UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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GODBERSEN-SMITH CONSTRUCTION COMPANY
d/b/a GOMACO CORPORATION
Petitioner

v.

GUNTERT & ZIMMERMAN CONST. DIV., INC.
Patent Owner

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Case PGR2024-00026
Patent No. 11,772,723

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# EXPERT DECLARATION OF WILLIAM SINGHOSE IN SUPPORT OF PETITION FOR POST GRANT REVIEW

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## I. INTRODUCTION AND SUMMARY OF OPINIONS

1. I, William Singhose, have been retained as an independent expert by Godbersen-Smith Construction Company d/b/a GOMACO Corporation ("Petitioner" or "GOMACO") in connection with a post grant review of U.S. Patent No. 11,772,723 (the "'723 patent") (Ex. 1001). I have prepared this declaration in connection with Petitioner's Petition for Post Grant Review.

2. Specifically, this document contains my opinions about the technology claimed in claims 1-7 of the '723 patent (the "Challenged Claims") and the grounds against these claims that have been asserted by Petitioner. I was not asked to provide any opinions that are not expressed herein.

## II. SUMMARY OF OPINIONS

3. This declaration considers the Challenged Claims of the '723 patent. Below, I set forth the opinions I have formed, the conclusions I have reached, and the bases for these opinions and conclusions. I believe the statements contained in this declaration to be true and correct to the best of my knowledge. In forming my opinions, I have assumed that the priority date of the '723 patent is March 26, 2010, which I am told is the earliest effective filing date of the '723 patent. My opinions would not change if I assumed a later effective filing date.

4. Based on my experience, knowledge of the art at the time of the applicable priority date, analysis of Petitioner's asserted ground and references,

and the understanding a person of ordinary skill in the art would have had of the claims in light of the specification as of the applicable priority date, it is my opinion that the Challenged Claims of the ’723 patent would have been obvious over the asserted obviousness grounds and lack written-description support in the specification of the ’723 patent.

5. I am being compensated for my time at the rate of $750 per hour. This compensation is in no way contingent upon the nature of my findings, the presentation of my findings in testimony, or the outcome of this proceeding.

## III. BACKGROUND AND QUALIFICATIONS

6. I believe that I am well qualified to serve as a technical expert in this matter based upon my educational and work experience, discussed below and in my curriculum vitae, which is submitted as Exhibit 1003.

7. I am a Professor of Mechanical Engineering at the Georgia Institute of Technology (“Georgia Tech”). I received a B.S. in Mechanical Engineering from the Massachusetts Institute of Technology (“MIT”) in 1990. I then received an M.S. in Mechanical Engineering from Stanford University in 1992. Finally, I received a Ph.D. in Mechanical Engineering from MIT in 1997. After receiving my Ph.D., I was a postdoctoral researcher at MIT before becoming a professor at Georgia Tech.

8. Based on my work experience, described in my curriculum vitae and in more detail below, I am knowledgeable about the subject matter of the ’723 patent and the related prior art. Specifically, my qualifications as an expert in the fields of heavy machinery, automation, and product design stem from my prior work experience, as well as my experience as a Professor in the Woodruff School of Mechanical Engineering at Georgia Tech performing research, teaching, working, and consulting. I have several patents and dozens of publications that are directed toward understanding and improving heavy machinery.

9. In my current position at Georgia Tech, I teach courses in mechanical design, system dynamics, and controls. I also lead teams of professors, post-docs, graduate students, and undergraduate students that conduct research in mechanical design, dynamics, controls, automation, robotics, spacecraft, human-machine interfaces, and product design. During my more than 25 years at Georgia Tech, I have also had visiting appointments at MIT, Stanford, the Polytechnic University of Madrid, and the Tokyo Institute of Technology.

10. Throughout my upbringing, I was exposed to various types of construction equipment and heavy machinery. My mother was a truck driver and my father was an operator of various types of heavy machinery. Our family owned log trucks, road graders, excavators, bulldozers, front-end loaders, truck-mounted hoists, and tractors. I worked in road construction for more than two years at my

family-owned road-construction company. I operated many types of road construction equipment, including paving machines, dump trucks, steam rollers, and compactors.

11. I also worked one summer as a lab technician at Riverside Cement Company. My job responsibilities included preparing various types of concrete mixtures and testing their mechanical properties under various conditions and over extended periods of time. These activities required me to operate forklifts, cement pumps, sand sifters, flat-bed trucks, climatic test chambers, and compression testing machines.

12. Throughout my engineering career, I have worked with heavy machinery and large automated systems. Before starting my teaching career at Georgia Tech, I worked as a full-time mechanical engineer for several companies, including Walt Disney World, Apple Computers, Inc., and Convolve, Inc.

13. In my role at Walt Disney World, I designed and developed a number of structures and components for the parks' rides, including, but not limited to, operational control procedures for the Body Wars simulators. These simulators are rooms that hold about 40 people at a time. The entire rooms, and the guests seated within, are automatically manipulated through a series of preprogrammed motions using six large linear hydraulic cylinders. The machines were equipped with numerous transducers that enabled accurate feedback control of the power drives.

14. For Convolve, Inc., I analyzed the dynamics of automated robots, satellites, and NASA high-altitude balloons. I also developed automated control systems for manufacturing machines, large-scale coordinate measuring machines, and laser interferometer sensors. One of my Convolve projects required the development and installation of a system to control a crane at the Savannah River Nuclear facility. The crane was a large overhead bridge structure that moved barrels of nuclear waste. The system we developed reduced the unwanted pendulum swing of the barrels.

15. Throughout my years at Georgia Tech, I have worked as an engineering consultant or research partner for numerous companies. For example, I worked with Boeing for several years to improve the safety of their overhead bridge cranes. The crane controllers that I developed have been deployed at multiple Boeing manufacturing facilities. One of the Boeing cranes I operated included four large rotary slew drives that enabled the controlled rotation of very large aircraft components. I have also worked on several projects involving boom cranes that travel on crawler tracks.

16. In addition to my engineering experience as a professor and an engineer, I have commercialized technology developed in my research group at Georgia Tech by founding two companies: CAMotion Cranes and InVekTek. CAMotion Cranes designs and installs crane control systems that decrease payload

swing, automatically avoid obstacles, and improve crane safety. These improvements are achieved through sensor systems and control methods that my research group developed, patented, and deployed. CAMotion Cranes was acquired by PAR Systems in 2013. InVekTek develops and commercializes control systems for robotic and industrial material-handling systems. The control systems are embedded in motor drives to reduce unwanted machine motion.

## IV. MATERIALS CONSIDERED

17. In forming my opinions, I have analyzed the materials listed in Appendix A. My opinions are based on my experience, knowledge of the relevant art, the documents identified in Appendix A, and the documents discussed in this declaration.

## V. LEGAL STANDARDS

18. I am not a lawyer. My understanding of the legal standards to apply in reaching the conclusions in this declaration is based on discussions with counsel for Petitioner, my experience applying similar standards in other patent-related matters, and my reading of the documents submitted in this proceeding. In preparing this declaration, I have tried to faithfully apply these legal standards to the Challenged Claims.

### A. Claim Construction

19. I have been instructed that the terms appearing in the ’723 patent should be interpreted in view of the claim language itself, the specification, the prosecution history of the patent, and any relevant extrinsic evidence. The words of a claim are generally given their ordinary and customary meaning, which is the meaning that the term would have to a person of ordinary skill in the art at the time of the invention, which I have assumed here is March 26, 2010. While claim limitations cannot be read in from the specification, the specification is the single best guide to the meaning of a disputed term. I have followed these principles in reviewing the claims of the ’723 patent and forming the opinions set forth in this declaration.

20. I am told that claim construction is not necessary where there is no controversy as to the meaning of the terms with respect to the prior art. I am told that in the district court, GOMACO identified for construction the terms “swing leg” and “hinge bracket” of U.S. Patent No. 10,029,749. The term “swing leg” and the similar term “hinged bracket” also appear in the ’723 patent. In my opinion, the prior art asserted in the petition grounds discloses an embodiment within the indisputable scope of the ordinary and customary meaning of the claims and in particular the “swing leg” and “hinged bracket” terms. Therefore, it is my opinion

that no explicit claim constructions are needed to apply the prior art to the challenged claims.

### B. Level of Ordinary Skill

21. I understand a person of ordinary skill in the art is determined by looking at, among other considerations, (i) the type of problems encountered in the art; (ii) prior art solutions to those problems; (iii) rapidity with which innovations are made; (iv) sophistication of the technology; and (v) educational level of active workers in the field.

22. In light of these considerations, a person of ordinary skill in the art ("POSITA") pertinent to the '723 patent would have had at least a four-year degree in mechanical engineering or a closely related field and at least two years of experience designing, developing, or operating heavy machinery, including their components and control systems. Additional education could substitute for professional experience and significant work experience—such as working with, servicing, or operating heavy machinery in the field—could substitute for formal education.

23. The '723 patent describes the technology at a level that someone with the above education and work experience would understand. A POSITA, as described above, would understand the different mechanical components and functionality of control systems of heavy machinery that are required to practice

the Challenged Claims. They would have gained this understanding from either developing those components and control systems, or from operating the machinery in the field, which frequently requires knowledge of the machines to perform repairs in the field, reconfigure and calibrate the components and control systems for different operations, and perform maintenance on the components and control system consistent with the requirements of operator manuals. Indeed, operator manuals for heavy machinery assume that the operator is familiar with the mechanical components, hydraulic systems, and control systems and how they work, at least at the level described in the ’723 patent.

24. I often find it useful to compare the claimed subject matter to the topics taught in engineering curricula. This helps guide the selection of the formal educational requirements. My requirement of a four-year degree in mechanical engineering or a closely related field is based on my experience teaching mechanical engineering students for more than 25 years. The material taught to mechanical engineering students covers the subject matter of the Challenged Claims. For example, in our sophomore-level design class at Georgia Tech we teach the students how to use a processor and sensors to control the actions of an automated machine. The students are then required to design, build, and demonstrate an automated machine in an end-of-the-term “robot” contest. All of the machines have some type of frame to which the students attach the processor,

sensors, and moving components. The machines very often have telescoping mechanisms that allow the machines to reach outward from the main frame to perform tasks. Every machine that I have guided my students to design and construct have used bearings. These include both roller bearings for wheels and plain bearings for sliding or telescoping components. Therefore, after their sophomore year, mechanical engineering students would be able to understand the majority of the claimed features, as well as how those features would be combined and operate.

25. As noted in my proposed definition of a POSITA above, I believe that work experience could substitute for formal educational training. The basis for this opinion is twofold. First, the claimed technology is not sophisticated. The claimed subject matter combines machine frames, swing legs, jacking columns, crawler tracks, slew drives, transducers, and processors. The combination and use of such components can be learned through on-the-job-training, such as while operating and maintaining construction equipment. I note that none of the claims require the design of the more sophisticated components such as the transducers or processors; only the use of such components in combination with the other components is required. Second, when I worked in the construction industry, I learned a great deal about the design and operation of the machines that I operated. It is often the case that machine operators are also required to maintain, debug, and even repair (to a

limited extent) the machines that they operate. For example, when I operated an asphalt paving machine, I had to continually clean and adjust the telescoping mechanism that was used to adjust the width of the screed that spreads and finishes the asphalt.

26. I was at least a POSITA as of March 26, 2010.

**C. Obviousness**

27. I have been told that under 35 U.S.C. § 103, a patent claim may be obvious if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole 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.

28. I have been told that a proper obviousness analysis requires the following:

a. Determining the scope and content of the prior art;

b. Ascertaining the differences between the prior art and the claims at issue;

c. Resolving the level of ordinary skill in the pertinent art; and

d. Considering evidence of secondary indicia of non-obviousness (if available).

29. 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 invention. For my obviousness analysis, counsel for Petitioner instructed me to assume that the date of invention for the Challenged Claims is March 26, 2010. My opinions would not change if I assumed a later date of invention.

30. I have been told that a reference may be modified or combined with other references or with a POSITA's own knowledge if the person would have found the modification or combination obvious. I have also been told that a person of ordinary skill in the art is presumed to know all the relevant prior art, and the obviousness analysis may take into account the inferences and creative steps that a person of ordinary skill in the art would employ.

31. I have been told that obviousness grounds cannot be sustained by mere conclusory statements and must include some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness. I have been told that whether a prior art reference renders a patent claim 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 suggestion to combine known elements to achieve the claimed invention. I have been told that a suggestion to combine known elements to achieve the claimed invention may come from the prior art as a whole or individually and may consider the inferences and

creative steps a person of ordinary skill in the art would employ, as filtered through the knowledge of one skilled in the art.

32. I have been told that there is no rigid rule that a reference or combination of references must contain a "teaching, suggestion, or motivation" to combine references. But I also have been told that the "teaching, suggestion, or motivation" test can be used in establishing a rationale for combining elements of the prior art. I have also been told to be aware of distortions caused by hindsight bias, and that reading into the prior art the teachings of the invention at issue is improper.

**D. Written Description**

33. I have been informed that patents must contain a written description of the invention, which is known as the written-description requirement. I have been informed that a patent claim is invalid if any portion of the claim fails the written-description requirement. I have been told that the written-description test is the same whether the claim element is essential or auxiliary to the invention.

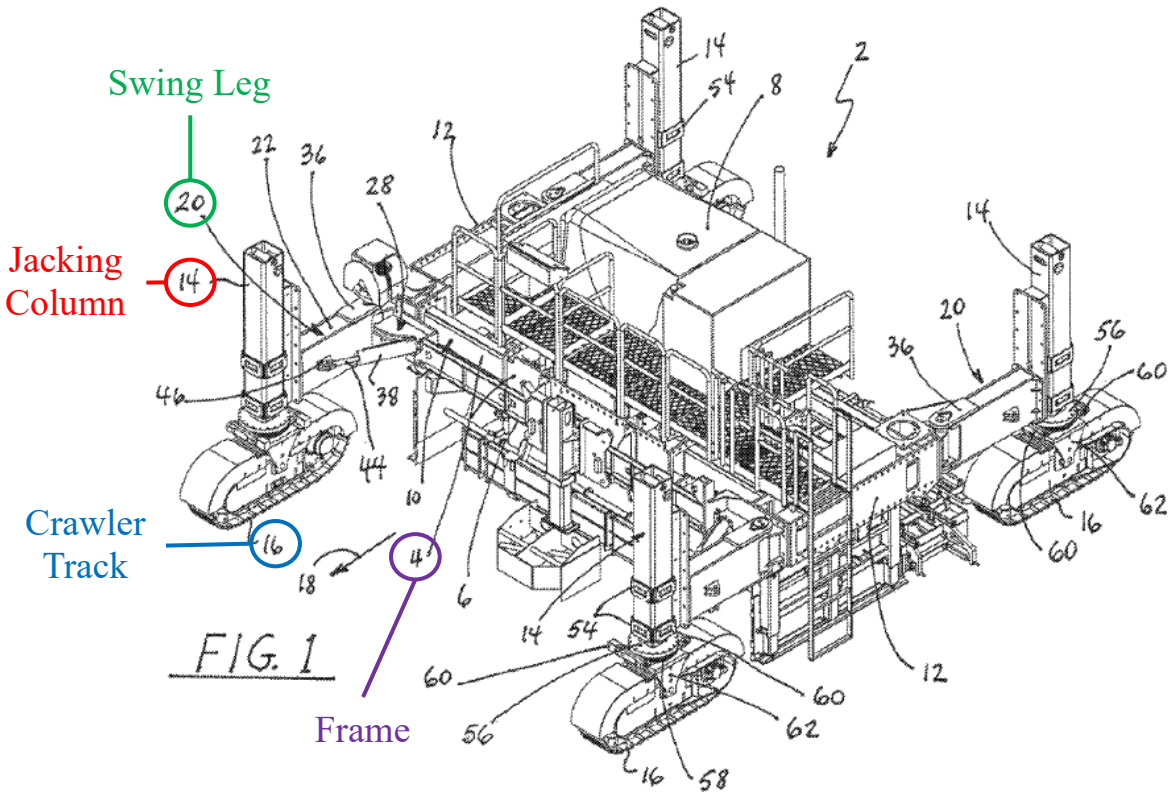
34. I have been informed that, to provide adequate written description, the specification must reasonably convey to those skilled in the art that the inventor had possession of the claimed subject matter as of the filing date. I have been informed that this requires an objective inquiry into the four corners of the specification from the perspective of a POSITA to determine whether the

specification shows that the inventor actually invented what is claimed. I have been informed that, while the written-description requirement does not demand any particular form of disclosure or that the specification recite the claimed invention verbatim, a description that merely renders the invention obvious does not satisfy the requirement.

