine", June 2019
127. Flores, Ryan, "Design of Load-lock Door for Unit Dose Continuous Lyophilization Process for Complex Biologics", June 2019

S.M. Theses:

- 1) Hou, William M., "Conceptual Design of an Automated System for Emplacement and Retrieval of Nuclear Waste," January 1987.
- 2) Schena, Bruce, "Design Methodology for Large Work Volume Robotic Manipulators: Theory and Application," Sept. 1987.
- 3) Gedney, Richard, "Sensor and Control System Design for Automated Testing of Structural Materials," January 1988.
- 4) Damazo, Bradford, "Mechanical, Sensor, and Control System Design of an Accelerometer Calibrator with One Part Per Million Accuracy," January 1988.
- 5) Ousterhout, Karl, "Design of a Force and Position Servo Controlled Robotic Gripper with a 50:1 Grip Force to Weight Ratio," January 1988.
- 6) Levy, David, "Studbot: A Construction Robot for the Automated Assembly of Steel-Stud Partition Walls," Sept. 1987.
- 7) Ziegler, Andrew, "Studwelder: A Construction Robot for In-Situ Automated Welding of Shear Studs," June 1988.
- 8) Heatzig, Eric, "Modular digital servo controller," June 1989 (Civil Engineering).
- 9) Hochmuth, Catrsten, "Design and Construction of a machine tool axis prototype for evaluation of adaptive and learning control systems," January 18, 1990.

- 10) Carey, John, "Methodologies of Controller Design for Precision Linear Motion Systems," June 1992.
- 11) Gaub, Heinz, "Hydrostatic Linear Motion Bearings for Precision Machine Tools," June 1992.
- 12) Schmeichen, Philip, "Design of Precision Kinematic Systems," Jan. 1993.
- 13) Bhatena, Firdaus, "Mapped Control Systems for Precision Machines," (Co-supervisor with Prof. Lang), June 1993.
- 14) Mintz, David, "Models for the development of precision machine tools", June 1993.
- 15) Smith, Michael, "Adaptive Control Systems for Precision Machines," (Co-supervisor with Prof. Annaswamy), June 1993.
- 16) Br  nner, Christoph, "Self Compensating Hydrostatic Bearings for Grinding Machine Tables," January 1994.
- 17) Chiu, Michael, "Design of a Precision High Speed Tool Servo," January 1994.
- 18) Wasson, Kevin, "High Speed Hydrostatic Spindle Design," 1994.
- 19) Doubleday, Roland, "A control system for a testhead manipulator," June 1995.
- 20) Vallance, Ryan, "Design and prototype fabrication of a manipulator for semiconductor test equipment," June 1996.
- 21) Culpepper, Martin, "Design of Debris Cleaner Using a Compound Auger and Vacuum Pick Up," January 1997.