## VI. THE ’723 PATENT

### A. Overview of the ’723 Patent

35. Generally, the ’723 patent describes and claims a paving machine with one or more swing legs. As shown below, each swing-leg assembly of the ’723 patent contains a jacking column 14, a crawler track 16, and a swing leg 20 that couples the jacking column to frame 4. [Ex. 1001 (’723 patent), 8:55-10:53.]




[Ex. 1001 ('723 patent), Fig. 1 (annotated).]

The crawler tracks "are mounted to" and rotate relative to the jacking columns. [Ex. 1001 ('723 patent), 8:67-9:3.] Each jacking column includes two hollow tubes (outer 48 and inner 50) that telescope relative to each other in response to an internal hydraulic actuator that extends and retracts, which raises and lowers the machine. [Ex. 1001 ('723 patent), 8:65-67, 11:22-41.]

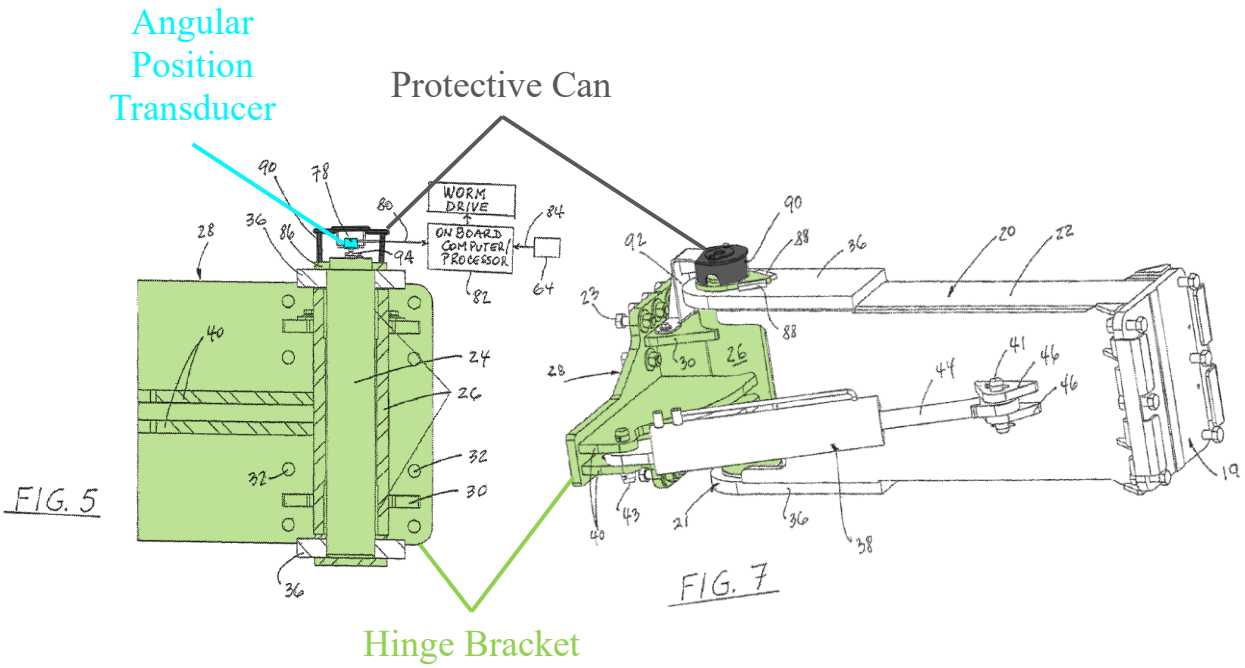
36. The swing leg is fixed to the jacking column on one end and is pivotally connected to the machine on the other, allowing the swing leg to pivot about a vertical axis. [Ex. 1001 ('723 patent), 2:27-35, 9:32-39.] When the swing leg pivots, it swings the jacking column and crawler track to various positions.

[Ex. 1001 (’723 patent), 10:54-11:4.] Every feature described above predates the ’723 patent, as the specification admits. [Ex. 1001 (’723 patent), 1:31-5:62 (describing features as “conventional” and “well known”).]

37. Regarding the ’723 patent’s purported invention, the specification discloses actuators that pivot the swing leg and a “slew or worm gear drive” that rotates the crawler track. [Ex. 1001 (’723 patent), 6:19-25, 6:38-43, 7:1-8, 11:42-63.] Angular position transducers provide outputs to a processor, which uses those signals to control rotation of the crawler track as the swing leg pivots. [Ex. 1001 (’723 patent), 6:19-30.] Under this design, “no matter what the swing leg angle is, the crawler track stays straight ahead in the paving direction and position.” [Ex. 1001 (’723 patent), 6:31-33.] It is this coordinated rotation of the swing leg and crawler track that forms the basis of the purported invention.

38. The ’723 patent describes the angular position transducer 78 that measures the orientation of the swing leg as being attached to the hinge bracket. For example, the specification states it is “placed on top of swing leg pivot shaft 24,” which is the part of the hinge bracket “that pivotally engages the swing leg.” [Ex. 1001 (’723 patent), 7:42-46, 12:15-17.] Further disclosure indicates that angular position transducer 78 is “mounted inside a downwardly open protective can 90” that “is bolted to hinge bracket 28 via an upright holding arm 92.” [Ex. 1001 (’723 patent), 1001, 12:28-30.] The specification never describes an

angular position transducer "disposed on the modular frame or the swing leg," as claimed. [Ex. 1001 ('723 patent), 22:47-48.] The annotated versions of Figures 5 and 7 below show how the disclosed angular position transducer is attached to the hinge bracket.




[Ex. 1001 ('723 patent), Figs. 5, 7 (annotated).]

**B. Prosecution History**

39. During prosecution of the application that issued as the '723 patent, the Examiner never applied the prior art that I analyze below in my analysis of the petition grounds in any rejection. Furthermore, this prior art and the Board's decisions on IPRs of patents related to the '723 patent (for which I provided an expert declaration) do not appear as References Cited on the face of the '723

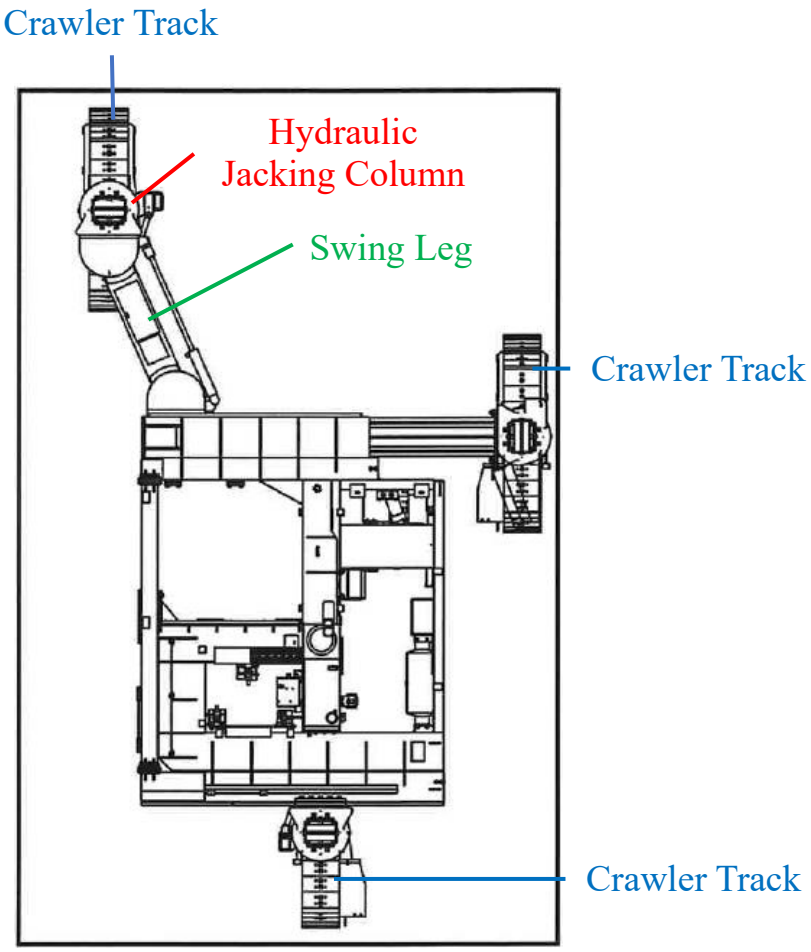
patent. [Ex. 1001 (’723 patent), Item (56).] In a preliminary amendment, Applicant canceled the originally filed claims and added seven new claims. [Ex. 1004, 140-143.] The Examiner allowed the claims after Applicant filed a terminal disclaimer following a double-patenting rejection. [Ex. 1004, 150-152, 171, 173, 192.]

## VII. ANALYSIS OF PETITION GROUNDS

### A. Ground 1: Claims 1-7 Are Obvious over CIII, Rio, and Files

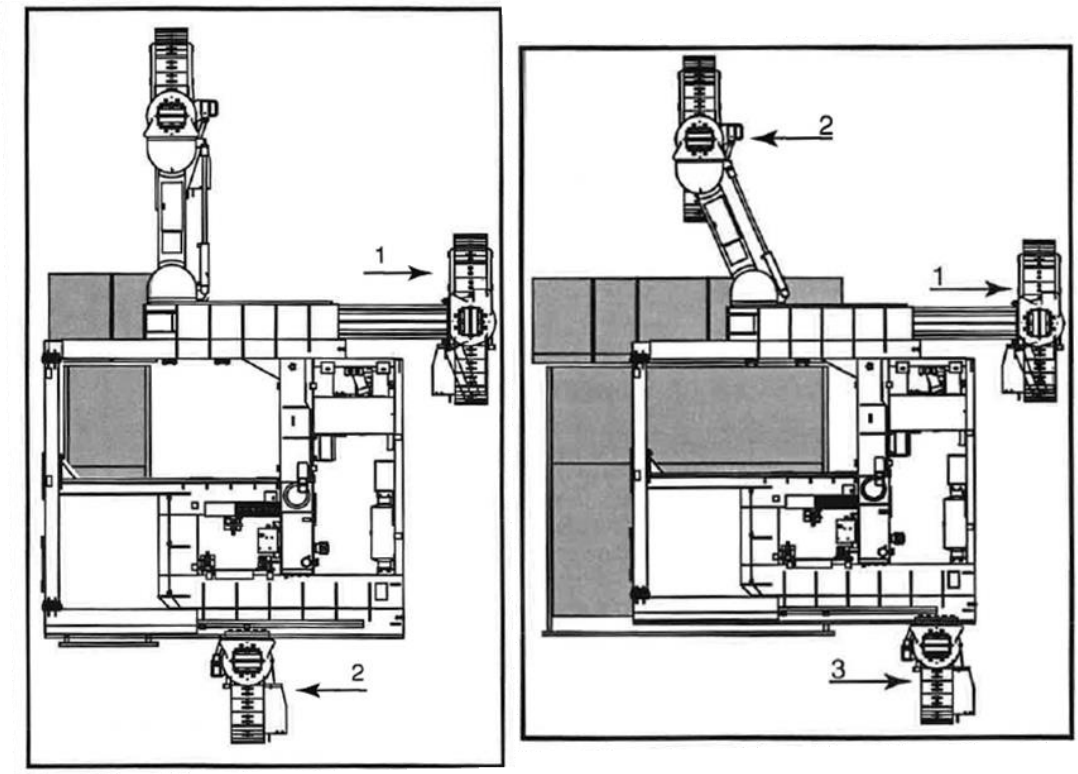
#### 1. Summary of CIII

40. “Commander III New Generation Trimmer/Paver Operator/Service Manual G21 Controls” (“CIII”; Ex. 1005) discloses a slipform paver that can be converted between three-track and four-track configurations, depending on the project. [Ex. 1005 (CIII), 42, 194, 204-206, 209; *see* Ex. 1005 (CIII), 15 (depicting three-track configuration), 19 (depicting four-track configuration).] Its three-track configuration includes a pivoting swing leg, a laterally telescoping leg, and a slidable rear-mounted leg. [Ex. 1005 (CIII), 76, 201, 204.] The swing leg is shown on the top left of the annotated version of a schematic diagram from CIII provided below.




[Ex. 1005 (CIII), 201 (annotated top-down view).]

41. CIII describes using different leg positions for different types of jobs. [Ex. 1005 (CIII), 76.] The two schematic diagrams below show how the three tracks can be moved to various positions. The swing leg, mounted to the front left of the machine frame on one end and the hydraulic jacking column on the other end, can pivot left and right to move its corresponding track. [Ex. 1005 (CIII), 79-80, 34.]



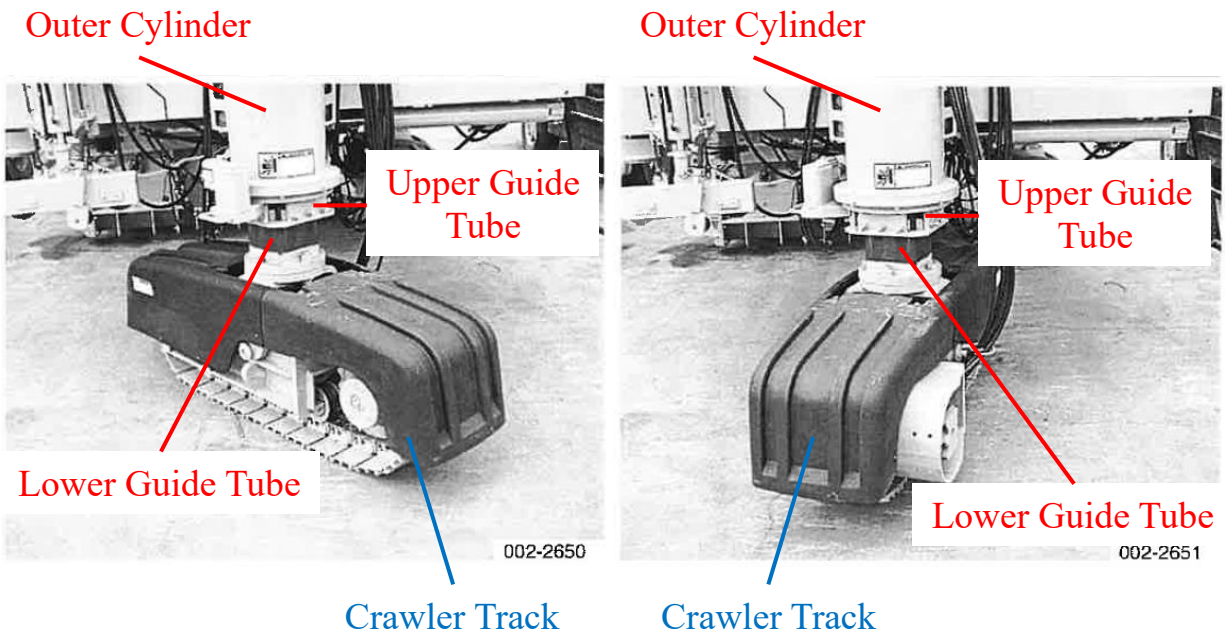

[Ex. 1005 (CIII) (top-down views showing positioning for curb and gutter projects (left) and sidewalk projects (right)).]

42. The hydraulic jacking column has an outer cylinder fixed to the swing leg, a rectangular-shaped "upper guide tube" (also referred to as an "outer guide tube"[1]), and a slightly smaller rectangular-shaped "lower guide tube" (also referred

[1] [*See* Ex. 1005 (CIII), 175, (calling the component both "outer guide tube" and "upper guide tube").]

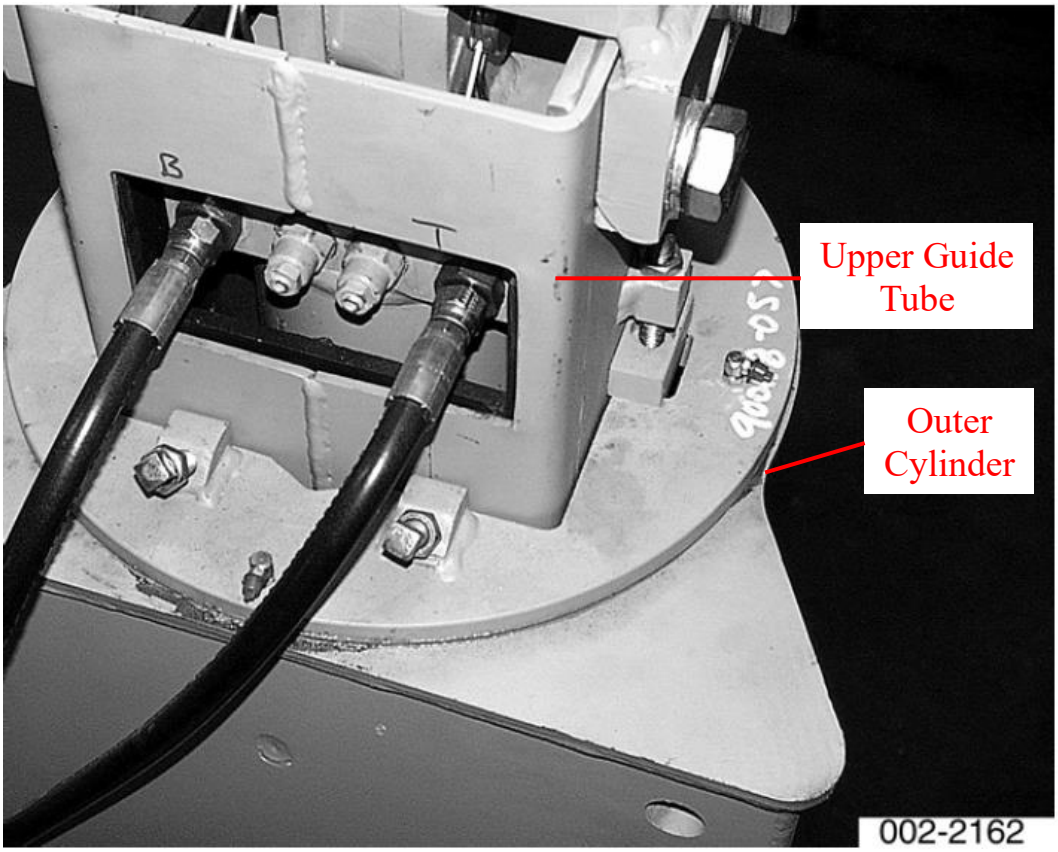
to as an "inner guide tube"[2]) that telescopes into and out of the upper guide tube. [Ex. 1005 (CIII), 74, 173-175.] These guide tubes are configured such that, when a rotational torque is applied to the upper guide tube, the upper guide tube and the lower guide tube rotate in unison relative to the outer cylinder. [Ex. 1005 (CIII), 193, 195.] This rotation of the guide tubes also rotates the crawler track, attached to the bottom of the lower guide tube. [Ex. 1005 (CIII), 193, 195.] This rotation relative to the outer cylinder is depicted in the images below. Note that, based on the label affixed to the outer cylinder, the outer cylinder is at the same position in both of the images below. However, the crawler track has rotated through a large angle.

[2] [*See* Ex. 1005 (CIII), 173-174, 376 (calling the component both "inner guide tube" and "[l]ower guide tube").]




[Ex. 1005 (CIII), 193, 195 (annotated).]

The upper guide tube also protrudes from the top of the outer cylinder, as shown below. [Ex. 1005 (CIII), 175.]

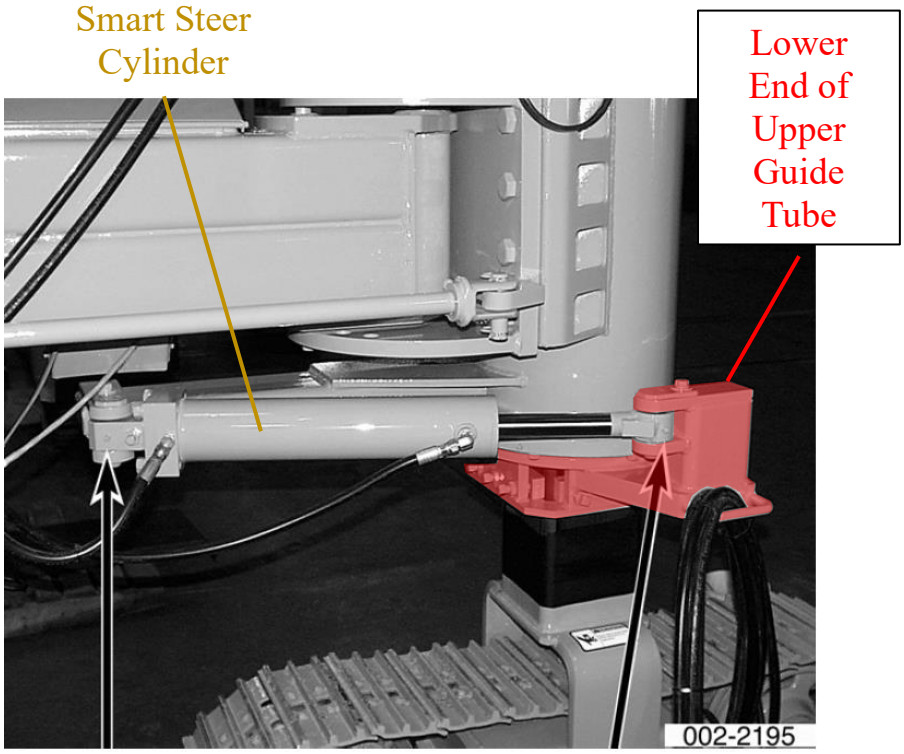



[Ex. 1005 (CIII), 175 (annotated image showing top of jacking column).]

Each jacking column has an internal hydraulic "lift cylinder" that extends/retracts to control the jacking column's vertical position (and thus the elevation of the machine). [Ex. 1005 (CIII), 373-374, 79.]

43. CIII further discloses a hydraulic "smart steer cylinder," depicted below, that attaches between the lower end of the upper guide tube and a lever arm that protrudes from the outer cylinder. [Ex. 1005 (CIII), 407-409, 165.] The upper and lower guide tubes rotate together because of their rectangular cross-sections. [Ex. 1005 (CIII), 407-409, 165.] Thus, the steering cylinder, when actuated, rotates

both guide tubes and the crawler track in unison relative to the outer cylinder. [Ex. 1005 (CIII), 407-409, 373-374, 193, 195.]

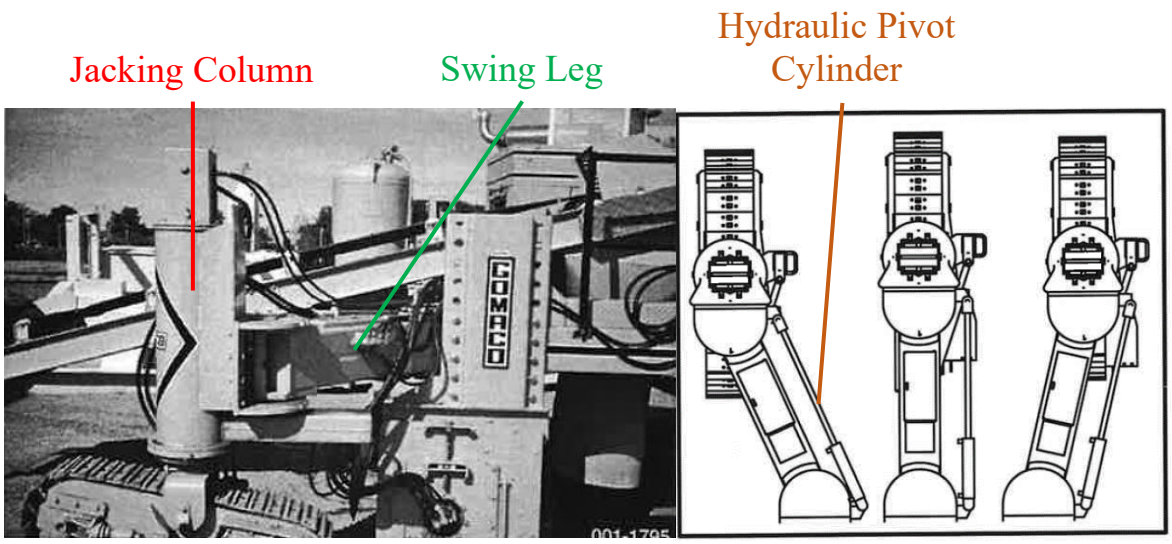



[Ex. 1005 (CIII), 165 (annotated).]

44. An electronic steering system for each leg assembly, consisting of "a sensor, a feedback pot [potentiometer], a servo valve and a control loop on a S2X controller," is "networked to the other S2X controllers on the machine, including the Pancon controller in the control box." [Ex. 1005 (CIII), 407.] The Pancon controller is the central controller that receives signals from the S2X controller associated with each crawler track and sends corrective steering signals to the appropriate S2X controller when required. [Ex. 1005 (CIII), 406-408.] For each

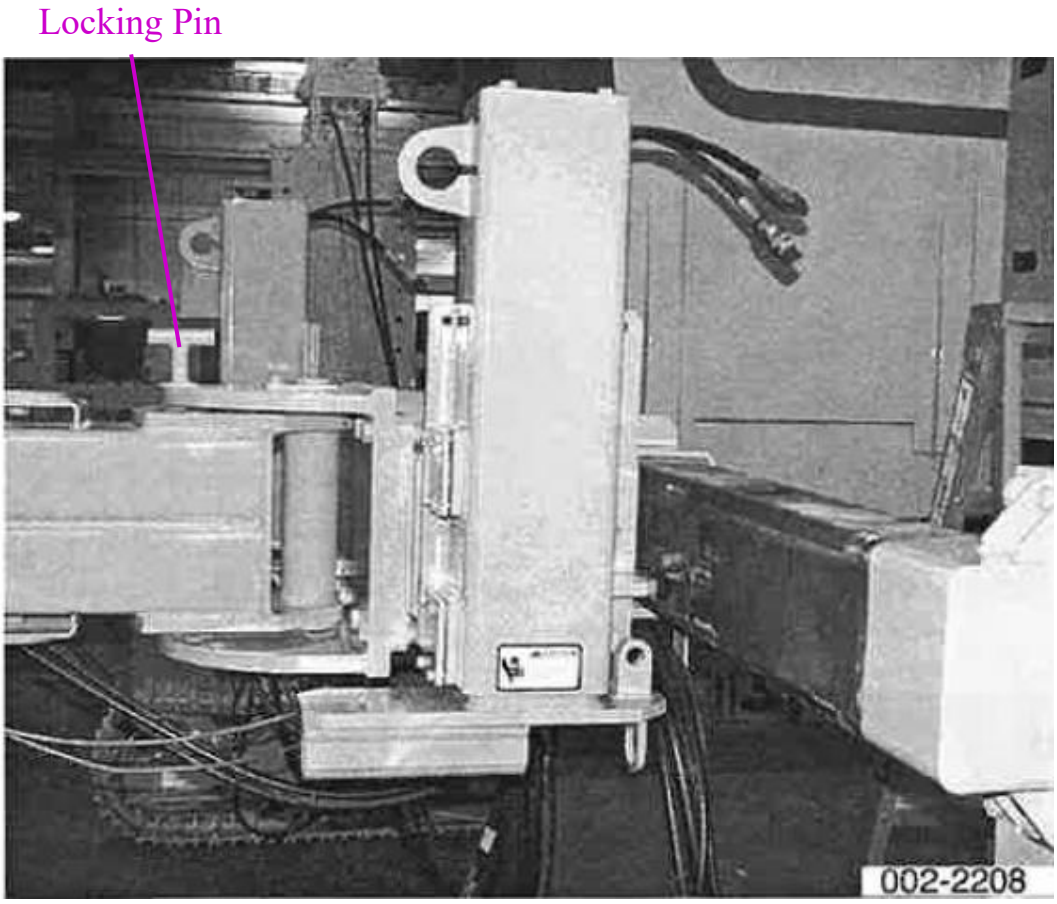
crawler track, "[t]he feedback pot measures the position of the track and sends a continuous signal to the S2X, indicating the track position." [Ex. 1005 (CIII), 408.] The feedback pot associated with the steering cylinder is what makes this cylinder "smart." [Ex. 1005 (CIII), 408.] The Pancon controller receives signals from each S2X controller indicating the track positions, compares the steer signal and feedback pot signals for each leg assembly, and generates corresponding corrective signals that cause each track to rotate to the desired position. [Ex. 1005 (CIII), 408.]