- 22) Scrivens, Jevin, "A Wireless Robot for Semiconductor Manufacturing Equipment," June, 1997.
- 23) Houdek, Phillip, "Design and Implementation Issues for Stewart Platform Configuration Machine Tools," June 1997.
- 24) Alden, John, "Active Kinematic Coupling," June 1997.
- 25) Ellahi, Farooq, "An Integrated Decanter Centrifuge-Pitot Pump," June 1997.
- 26) Brienlinger, Keith, "Hexapod Home Flight Simulator," August 1998.
- 27) Balakrishnan, Asha, "Planarized Ball Grid Arrays," June 1999.
- 28) Schmidt-Lange, Michael, "A graduate level treatment of the design of a machine for the 1999 2.007 Contest," June 1999.
- 29) Rohatgi, Gaurav, "Damped Tool Holder - Approaches for Chatter Reduction in Deep Cavity and Intricate Surface Milling," June 1998.
- 30) Cortesi, Roger, "An Easy to Manufacture Non-Contact Precision Linear Motion System and Its Applications," August 2000.
- 31) Sprunt, Alex, "Electrical Contact tester," June 2002.
- 32) Robertson, Alec, "Precision Aerostatic Spherical Joint," June 2003.
- 33) Montgomery, Sean, "Electronics Curriculum for 2.007," June 2003.
- 34) Werkmeister, Jaime, "Mesomill," June 2004.
- 35) Thompson, Kate, "MEMS Fluid Coupling," June 2004.
- 36) Abu-Ibrahim, Fadi, "Low-cost precision waterjet," June 2004.
- 37) Vanderpoel, Timothy, "Design of a Snowboard Simulating Exercise Device," June 2005.
- 38) Figueredo, Stacy, "Monolithic Plastic Biopsy Device," June 2006.
- 39) Durand, Keith, "Design of an Energy Efficient and Economical Actuator for Automobile Windows," June 2007.
- 40) Jonnalagadda, Aparna, "Automotive Energy Harvesting," Jan. 2007.
- 41) Trimble, Zachary, "Rotating Energy Harvesting Device," June 2007.
- 42) Rothenhofer, Gerald, "Hydrocline linear motion axis," June 2007.
- 43) Zurovcik, Danielle, "Negative Pressure Wound Therapy Device," June 2007.
- 44) Kuhn, David, "Desktop systems for manufacturing carbon nanotube films by chemical vapor deposition," June 2007.
- 45) Edinger, Sarah, "Multi Motion Door," Jan. 2008.
- 46) Bassett, Erik, "Linear clutch for needle insertion," June 2008.
- 47) Rojas, Folkers, "CSPonD Heat Exchanger," January 2011.
- 48) Zimmerman, Julia, "Single-use Lancet and Capillary Loading Mechanism for Complete Blood Count Point of Care Device," January 2011.
- 49) Fennell, Gregory, "Offshore Renewable Energy Storage System," June 2011.
- 50) Bosworth, William, "Design and Parametric Simulation of Radially Oriented Electromagnetic Actuators," June 2011.
- 51) Begg, Nikolai, "Bistable Flexure-based Trocar," June 2011.