45. CIII also discloses a hydraulic cylinder that swings the leg left or right. [Ex. 1005 (CIII), 79-80, 34.] This swing leg and its various positions are shown below.




[Ex. 1005 (CIII), 79-80 (annotated).]

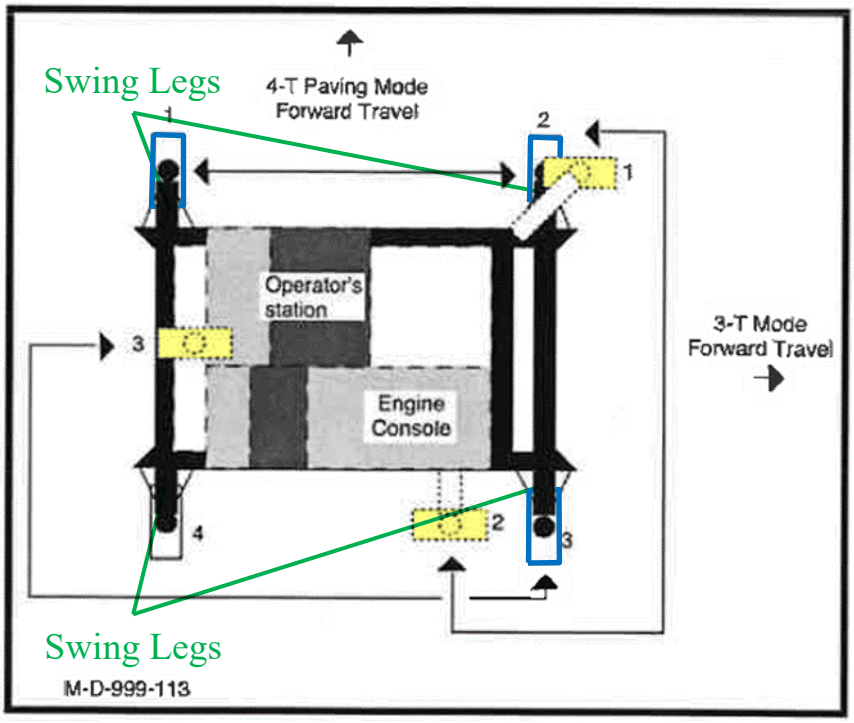
46. To swing the leg, an operator supports the corresponding corner of the machine frame with blocking, raises the crawler track off the ground with the jacking column, removes the pin locking the leg in place, and holds a switch to extend or retract the pivot cylinder until the leg reaches the desired position. [Ex. 1005 (CIII), 79-80.] The operator then reinserts the locking pin, shown below, to lock the swing leg in place in its desired position. [Ex. 1005 (CIII), 80.]




[Ex. 1005 (CIII), 85 (annotated).]

47. CIII also discloses how to convert the paver from its three-track to four-track configuration by removing the jacking columns and crawler tracks in the

three-track configuration (highlighted in yellow in the diagram below), attaching them as indicated by the blue outlines to swing legs (identified in green below) on a four-track frame, and attaching a fourth jacking column and crawler track assembly to the final swing leg on the rear-left corner. [Ex. 1005 (CIII), 204-206, 209, 253.]




[Ex. 1005 (CIII), 204 (annotated top-down view).]

48. The four-track configuration allows the slipform paver to carry out different projects. For example, as shown below, an auger can spread concrete placed in front of the slipform paver "evenly across the width of the paving mold" that is "mounted to the machine frame." [Ex. 1005 (CIII), 199, 211, 240-242.]



Concrete spread evenly in front of machine

[Ex. 1005 (CIII), 242.]

49. As the slipform paver moves forward, it levels and finishes the concrete. [Ex. 1005 (CIII), 241-245.] Examples of such finished concrete are shown below.



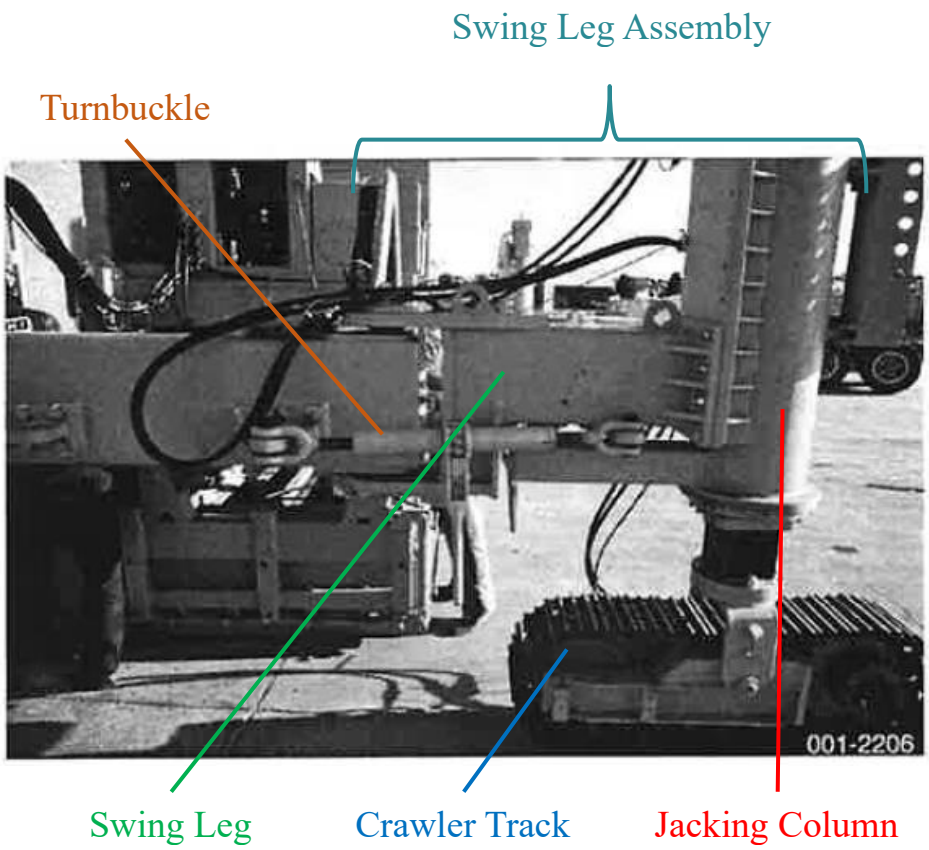
Finish concrete around header



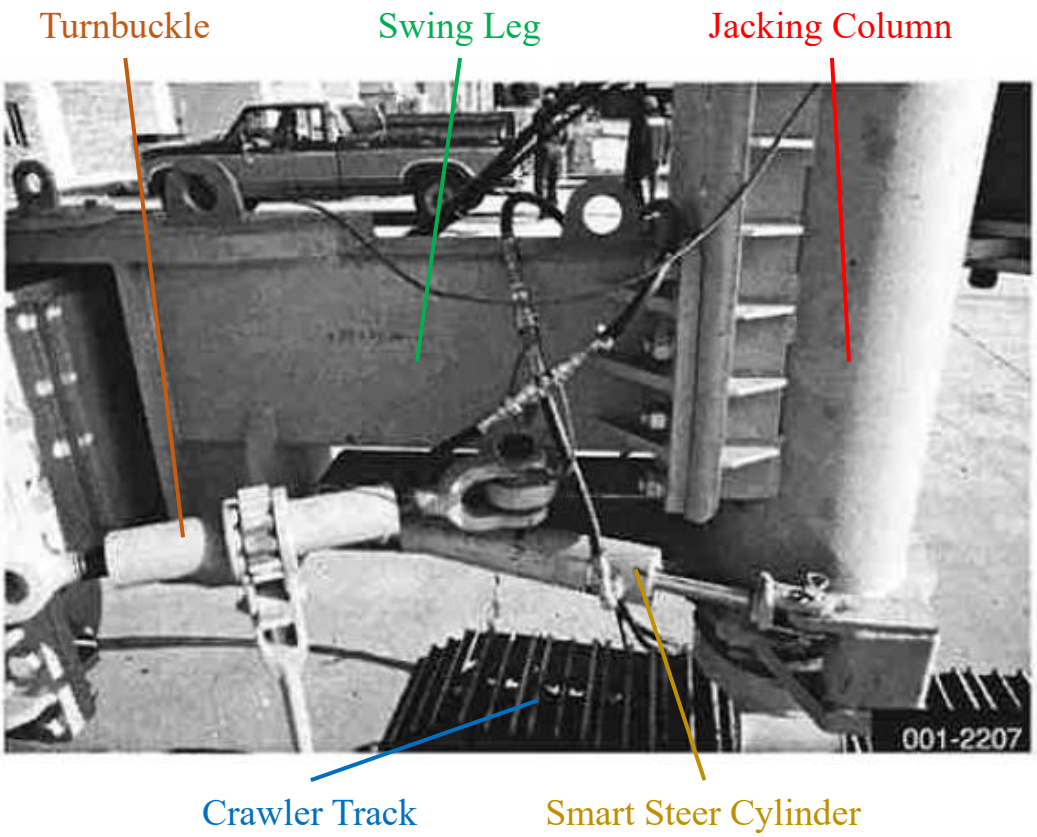
Check concrete grade

[Ex. 1005 (CIII), 241 (left), 243 (right).]

50. Each of the four swing-legs has two turnbuckles that can be adjusted for minor swing-leg rotations or removed for larger rotations. [Ex. 1005 (CIII), 209, 253.] A turnbuckle was one of several known mechanisms used to hold a swing leg at a fixed position and commonly included extendable rods to change the length of the turnbuckle via, for example, a ratchet mechanism. CIII discloses removing the turnbuckles when rotating the swing legs from "paving mode to barrier/transport mode." [Ex. 1005 (CIII), 253.] A swing-leg assembly with the turnbuckles attached is depicted in each of the below annotated images.



[Ex. 1005 (CIII), 209 (annotated, depicting outer side of a first swing-leg assembly).]

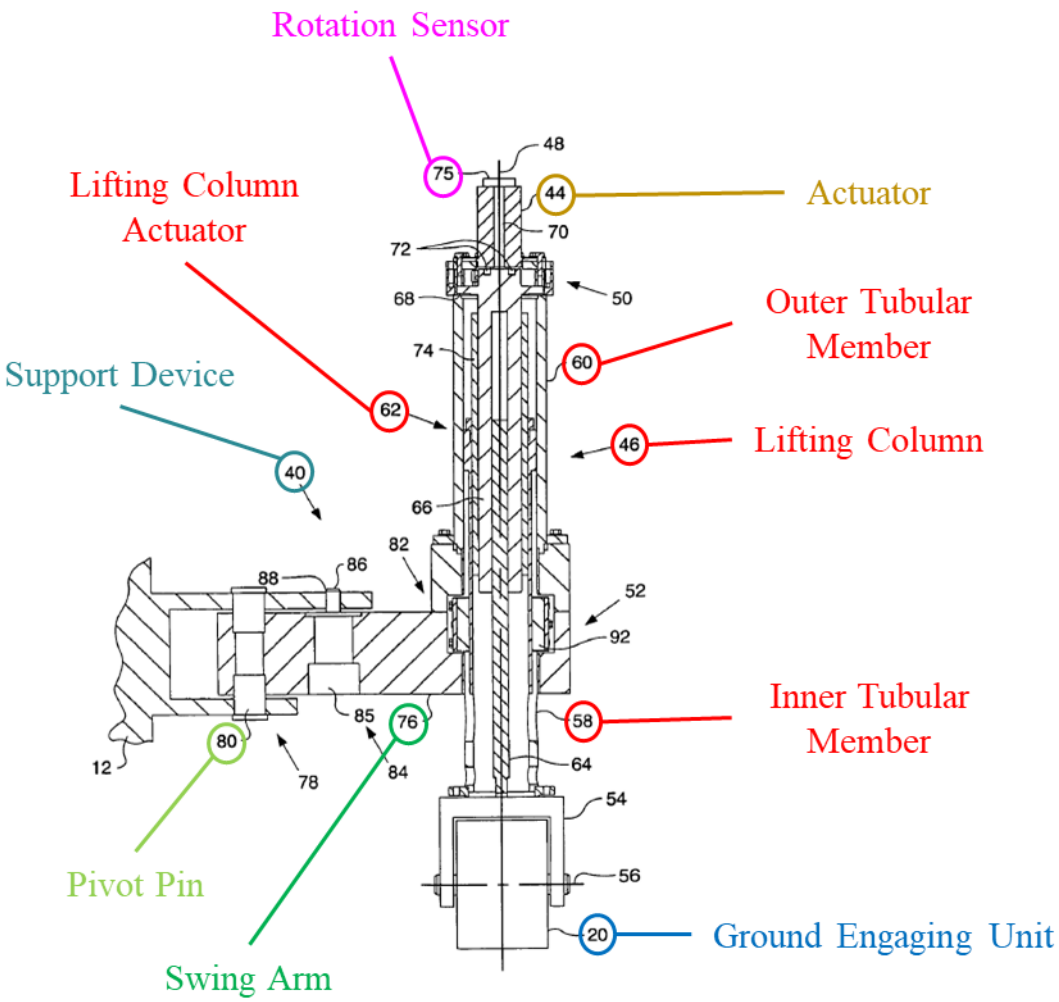



[Ex. 1005 (CIII), 265 (annotated, depicting inner side of a second swing-leg assembly).]

**2. Summary of Rio**

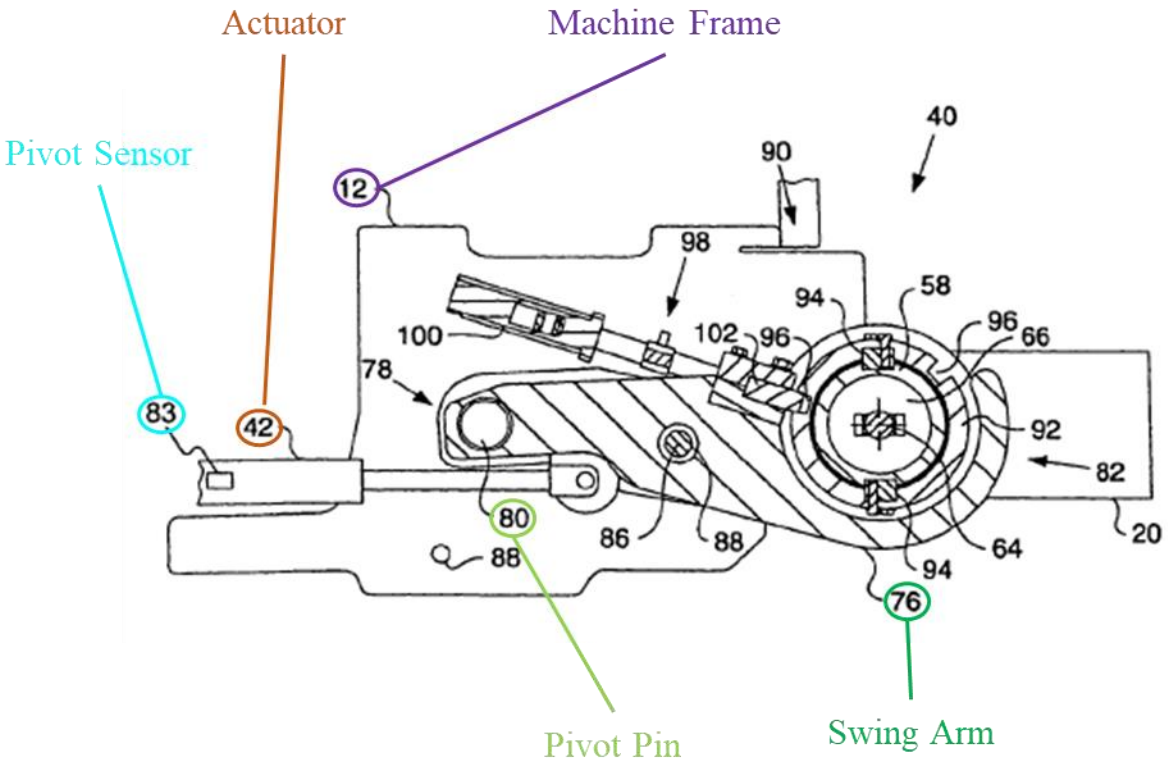
51. U.S. Patent No. 7,523,995 ("Rio"; Ex. 1006) discloses a road-milling machine with a machine frame 12 supported by four ground engaging units (e.g., tracks). [Ex. 1006 (Rio), 1:5-7, 3:43-45, 3:48-49.] As shown below, support device 40, consisting primarily of swing arm 76 and lifting column 46, connects the

ground engaging unit 20 to machine frame 12. [Ex. 1006 (Rio), 4:38-40, 4:51-53, 6:12-15.] Lifting column 46 has two hollow tubes (i.e., "inner tubular member 58" and "outer tubular member 60") that telescope relative to each other in response to an internal hydraulic "lifting column actuator 62" that extends and retracts. [Ex. 1006 (Rio), 5:32-53.] The extension/retraction of "lifting column actuator 62" raises and lowers the machine. [Ex. 1006 (Rio), 5:32-53.] Figure 2 of Rio shows these components:

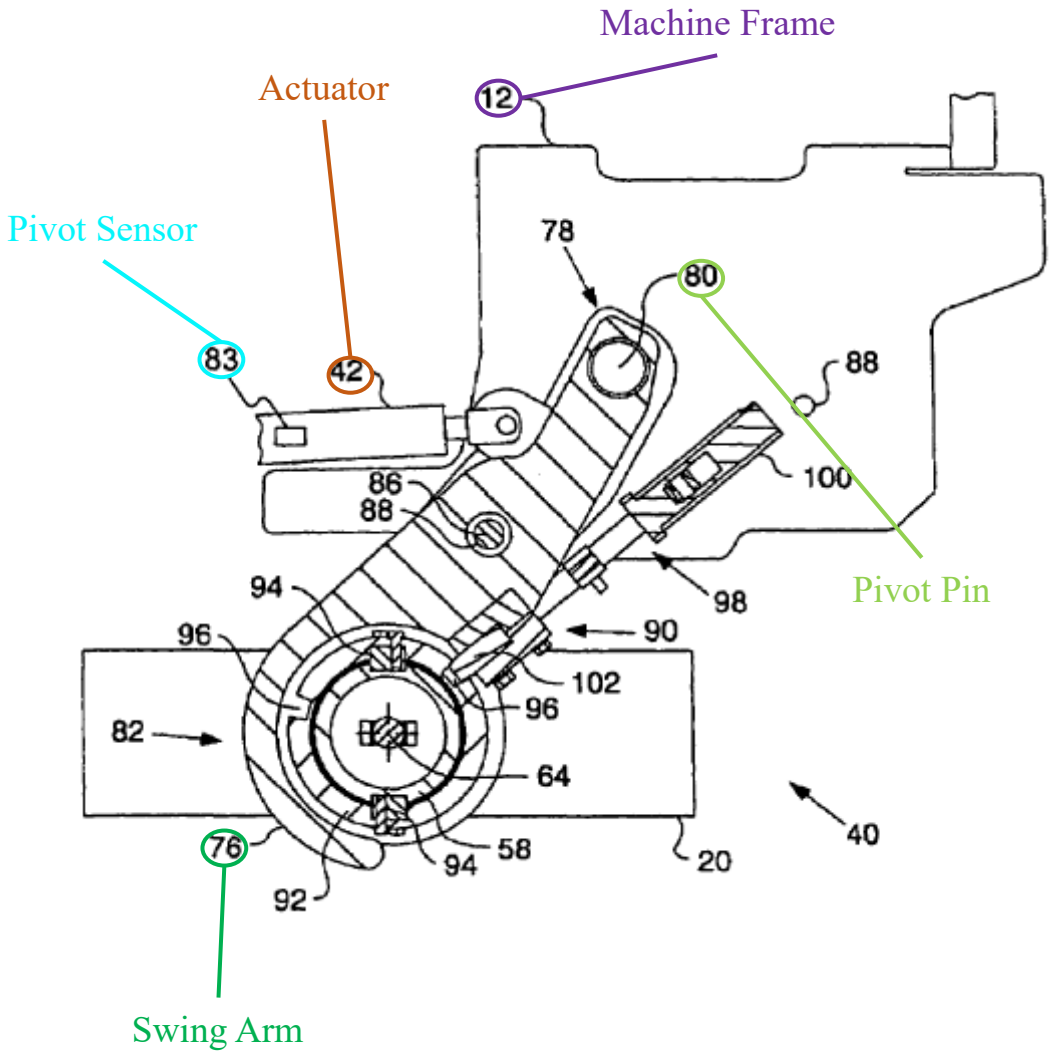


[Ex. 1006 (Rio), Fig. 2 (annotated).]

52. Rio further discloses a first actuator 42 that pivots swing arm 76 about pivot pin 80, moving ground engaging unit 20 between retracted and projecting positions (shown below in Figures 3 and 4, respectively). [Ex. 1006 (Rio), 6:19-22.] Second actuator 44 (shown at the top of the lifting column in the figure above) rotates ground engaging unit 20 about a vertical lifting column axis 48. [Ex. 1006 (Rio), 4:56-60, 6:4-6.] Actuators 42 and 44 may be linear actuators or rotary actuators such as "worm or sun gear designs." [Ex. 1006 (Rio), 4:61-5:3.] Although Figure 2 shows the second actuator 44 at the top of the lifting column in a "typical embodiment," Rio discloses "another of the preferred embodiments" in which "the second actuator 44 is positioned on the lifting column 46 . . . along the lifting column axis 48" in any position that "avoids problems caused by an accumulation of mechanical devices at a single location on the lifting column 46." [Ex. 1006 (Rio), 4:53-60, 5:8-24.]




[Ex. 1006 (Rio), Fig. 3 (annotated, depicting retracted position).]



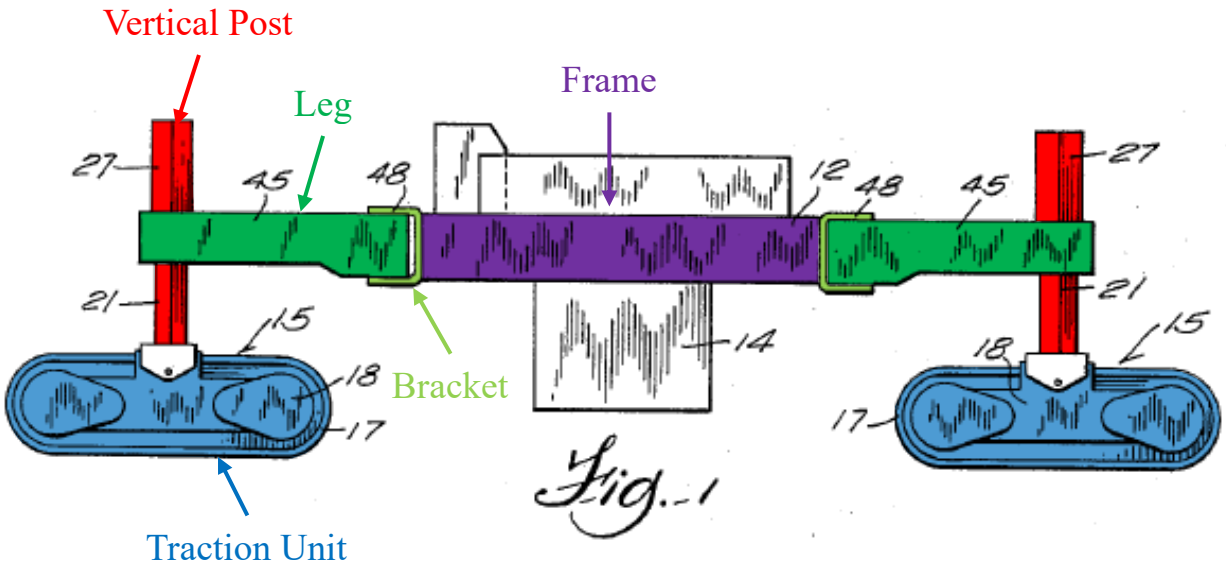

[Ex. 1006 (Rio), Fig. 4 (annotated, depicting projecting position).]

53. Rio discloses a rotation sensor 75 (shown in Figure 2 above) associated with actuator 44 that generates signal 124 "indicating the instantaneous rotation angle of the one ground engaging unit 20." [Ex. 1006 (Rio), 7:23-27.] A pivot sensor 83 associated with actuator 42 or the swing arm 76 generates signal 122 "indicating the instantaneous angular position of the swing arm 76 relative to the machine frame 12." [Ex. 1006 (Rio), 7:19-23.] Controller 32 uses these signals

to counter-rotate ground engaging unit 20 *while swing arm 76 pivots* so that the wheel/track "remain[s] parallel to the machine frame 12 at all points in the pivot arc." [Ex. 1006 (Rio), 6:65-7:13, 8:31-55.] Therefore, Rio teaches the simultaneous arm swing and counter rotation of the ground engaging unit that is central to the claims of the '723 patent.

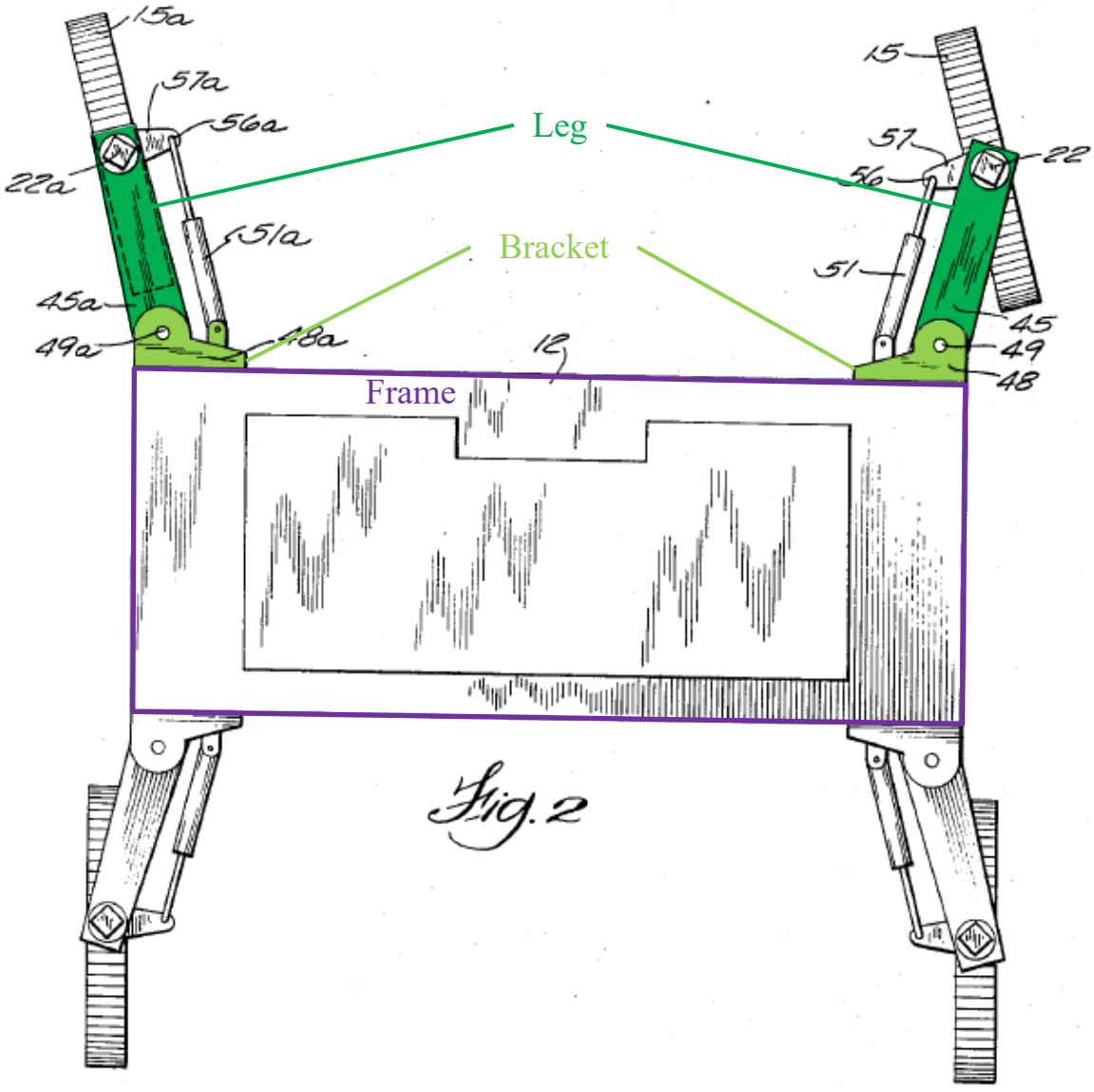
### 3. Summary of Files

54. U.S. Patent No. 3,792,745 ("Files"; Ex. 1012) discloses a vehicle for carrying construction tools, similar to CIII, including "a rectangular frame and four individual traction units each of which supports a vertical post and a horizontally extending leg," as depicted below. [Ex. 1012 (Files), 1:27-29.] Files explains that its tool can be a "roadway forming tool," making it a road construction machine. [Ex. 1012 (Files), 4:21-24].



[Ex. 1012 (Files), Fig. 1 (annotated).]