- 52) Wong, Anthony, "Water Hydrostatic Bearings for Ships," June 2012.
- 53) Bridgers, Daniel, "Ex-Vivo Brain Holding Fixture for MRI Studies," June 2012.
- 54) Rosario, Matthew, "Characterization of Cardiac Lead Perforation Risk via a Dynamic Simulated Environment," January 2012.
- 55) Meredith, James. "Design, Construction and Testing of an Ocean Renewable Energy Storage Scaled Prototype," January 2012.
- 56) Gorbaty, Emily, "Development of an efficient off-grid pumping system and evaporation reduction strategies to increase access to irrigation for smallholder farmers in India," June 2013.
- 57) Carrasquillo, Omar, "Design of inflatable solar concentrator," June 2013.
- 58) Hopkins, Brandon James, "Mechanical design of flow batteries" June 2013.
- 59) Kluger, Jocelyn Maxine, "Nonlinear beam-based vibration energy harvesters and load cells" June 2014.
- 60) Bayless, Jacob, "A High-Speed Hysteresis Motor Spindle for Machining Applications" February 2014.
- 61) Sondej, Nicholas, "Direct Tablet Formation by Electrospinning and Compaction" June 2014.
- 62) Taylor, David Donald James, "Reducing Booster-Pump-Induced Contaminant Intrusion in Indian Water Systems with a Self-Actuated, Back-Pressure Regulating Valve" June 2014.
- 63) Simon, Kevin, "Low Cost Water Pump", June 2015
- 64) Abbott, Jonathan E., "Bee Care Technology" Jan 2016.
- 65) Mills, Nathan, "Pan Tilt Mechanism", June 2016.
- 66) O' Brien, Megan, "Design of a Mobile Torrefaction Reactor for In-Situ Conversion of Agricultural Waste to Solid Biofuel", June 2016.
- 67) Labib, Shahd, "Pill Forming Apparatus", June 2017
- 68) Beautyman, Michael, "Load Bearing Interface Design for a Pan-Tilt Mechanism for Severe Marine Environments", June 2017
- 69) Finley, Thomas, "Slip Clutch Design for Position Sensitive Systems in Marine Environments" , June 2017
- 70) Hamlet, Amanda, "Uranium Extraction from Seawater: Investigating Hydrodynamic Behavior and Performance of Porous Shells ", June 2017
- 71) Krol, Przemyslaw Michal, "Productization and Instrumented Testing of a Corrosion Fatigue Test Device", June 2017
- 72) Cervantes, Thomas "Thumb Ligament Stiffness Measurement Instrument", January 2018
- 73) Johnson, Hilary, "Braille Writer", January 2018
- 74) Leibowitz , Dalia, "Design of a Large-Dose Minimally Invasive Drug Delivery Device for Tuberculosis", June 2018
- 75) Carrus, Justin, "Brick Press for Africa", June. 2018
- 76) Huynh, Daniel, "Next Generation Probabilistic Prediction Model for Submarine Propulsion Shaft Life", June 2018
- 77) Yue, Brian, "Design of a Construction Saw Kickback Evaluation Machine for the Comparison of Kickback Energies in Pipe Cutting Applications", June 2019
- 78) Duenner, Andrew, "A Framework for Error Budgeting in Engineering Design", June 2019
- 79) Peng, Val, "Design and System Integration of a Low-Cost Packing Method for Profitable Utilization of Water Hyacinth (*Eichhornia crassipes*)", June 2019
- 80) Canning, Julia, "Gesture Sensing with Flexural Ultrasonic Transducers", June 2019
- 81) Burcat, Steven, "Development of a Benchtop Chainsaw Kickback Measurement Device for Manufacturing", June 2019
- 82) Gray, Luke, "Open Ocean Sargassum Sequestration", June 2019
- 83) Southerland, Sarah, "Utilization of High Contaminant Recycled HDPE in Concrete Aggregate and Investigation into Additional Industrial Applications", January 2021
- 84) O'Connell, Ellen, Lyophilization system vial supports, 2021
- 85) Flores, Ryan, Lyophilization system load lock, work started June 2020