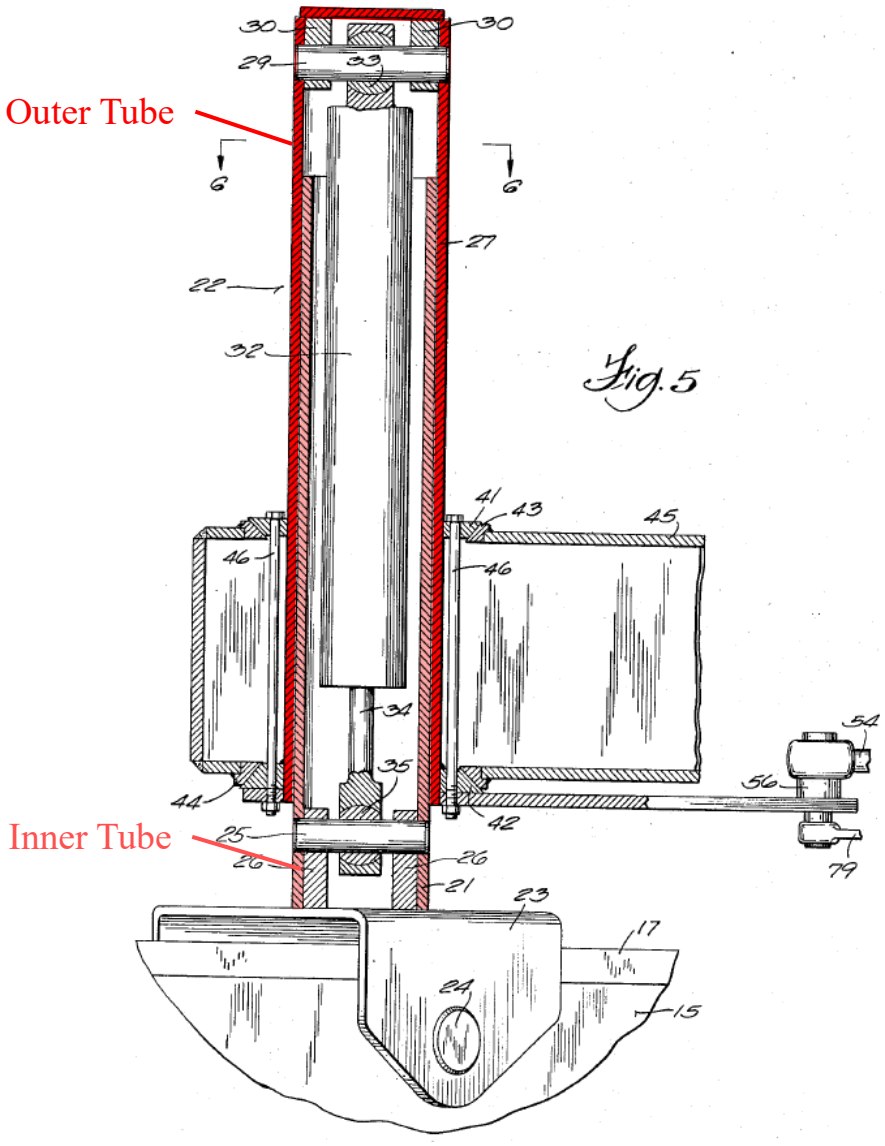
55. One end of each leg "is connected to the frame by a vertical pin allowing horizontal swinging of the leg for the lateral adjustment of the respective traction unit." [Ex. 1012 (Files), 1:29-32.] As shown below in annotated Figure 2, each "leg is removably secured to the vehicle frame" via a bracket 48. [Ex. 1012 (Files), 1:58-61, 2:57-63.] "The fixed end of leg 45 fits between the upper and lower plates of the bracket 48 and is secured thereto by the vertical pin 49 which allows the projecting end of the leg to pivot laterally." [Ex. 1012 (Files), 2:57-61.]




[Ex. 1012 (Files), Fig. 2 (annotated).]

56. "Each post is telescopic for adjusting the height of the frame and comprises two or more tubes in telescoping relation." [Ex. 1012 (Files), 1:34-36.] For example, as depicted below, each post includes a hydraulic cylinder that "either lifts or lowers outer tube 27 in sliding relation on [inner] tube 21."

[Ex. 1012 (Files), 2:21-24, 2:32-35.] Tubes 21 and 27 have square cross-sections and, "[f]or a sliding fit[,] the lower inner end of tube 27 and the upper outer end of tube 21 may be fitted with shims." [Ex. 1012 (Files), 2:48-56.]




[Ex. 1012 (Files), Fig. 5 (annotated).]

### 4. Comparison of ’723 Patent Claims to ’749 patent Claims

57. The ’723 patent issued from a continuation application claiming priority to U.S. Patent No. 10,029,749 (’749 patent”; Ex. 1033), which was the subject of a prior IPR in which the Board found all claims unpatentable based on the same CIII and Rio prior art asserted here. [*See Godbersen-Smith Const. Co. v. Guntert & Zimmerman Const. Div., Inc.*, IPR2020-01698, Paper 80 (Apr. 12, 2022) (“’749 FWD”).]

58. The table below shows how claims 1, 4, and 7 of the ’723 patent contain substantively similar limitations to those found in claims 2-4, 7, 11, and 17-18 of the invalidated ’749 patent. For purposes of patentability, the limitations of the ’723 patent identified below do not meaningfully differ from the corresponding limitations of the ’749 patent.

| **’723 Patent Claim Language** | **’749 Patent Claim Language** |
|---|---|
| [1pre]: “A paving machine comprising:” | [17pre]: “A paving machine . . . comprising”<br><br>[Ex. 1033, 23:54-57.] |
| [1A]: “a modular frame;” | [17A]: “a module frame”<br><br>[Ex. 1033, 24:1.] |
| [1B]: “a plurality of swing legs,” | [17B]-[17C]: “two or more swing leg assemblies, each swing leg assembly comprising: a swing leg” |

| | |
|---|---|
| | [Ex. 1033, 24:2-4.] |
| [1C]: "each swing leg coupled to a surface of the modular frame via a hinged bracket and hydraulically actuated to pivot the swing leg about a vertical axis," | [2]-[4], [18A]-[18C]: both, "a hinge bracket arranged to be interposed between the swing leg and the surface of the module frame"; "wherein the hinge bracket . . . permits pivotal movements of the swing leg . . . about a second upright axis"; "a hydraulic actuator . . . permitting the swing leg to pivot relative to the module frame"<br><br>[Ex. 1033, 23:2-14, 24:36-47.] |
| [1D]: "wherein a first angular position transducer . . . to measure an angular position between the swing leg and the modular frame and further emit a first signal indicative of the measured angular position to an onboard computer or processor;" | [17G]: "a second angular position transducer between the swing leg and the module frame, configured to emit a second signal which is indicative of an angular orientation of the swing leg relative to the module frame"[3]<br><br>[Ex. 1033, 24:17-21.]<br><br>[17I]: "a processor operable to receive the first and second signals"<br><br>[Ex. 1033, 24:26-27.] |

[3] Even though the '723 patent uses the term "first" and the '749 patent uses the term "second," the first angular position transducer and first signal of the '723 patent correspond to the second angular position transducer and second signal of the '749 patent.

| | |
|---|---|
| [1E]: "a jacking column secured to each swing leg, the jacking column comprising:" | [17E]: "an upright jacking column secured to the swing leg"<br><br>[Ex. 1033, 24:7.] |
| [1I]: "a crawler track . . . rotatably coupled to the jacking column;" | [17D]: "a crawler track"<br><br>[Ex. 1033, 24:6.]<br><br>[17E]: "a rotary connection between the jacking column and the crawler track permitting relative rotational movements of the crawler track and the jacking column about a first upright axis"<br><br>[Ex. 1033, 24:8-11.] |
| [1J]: "a slew gear drive secured at a lower end of the inner tube and to a top of the yoke to translate relative rotational movements between the jacking column and the crawler track about the upright axis, . . ." | [17H]: "a power drive between the jacking column and the crawler track, configured for translating relative rotational movements between the jacking column and the crawler track"<br><br>[Ex. 1033, 24:22-25.]<br><br>[11]: "the power drive comprises a slew gear drive"<br><br>[Ex. 1033, 23:37-38.] |
| [1K]: "a second angular position transducer configured to measure an angular position of the crawler track and yoke relative to the jacking column and further emit a second signal indicative of the measured angular position via a lead to an onboard computer or processor." | [17F]: "a first angular position transducer between the jacking column and the crawler track, configured to emit a first signal which is indicative of |

| | |
|---|---|
| | an angular orientation of the crawler track relative to the jacking column"),[4]<br><br>[Ex. 1033, 24:12-16.]<br><br>[17I]: "a processor operable to receive the first and second signals"<br><br>[Ex. 1033, 24:26-27.] |
| Claim 4: "The paving machine of claim 1, wherein the slew gear drive is configured to steer and/or maintain the crawler track in a preset position . . . ." | [7]: "a feedback for maintaining the orientation of the crawler track independently of angular inclinations of the crawler track relative to the module frame"<br><br>[Ex. 1033, 23:25-28.] |
| [7P]: "The paving machine of claim 1, wherein the processor is configured to: | [17I]: "a processor operable to"<br><br>[Ex. 1033, 24:26.] |
| [7A]: receive the first and second signals; | [17I]: "receive the first and second signals"<br><br>[Ex. 1033, 24:26-27.] |
| [7B]: "determine a change of the first angular orientation based on the first signal;" | In the '749 FWD, the Board found a much more complex term obvious over the same prior art used here. That more complex term contains the limitation |

[4] Even though the '723 patent uses the term "second" and the '749 patent uses the term "first," the second angular position transducer and second signal of the '723 patent correspond to the first angular position transducer and first signal of the '749 patent.

| | |
|---|---|
| | here in [7B] of the ’723 patent. In the ’749 FWD, when addressing [17I] (“a processor operable to receive the first and second signals and configured to emit a control signal for activating the power drive and thereby rotationally move the crawler track relative to the jacking column to maintain an orientation of the crawler track in response to changes of the first signal caused by pivotal motions of the swing leg about an upright pivot shaft”), [Ex. 1033, 24:26-33], the Board found that “CIII, as modified by Rio’s teachings of its control system, discloses the subject matter of the ‘processor’ limitation” based in part on Rio’s teaching that “controller 32 actuates first actuator 42 to move swing arm 76 and pivot sensor 83 tracks the movement” and that “controller 32 uses signals 122, 124 to maintain the track in the same running direction.” [’749 FWD at 67-68, 95-96.] This means that a change of the angular orientation of Rio’s swing arm relative to the frame (the ’723 patent’s “first angular orientation”) is determined based on the corresponding signal 122 indicating the angular orientation of the swing arm relative to the frame (the ’723 patent’s “first signal”) so that the corresponding change to the angular orientation of the crawler track can be made. Accordingly, the Board found [7B] of the ’723 patent to be within the scope of [17I] of the ’749 patent. |

| | |
|---|---|
| [7C]: "in response to determining the change of the first angular orientation, determine a target second angular orientation based on the determined change of the first angular orientation and the second angular orientation based on the second signal; and" | In the '749 FWD, the Board found a much more complex term obvious over the same prior art used here. That more complex term contains the limitation here in [7C] of the '723 patent. In the '749 FWD, when addressing [17I] ("a processor operable to receive the first and second signals and configured to emit a control signal for activating the power drive and thereby rotationally move the crawler track relative to the jacking column to maintain an orientation of the crawler track in response to changes of the first signal caused by pivotal motions of the swing leg about an upright pivot shaft"), [Ex. 1033, 24:26-33], the Board found that "CIII, as modified by Rio's teachings of its control system, discloses the subject matter of the 'processor' limitation" based in part on Rio's teaching that "controller 32 actuates first actuator 42 to move swing arm 76 and pivot sensor 83 tracks the movement" and that "controller 32 uses signals 122, 124 to maintain the track in the same running direction." ['749 FWD at 67-68, 95-96.] This means that, in response to determining the change of the angular orientation of Rio's swing arm relative to the frame (the '723 patent's "first angular orientation"), a target angular orientation of Rio's track relative to its lifting column (the '723 patent's "second angular orientation") is determined based on the determined change of the angular orientation of Rio's swing arm relative to the frame |

| | |
|---|---|
| | (the ’723 patent’s “first angular orientation”) and the angular orientation of Rio’s track relative to its jacking column (the ’723 patent’s “second angular orientation”) based on the corresponding signal 124 indicating the angular orientation of the track relative to the lifting column (the ’723 patent’s “second signal”) so that the corresponding change to the angular orientation of the crawler track can be made. Accordingly, the Board found [7C] of the ’723 patent to be within the scope of [17I] of the ’749 patent. |
| [7D]: “send a control signal to the slew drive in order to cause the second angular orientation of the crawler track to rotate to the target second angular orientation.” | [17I]: “emit a control signal for activating the power drive and thereby rotationally move the crawler track relative to the jacking column to maintain an orientation of the crawler track”<br><br>[Ex. 1033, 24:27-30.] |

59. Accordingly, the only limitations in the claims of the ’723 patent that are not found in those determined to be unpatentable in the ’749 patent are those underlined in the listing below. As I explain further in my analysis of the grounds, many of these limitations are taught by the same CIII and Rio references relied on in the IPR of the ’749 patent. Any that are not taught by CIII and Rio are taught by Files.

- [1D]: "first angular position transducer is disposed on the modular frame or the swing leg";
- [1F]: "telescoping outer and inner tubes with an upright axis";
- [1G]: "a vertically oriented hydraulic actuator located along the upright axis, the hydraulic actuator comprising a cylinder and a piston operable within the outer and inner tubes";
- [1H]: "spaced apart axial bearings coupled to the outer tube and/or the inner tube";
- [1I]: "a crawler track coupled to a yoke";
- [1J]: "wherein the slew gear drive is capable of steering the crawler track under load without lifting the crawler track";
- [2]: "wherein the axial bearings are configured to limit rotational backlash between the inner and the outer tubes of the jacking column, while keeping the tubes aligned and allowing them to slide against each other";
- [3]: "wherein rotational movement of the crawler track ranges between 180 degrees on either side the upright axis";
- [5]: "wherein the slew gear drive is configured for precision movement between the jacking column and the crawler track and to limit backlash to avoid adversely affecting steering accuracy of the crawler track"; and

- [6]: "wherein the swing leg is configured to relocate the jacking column with the crawler track while moving and under load."

### 5. CIII, Rio, and Files Are Analogous Art

60. I understand that a prior art reference is analogous art if it is in the same field of endeavor as the patent or is reasonably pertinent to the particular problem faced by the inventor (even if it is not in the same field of endeavor as the patent). CIII, Rio, and Files are analogous art to the '723 patent.

61. CIII, Rio, and Files are analogous art to the '723 patent because they are in the same field of endeavor as the '723 patent. The '723 patent "concerns concrete slipform paving machines," which is a form of road-construction machine, with swing-leg assemblies. [Ex. 1001 ('723 patent), 1:31-35, Abstract.] CIII, Rio, and Files each describe swing-leg assemblies for road-construction machines. [Ex. 1005 (CIII), 79-80, 209, 253; Ex. 1006 (Rio), 8:18-9:14, Fig. 2; Ex. 1012 (Files), 1:27-46, 2:7-11, 4:21-24, Fig. 2; *see* Ex. 1001 ('723 patent), 1:35-38, 2:15-21, 8:55-9:4, 9:32-39, Fig. 1.] Additionally, both the '723 patent and CIII disclose concrete slipform paving machines. [Ex. 1001 ('723 patent), Fig. 1, 1:31-35; Ex. 1005 (CIII), 19, 240-249.]

62. Rio is also analogous art because it is reasonably pertinent to the problems the '723 patent purports to solve, namely, reducing the profile of the actuator used to rotate the crawler tracks and the "costly" and "time-consuming"

processes associated with repositioning and controlling swing legs and crawler tracks on road-construction machines, which often required extensive manual intervention. [Ex. 1001 (’723 patent), 2:11-14, 4:23-39, 5:9-12; Ex. 1006 (Rio), 2:30-41.] Rio eliminated these hardships in the same way as the ’723 patent—by using a rotary actuator to rotate the crawler tracks and automating the positioning of swing legs and crawler tracks. [Ex. 1006 (Rio), 2:30-41, 4:61-5:7, 8:31-9:14, 9:37-42.]

63. Files is also analogous art because it is reasonably pertinent to the particular problems the ’723 patent purports to address. Like the ’723 patent, it identifies that, in the prior art, moving the swing legs to “different lateral positions” required that “the steering linkage be disconnected and readjusted,” and discloses techniques for steering a crawler track attached to the bottom of a jacking column. [Ex. 1012, 1:22-24, 2:63-3:15; *see* Ex. 1001 (’723 patent), 4:12-39, 6:38-43.] Moreover, similar to the ’723 patent’s disclosure of minimizing backlash, Files discloses that its jacking columns are designed so that their outer and inner tubes are “firmly interlocked rotationally so that the steering effort is transmitted rotationally from tube 27 to tube 21 with no lost motion.” [Ex. 1012, 4:29-37; *see* Ex. 1001 (’723 patent), 11:34-37.]

### 6. Rationale for Combining CIII, Rio, and Files

#### a. Combining CIII and Rio

64. A POSITA would have been motivated to combine CIII and Rio and would have had a reasonable expectation of success in doing so. The Board agreed with my opinion that this was the case in the '749 FWD.[5] ['749 FWD at 40-63.] It would have been obvious to use Rio's rotary actuator instead of CIII's steering cylinder to rotate each crawler track and to incorporate Rio's teaching of a control system that maintains the track in a desired orientation as the corresponding swing leg pivots. As I explain below, a POSITA would have been motivated to make this combination for various reasons, including greater rotational range of motion of the crawler track, improving maneuverability of the paver, reducing the amount of time needed to adjust the positions of the swing legs and crawler tracks and to set up the steering system, to eliminate bulky linkages, to simplify the jacking-column design, to improve the maintenance of the jacking column, and to automate the rotation of the swing leg and crawler track.

[5] Throughout my declaration, each time I discuss what the Board previously found in the '749 FWD and cite to that decision, I am indicating that I agree with those findings.

65. A POSITA would have been motivated to modify CIII by replacing each steering cylinder with Rio's rotary actuator 44 (e.g., worm-gear design). A POSITA would have recognized that a rotary actuator would give the crawler track greater rotational range of motion than CIII's steering cylinder, including 180° rotation of the crawler track in either direction in Rio's worm-gear design. [U.S. Patent Publication No. 2010/0181136 ("Swasey"; Ex. 1013), ¶¶ [0041], [0044] (disclosing worm-gear rotary actuator that can "be turned either clockwise or counterclockwise, in full circles," while simultaneously "bearing a very large load and providing a significant amount of torque"); U.S. Patent No. 4,029,165 ("Miller"; Ex. 1008), 2:51-53, 7:36-60, Fig. 7 (disclosing a rotary actuator for 360° steering); U.S. Patent Publication No. 2003/0173130 ("Johns"; Ex. 1009) ¶ [0024] (disclosing a slew drive that permits "180 degrees of rotation, left or right").] Greater range of motion would have led to greater maneuverability of the paver, faster adjustments in crawler-track position, and fewer risks to the safety of the operators.

66. A POSITA would have been motivated to provide these benefits of Rio to facilitate eliminating CIII's manual adjustments required to "center the stroke of the steer cylinder" after "adjusting the swinging legs." [Ex. 1005 (CIII), 209.] This centering the stroke requires supporting the frame, lowering the frame onto the support to take the weight off the track, removing four bolts from the track

yoke, extending/retracting the steer cylinder to the desired position, turning the track on the center spindle bolt to face straight ahead, and reattaching the track yoke via the bolts. [Ex. 1005 (CIII), 209.] Eliminating the need for these manual adjustments greatly reduces the risk that an accident might occur due to operator error during the adjustment process.

67. A POSITA would have further been motivated to implement Rio's rotary actuator to provide "a compact apparatus" with high torque that achieves "fine rotary steering control" and provides "rotary motion without the need for complicated and bulky linkages." [Ex. 1006 (Rio), 4:66-5:7.] CIII's steering cylinder assembly is the type of "bulky linkage[]" for which Rio provides a solution. [Ex. 1005 (CIII), 408.] Rotary actuators were well known before the '723 patent and were commonly used to rotate wheel and track assemblies, as disclosed in Rio, U.S. Patent No. 4,558,758 ("Littman"; Ex. 1007), Miller, Johns, and GT-3200 Trimmer/Slipform Paver ("GT-3200"; Ex. 1010), and U.S. Patent No. 5,127,335 ("Whitaker"; Ex. 1011). [Ex. 1007 (Littman), 3:31-5:52; Ex. 1008 (Miller), 2:51-53, 7:36-60, Fig. 7; Ex. 1009 (Johns), ¶ [0020], Fig. 2; Ex. 1010 (GT-3200), 3; Ex. 1011 (Whitaker), 4:7-16, Fig. 3.]

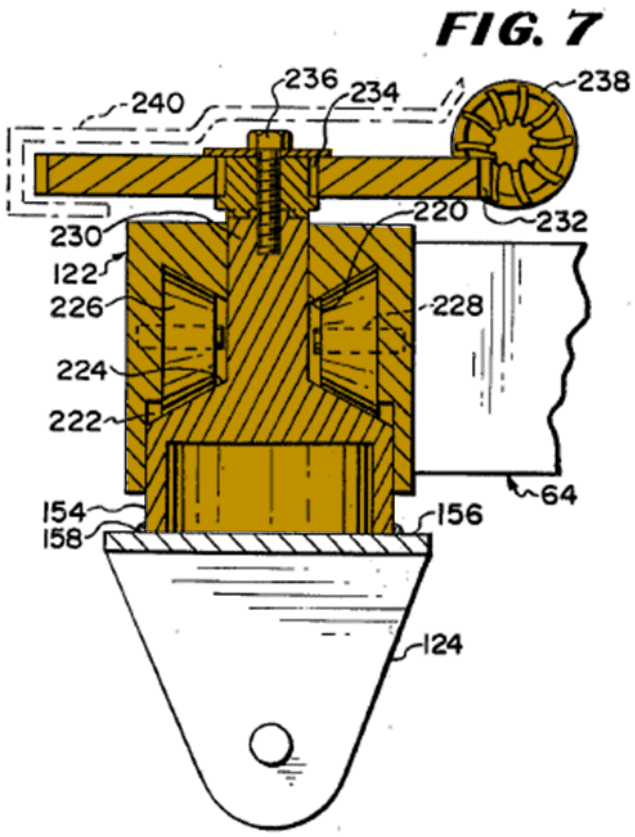
68. Both Rio and CIII disclose a sensor that measures the angular position of the crawler tracks and a controller that rotates the crawler tracks based on the receipt of multiple signals. [Ex. 1005 (CIII), 407-408; Ex. 1006 (Rio), 6:6-11,

8:39-47, 9:37-42.] Combining aspects of these swing-leg assemblies would have involved substituting one known element for another according to known methods to yield predictable results.

69. Given Rio's disclosure that rotary actuator 44 can be a worm-gear design and that rotary actuator 44 can be "positioned on the lifting column 46" anywhere "along the lifting column axis 48," a POSITA would have known to mount Rio's rotary actuator 44 at the bottom of CIII's jacking column between the jacking column's lower guide tube and the yoke associated with the crawler track. [Ex. 1006 (Rio), 5:8-11.] At a minimum, such a design would have been an obvious design choice. Given the finite number of places to mount a rotary actuator with a worm-gear design "along the lifting column axis 48," a POSITA would have been motivated to try positioning the rotary actuator between the jacking column's lower guide tube and the yoke attached to the crawler track. [Ex. 1006 (Rio), 5:8-11.]

70. A POSITA would have already been aware of such a design and the maneuverability that it provides. For example, Miller discloses a similar rotary actuator comprising a "driven gear 232," a "drive pinion gear 238 [that] engages the driven gear 232," and a steering spindle (housing) 122 that transfers rotational torque from driven gear 232 to the crawler track. [Ex. 1008 (Miller), 7:35-53, Fig. 7.] These components of the rotary actuator are highlighted in gold below in

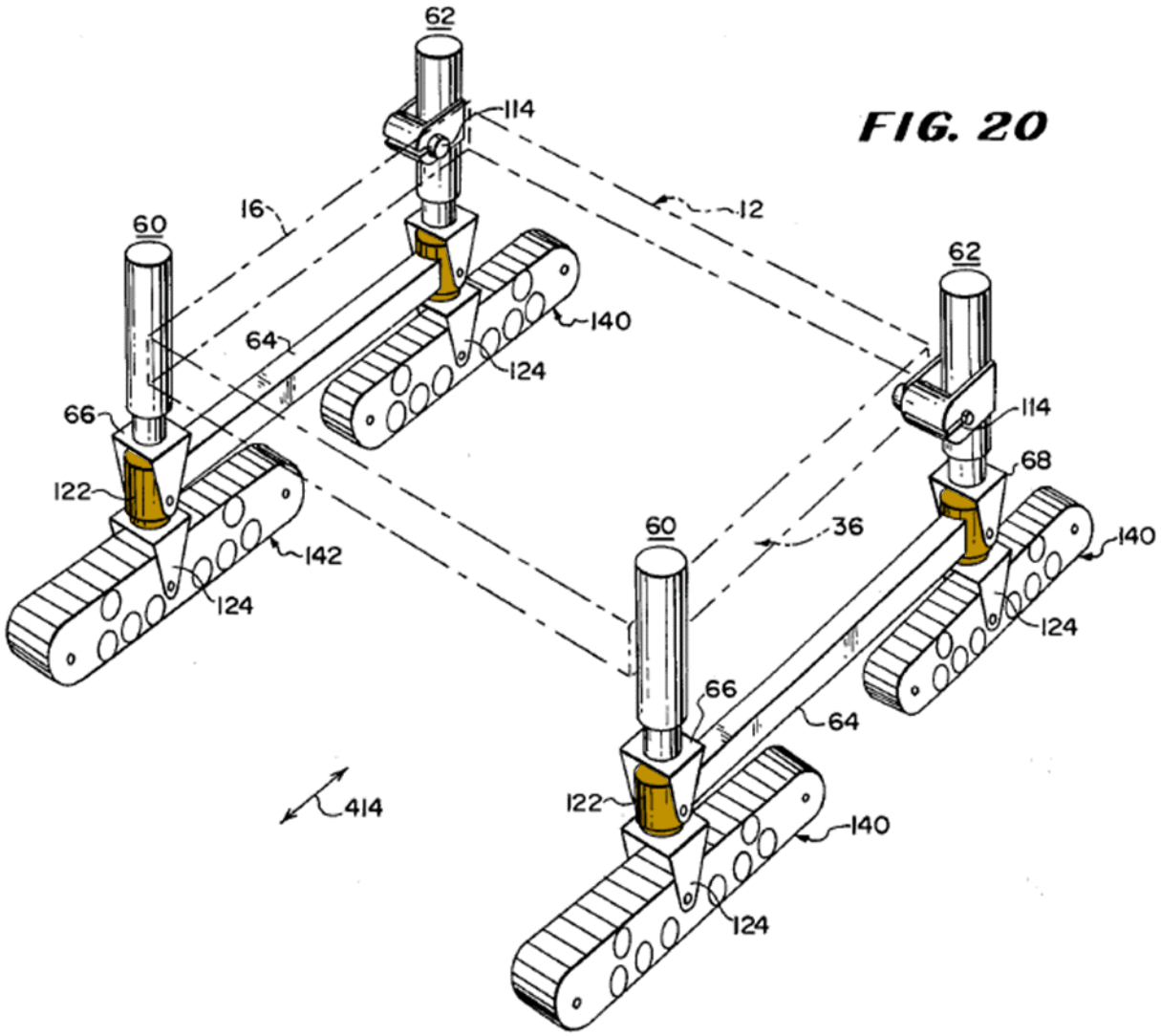
Figure 7. Miller's rotary actuator also includes a "drive motor," not pictured," that "would be mounted on a non-turning part such as the walking beam 64." [Ex. 1008 (Miller), 7:48-51.] Actuation of the drive motor creates rotational torque through the drive pinion gear 238, driven gear 232, and the vertical spindle 230 within steering spindle (housing) 122 that causes the crawler track to rotate.




[Ex. 1008 (Miller), Fig. 7 (annotated).]

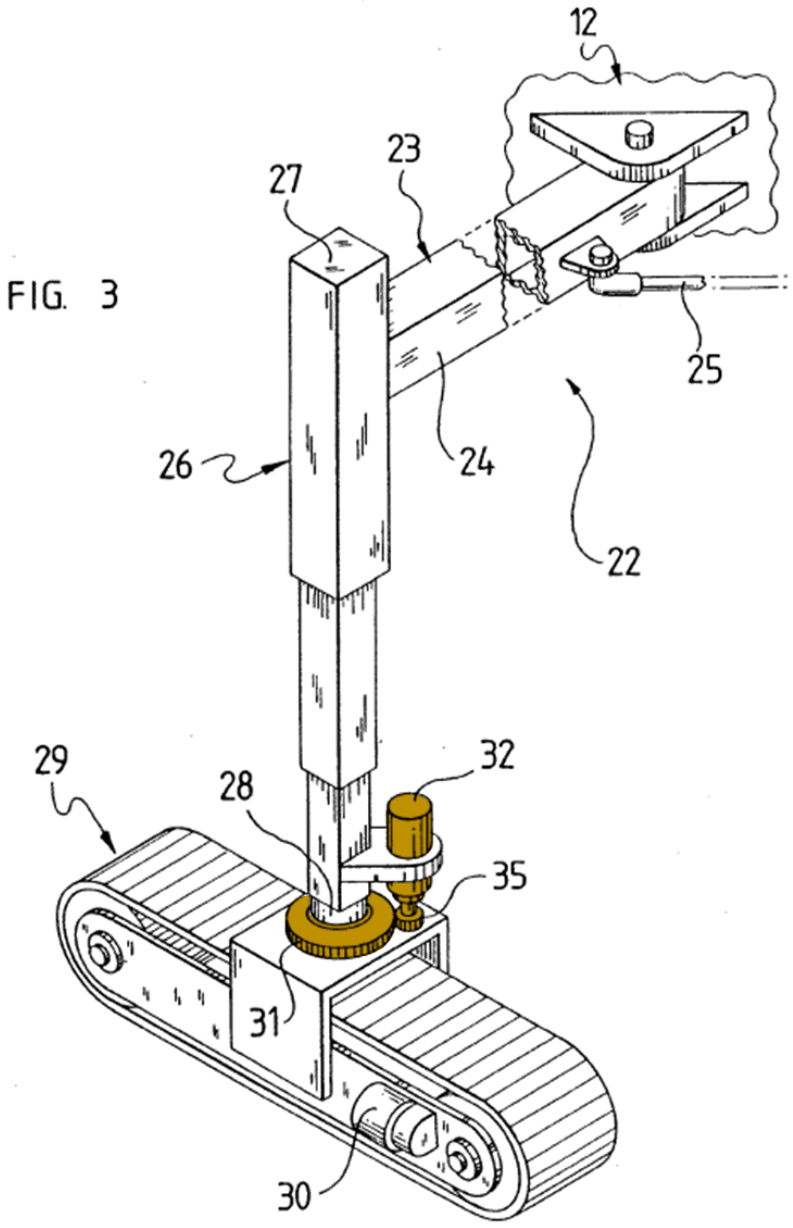
71. As can be seen in the embodiment from Miller depicted below in annotated Figure 20 (among others), Miller discloses that this rotary actuator is positioned between the bottom of each jacking column (adjustable or extendable

support means 60 and 62) and a "bogey-mount 124" (a yoke) associated with each crawler track (tractors 140). Though not pictured in the large-scale view of Figure 20, a POSITA would have understood from Figure 7 that the drive pinion gear 238 and driven gear 232 would again be positioned immediately above the steering spindles (housings) 122, shown highlighted below in gold, as they were in Figure 7 above.