Engineer Degree

- 1) Werkmeister, Jaime, "Development of Silicon Insert Molded Plastic (SIMP)", June 2005.

Doctoral Theses, Supervisor:

- 1) Demsetz, Laura, "Methodology for Formulating Designs of Task Specific Automated Construction Machinery," Jan. 1989. (Civil Engineering).
- 2) Everett, John, "Construction Automation: Basic Task Selection and Development of the Cranium," June 1991. (Civil Engineering).
- 3) Marsh, Eric, "Design of Precision Coordinate Measuring Machines," June 1994.
- 4) Van Doren, Matthew, "Precision Machine Design Methodology for Design of Semiconductor Processing Equipment," June 1995.
- 5) Scagnetti, Paul, "Design of Precision Grinding Machines for Ceramics," January 1996.
- 6) Ho, Chris, "Concurrent Development of a Rotationally-Symmetric Barb Joint for Modular Storage Systems through Product Innovation Research," June 1997.
- 7) Levy, David, "Portable Product Miniaturization and the Ergonomic Threshold," August 1997.
- 8) Braunstein, Daniel, "Precision Printed Circuit Board Manufacturing," August 1997.
- 9) Chiu, Michael, "High Precision Semiconductor Equipment Test Design," January 1998.
- 10) Nayfeh, Samir, "Design and Application of Damped Machine Elements," June, 1998.
- 11) Pfahnl, Andreas, "Design of Precision Temperature Controlled Precision Machine Tools," June 1998.
- 12) Hale, Layton, "Principles and Techniques for Designing Precision Machines," January 1999
- 13) Hochmuth, Carsten, "Platform Concept for Precision Machining Centers," January 1999
- 14) Kiani, Sefhir, "Multi-connection vias for printed circuit boards," January 1999.
- 15) Vallance, Ryan, "Precision Miniature Mechanism Manufacture," June 1999.
- 16) Muller, Luis, "Modular Semiconductor Test, Assembly & Packaging Manufacturing Equipment Design," June 1999.
- 17) Kane, Nathan, "Surface Self-Compensated Modular Linear Hydrostatic Bearings," June 1999.
- 18) Kotilainen, Markku Sami Antero, "Design and Manufacture of Modular Self-compensating Hydrostatic Journal Bearings," June 2000.
- 19) Culpepper, Martin, "Design and Application of Compliant Quasi-Kinematic Couplings," January 2000.
- 20) Bamberg, Eberhard, "Principles of Rapid Machine Design," June, 2000.
- 21) O'Sullivan, Donald, "Structural Elements with Mathematically Defined Surfaces for Enhanced Structural and Acoustic Performance," August 2001.
- 22) White, James, "The Nanogate: Nanoscale Flow Control," June 2003.
- 23) Qiu, Jin, "An Electrothermally-Actuated Bistable MEMS Relay for Power Applications," June, 2003.
- 24) Brienlinger, Keith, "Three Dimensional Routed Manifolds with Externally Inserted Cables," June, 2003.
- 25) Sihler, Joachim, "A Low Leakage 3-Way Silicon Microvalve," January 2004.
- 26) Awtar, Shorya, "Synthesis and Analysis of Parallel Kinematic XY Flexure Mechanisms," January 2004.
- 27) Li, Jian, "Electrostatic Zipping Actuators and Their Application to MEMS," January 2004.
- 28) Willoughby, Pat, "Elastically Averaged Precision Alignment," June 2005.
- 29) Sprunt, Alexander, "A Variable Capacitor Made from Single Crystal Silicon Fracture Surface Pairs," August 2005.
- 30) Yang, Xueen, "MEMS LC Tunable Filter," June 2005.
- 31) Graham, Marc, "Product Development by Deterministic Design," June 2006.
- 32) Hart, Anastassios John, "Continuous Growth Nanotubes," August 2006.
- 33) Thompson, Mary Kate, "A Multi-Scale Iterative Approach for Finite Element Modeling of Thermal Contact Resistance," August 2007.
- 34) Yaglioglu, Onnik, "Carbon Nanotube Based Electromechanical Probes," June 2007.
- 35) Ma, Hongshen, "Electrochemical Impedance Spectroscopy using adjustable nanometer-gas electrodes," June 2007.
- 36) Freeman, David, "Resonator PCV Valve," January 2008.
- 37) Weber, Alexis, "MEMS relays for make-break power switching applications: {111} silicon etched planar electrical contacts," June 2008.
- 38) Read, Melissa, "Design of a Standard Method and Instrumentation for the Measurement and Characterization of MEMS Fabricated Electrical Contacts," January 2009.

- 39) Walsh, Conor, "Image-guided robots for dot-matrix tumor ablation," June 2010.
- 40) Rothenhofer, Gerald, "Elements for the Design of Precision Machine Tools with High Required Loop Stiffness and their Application to a Prototype 450 mm Si-Wafer Grinder," August 2010.
- 41) Durand, Keith, "Hermetically sealed encasements for historic document display and preservation," January 2011.
- 42) Trimble, A. Zachary, "Energy harvesting of random wide-band vibrations with applications to an electro-magnetic rotational energy harvester," June 2011.
- 43) Figueredo, Stacy, "Parabolic Trough Solar Collectors: Design for Increasing Efficiency," June 2011.
- 44) Codd, Daniel Shawn, "Concentrated Solar Power on Demand," June 2011.
- 45) Hanumara, Nevan Clancy, "Design of Efficient Precision Medical Robotics," August 2012.
- 46) Zurovcik, Danielle, "Negative Pressure Wound Therapy," August 2012.
- 47) Heberley, Brian, "Advances in hybrid water-lubricated journal bearings for use in ocean vessels," June 2013.
- 48) Rojas, Folkers, "Continuous Feed of an Occluding Medium into an Uncontrolled Well," February 2014.
- 49) Padhye, Nikhil, "Film based pharmaceutical tablet manufacturing," August, 2015.
- 50) Begg, Nikolai D., "Increasing the Safety and Precision of Medical Tissue Puncture," June 2014.
- 51) Wortman, Tyler, "LesionAir: A low-cost tool for automated skin cancer diagnosis and mapping" June 2016
- 52) Jonart, Douglas, "Methods and Devices for Corrosion Fatigue Testing without Acceleration," June 2016
- 53) Haji, Maha, "Extraction of Uranium from Seawater: Design and Testing of a Symbiotic System". June 2017
- 54) Kluger, Jocelyn Maxine, "Synergistic Design of a Combined FloatingWind Turbine -Wave Energy Converter", June 2017
- 55) Taylor, David Donald James, "Tools for Managing Intermittent Water Supplies", June 2018
- 56) Melanie Tretault-Friend, "Thermal-Fluid Characterization And Performance Enhancement Of Direct Absorption Molten Salt Solar Receivers" June 2018 (co-advisor with Prof. E Baglietto in NSE)
- 57) Simon, Kevin, "Low cost water pumps", January 2019
- 58) Johnson, Hilary, "Design and analysis of adaptive hydraulic geometry for centrifugal pumps", work initiated January. 2018
- 59) Burcat, Steven, "Lyophilization machine", work initiated June 2020.

Doctoral Theses, Reader:

- 1) Bausch, John J. III, "Kinematic Methods for Automated Fixture Design," Jan. 1990.
- 2) Trumper, Dave, "Magnetic Suspension Techniques for Precision Motion Control," Sept. 1990 (Electrical Engineering and Computer Science).
- 3) Chai, Jangbom, "Non-Invasive Diagnostics of Motor-Operated Valves," June 1993.
- 4) Mosleh, Mohsen, "The Role of Wear Particles in Geometrically Constrained Frictional Systems in Dry Sliding," June 1994.
- 5) Walczyk, Daniel, "A Complete Sheet Metal Forming System Incorporating a New Quick Prototyping Method for Dies," January 1996.
- 6) Frey, Daniel, "Using Product Tolerances to Drive Manufacturing System Design," June 1997.
- 7) Williams, Mark, "Precision Six Degree of Freedom Magnetically-Levitated Photolithography Stage," October 1997.
- 8) Pfahnl, Andy, "Design of a Thermal Control System for an IC Test-In-Tray Handler," June 1998.
- 9) Ludwick, Stephen, "High-Speed Lens Cutting Machine," MIT, Mechanical Engineering, June, 1999.
- 10) Hidrovo, Carlos, "Development of a Fluorescence Based Optical Diagnostics Technique and Investigation of Particle Ingestion and Accumulation in the Contact Region of Rotating Shaft Seals," Mechanical Engineering, June 2001.
- 11) Liebman, Michael, "Five-Axis Grinding Machine for Centimeter-scale Parts," MIT, Mechanical Engineering, June 2002.
- 12) Sweetland, Mathew, "Precision Thermal Control System for Semiconductor Devices Under test," MIT, Mechanical Engineering, June 2002.

- 13) Meggiolaro, Marco, "Achieving Fine Absolute Positioning Accuracy in Large Powerful Manipulators," Mechanical Engineering, June 2002.
- 14) Sujan, Vivek, "Compensating for Model Uncertainty in the Control of Cooperative Field Robots," June, Mechanical Engineering, 2002.
- 15) Konkola, Paul, "Phase Interference Gratings," Mechanical Engineering, June, 2003.
- 16) Savran, Cagri, "A Robust Micromechanical Sensor for Label-free Biomolecular Detection in Real-time," Mechanical Engineering, Jan. 2004.
- 17) Griffith, Saul, "Self Assembling 3D structures," Mechanical Engineering, June 2004.
- 18) Turner, Kevin, "Wafer Bonding: Mechanics-Based Models and Experiments," Mechanical Engineering, June 2004.
- 19) Wilhelm, Eric, "Printed Electronics and Micro-Electromechanical Systems," Mechanical Engineering, June 2004.
- 20) Hai Ning, "Building E-Education Platforms for Design-Oriented Learning," Civil Engineering, June 2004.
- 21) Sparks, Andrew, "Scanning Probe Microscopy with Inherent Disturbance Suppression Using Micromechanical Devices," Mechanical Engineering, Sept. 2004.
- 22) Wilson, Andrew, "Wafer Bonding," June 2004.
- 23) Varanasi, Kripa "Damping mechanisms," June 2004.
- 24) Hashemi, Fardod, "Nanotweezers," June 2005.
- 25) Montesanti, Rick, "High speed tool servo," June 2006.
- 26) Balakrishnan, Asha, "Development of Novel Dynamic Indentation Techniques for Soft Tissue Applications," August 2007.
- 27) Winter, Amos, "Burrowing Robots," August 2010.
- 28) Yamamoto, Namiko, "CNT reinforced composites," June 2010.
- 29) Kesner, Samuel (Harvard), "Robotic Catheters for Beating Heart Surgery," January 2012.
- 30) Phan, Long, "Thermal imaging of buildings," May 2012.
- 31) Amin-Shahidi, Darya, "High Force Density Piezoelectric Reticle Assist Device," May 2013.
- 32) Gilbertson, Mathew, "Electromechanical Systems to Enhance the Usability and Diagnostic Capabilities of Ultrasound Imaging," May 2014.
- 33) Greenblatt, Elliot, "The Impact of Pathological Ventilation on Aerosol Deposition Imaging, Insight and Interventions," January 2015.
- 34) Weinstein, Lee, "Improving solar thermal receiver performance via spectral and directional selectivity", August, 2017
- 35) Xu, Ruzie, "Low-Frequency, Low-Amplitude MEMS Vibration Energy Harvesting", Oct .2017
- 36) Bousquet, Gabriel, "Optimal wind energy extraction at interfaces: from Dynamic Soaring to the amphibious Sailplane", Dec. 2017
- 37) Hopkins, Brandon, "Stopping Self-Discharge in Metal-Air Batteries", June 2018
- 38) Mannai, Sebastien, "A Novel Framework for Acoustic Diagnostic of Artificial Lift System for Oil-Production", June 2018
- 39) K.S. Kung, Design and Validation of a Decentralized Biomass Torrefaction System", June 2017.
- 40) Fan, Dixia "Mapping the Hydrodynamic Properties of Flexible and Rigid Bodies Undergoing Vortex-Induced Vibrations", June 2019
- 41) Zhou, Lei, "Magnetically Levitated Hysteresis Motor Driven Linear Stage for In-Vacuum Transportation Tasks", June 2019
- 42) Justin Beroz "Precision pipetting and crack-free colloidal assembly" June 2019
- 43) Guillermo F. Diaz Lankenau, "Tractor design for resource limited small farms", Dec. 2019
- 44) Max Carlson, "Design of Fouling-Resistant Coatings for Energy Systems: Theory and Proof of Principle at Realistic Conditions", June 2021

Postdoctoral Associates and Fellows supervised by Alexander H. Slocum

- 1) Hart, A.J., Carbon Nanotubes (2007). Current employer and title: Associate Professor of Mechanical Engineering, MIT.

- 2) Ma, Hongshen, "Electrochemical Impedance Spectroscopy using adjustable nanometer-gap electrodes," 2007. Current employer and title: Assistant Professor, University of British Columbia, Department of Mechanical Engineering, Multi-scale Design Laboratory, Vancouver, BC, Canada.
- 3) Hanumara, Nevan Clancy, "Efficient design of precision medical robots," 2012 MIT Postdoctoral Associate Appointment: August 2012 – August 2014. Current employer and title: MIT Dept. mech. Engineering, Research Scientist.
- 4) Gil, Antoni, "Concentrated Solar Power on Demand", MIT Postdoctoral Associate Appointment: September 2014-2017. Current employer and title: Unknown.