[Ex. 1008 (Miller), Fig. 20 (annotated).]

72. Similarly, Whitaker discloses "a ring gear 31 affixed to the tracked conveyor 29 and rotatively mounted to the lower end" of a jacking column's lower guide tube and rotated "about a vertical axis" via a steering motor 32 and pinion gear 35. [Ex. 1011 (Whitaker), 4:7-16, Fig. 3.] The rotary actuator components comprising the steering motor 32, pinion gear 35, and ring gear 31 are highlighted in gold in Figure 3, below. As can be seen in this figure, Whitaker's ring gear 31 is positioned between the bottom of lower end 28 of the jacking column (fluid operated downwardly extendible telescopic shaft 26 having an upper end 27 mounted to the free end 24 of the arm 23 and a lower end 28) and the yoke associated with the crawler track (collectively, tracked conveyor 29), with the steering motor 32 and pinion gear 35 off to the side. [Ex. 1011 (Whitaker), 3:63-4:16, Fig. 3.]




[Ex. 1011 (Whitaker), Fig. 3 (annotated).]

73. Johns similarly discloses a "slew drive 42" positioned between a wheel bracket 36 and a chassis 22 that supports heavy components such as "an engine" and "boom assembly 70," the slew drive "allow[ing] the wheel bracket 36 to be rotated about a vertical axis through 180 degrees of motion, thus, allowing

steering of the wheel 32." [Ex. 1009 (Johns), ¶¶ [0005], [0019]-[0020], Fig. 2.]

This is depicted in Figure 2 of Johns, below.

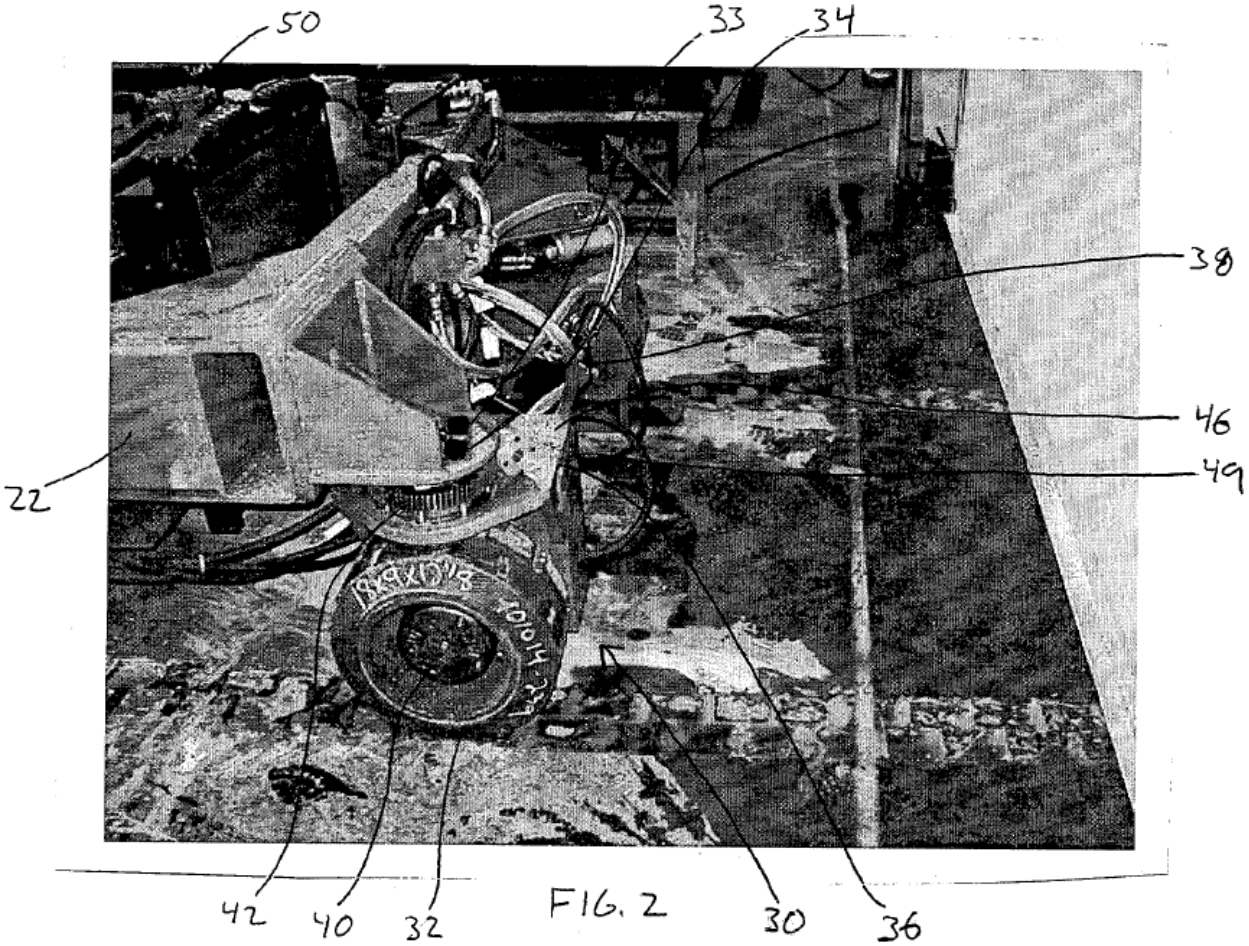



FIG. 2

[Ex. 1009 (Johns), Fig. 2.]

74. Littman likewise discloses another example of a rotary actuator similarly positioned. [Ex. 1007 (Littman), 5:14-59, Figs. 4-5 (disclosing rotary actuator 122 for wheels 90 at bottom of second section 70).]

75. And Swasey similarly discloses a worm-gear rotary actuator that "enables a large load to be placed directly on top of the unit 10 for omnidirectional

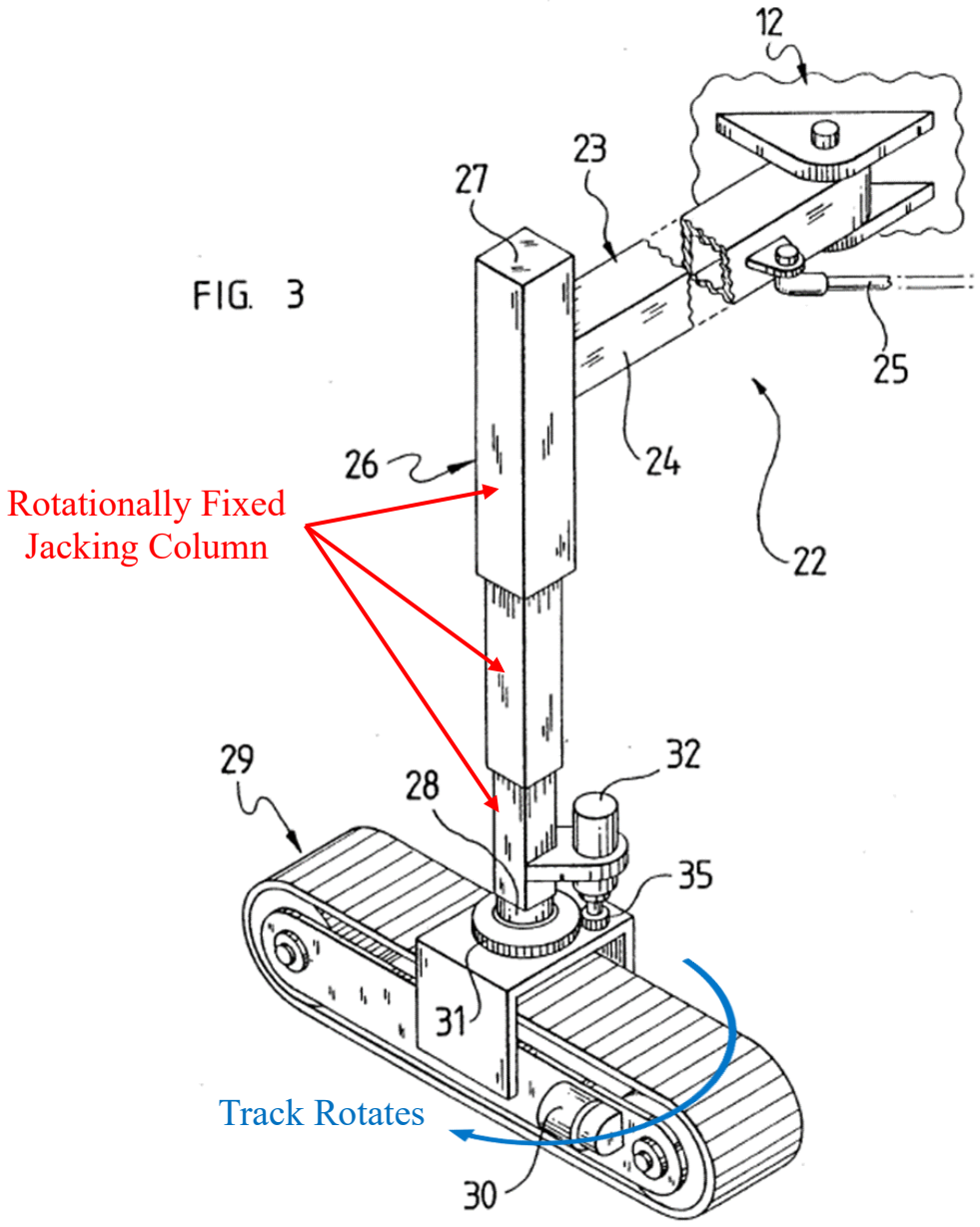
movement of the load without altering the orientation of the load relative to the unit 10," further motivating a POSITA to position the rotary actuator between the jacking column's lower guide tube and the yoke attached to the crawler track. [Ex. 1013 (Swasey), ¶¶ [0041], [0044]-[0045].]

76. A POSITA would have been motivated to mount Rio's rotary actuator with a worm-gear design in this way because it would have simplified CIII's jacking column design, as the guide tubes would no longer need to rotate relative to the outer cylinder. For example, this design would have allowed a POSITA to eliminate the required rotational relationship between the outer cylinder and upper guide tube.

77. To provide for this simpler design, it would have been routine and obvious to combine the outer cylinder and upper guide tube into one unitary component that allows the lower guide tube to telescope vertically, and then connect the rotary actuator to the bottom of the lower guide tube, allowing only the components below the jacking column, including the crawler track and associated yoke, to rotate, meaning fewer components to manufacture and move relative to each other during operation. Accordingly, a POSITA would have seen such a configuration as advantageous.

78. A POSITA would have been aware of such designs, for example, from references like Whitaker, the jacking column of which is depicted above in

Figure 3. [Ex. 1011 (Whitaker), 3:65-4:16, Fig. 3.] The annotated version of Whitaker Fig. 3 below clarifies how the telescoping jacking column remains rotational fixed as the rotary actuator turns the crawler track.




[Ex. 1011 (Whitaker), Fig. 3 (annotated).]

79. As another example, GT-3200 discloses a jacking column where the upper and lower guide tubes are rotationally fixed and a rotary actuator turns the track relative to the entire jacking column. [Ex. 1010 (GT-3200), 3.]

80. As another way to provide for this simpler design, it would have been routine and obvious to fix the upper guide tube to the nonrotatable outer cylinder, meaning each component of the jacking column is fixed rotationally, and then connect the rotary actuator to the bottom of the lower guide tube, allowing only the components below the jacking column, including the crawler tracks, to rotate. For example, a POSITA would have known to use a simple bracket (e.g., at the top or bottom of the outer cylinder). A POSITA would have understood that there were any number of known ways to fix the upper guide tube rotationally to the outer cylinder at the top, bottom, and/or anywhere in the middle of the outer cylinder, including the use of a key and keyway arrangement. [Ex. 1006 (Rio), 5:63-6:7.] Due to the geometry of the guide tubes, fixing the upper guide tube to the outer cylinder would have permitted the lower guide tube to telescope in and out of the upper guide tube but prevent it from rotating relative to the outer cylinder. This is evidenced by (1) the rectangular cross-sections of the upper and lower guide tubes and (2) the fact that one end of the steering cylinder is attached to the upper guide tube so that it can rotate the lower guide tube without preventing the lower guide tube from telescoping. [Ex. 1005 (CIII), 165, 173-175, 193, 195.] Alternatively, a

POSITA would have known to use a key and keyway design between the lower guide tube and the upper guide tube, which would have precluded the lower guide tube from rotating while allowing it to telescope into and out of the outer cylinder. Rio discloses a key and keyway design for this very purpose in its lifting column. [Ex. 1006 (Rio), 5:63-6:2 (explaining that "cylinder 66" and "inner tubular member 58" are "engaged" by "a pair of keys 74 fitted into corresponding longitudinal keyways" and that "[t]his key and keyway arrangement permits linear sliding movement between the inner tubular member 58 and the cylinder 66 while preventing rotational movement between these components").]

81. A design where each component of the jacking column is fixed rotationally would have been desirable, as relative movement between parts can create wear, leading to other problems, including loose connections and "vibration of the machine." [Ex. 1012 (Files), 1:13-17.] This design also would have improved the maintenance of the jacking column by eliminating the relative rotation between the upper guide tube and outer cylinder, and reduced the power needed to rotate the actuator because no portion of the jacking column would need to rotate. In view of these benefits and the existence of similar designs in Miller, Whitaker, Johns, Littman, and GT-3200, a POSITA would have known that positioning the rotary actuator below the bottom of the jacking column and above the crawler track was a simple and obvious design choice.

82. CIII discloses time-consuming manual adjustments for repositioning the swing legs and crawler tracks. In the three-track configuration, CIII discloses supporting the frame, raising the track off the ground, removing a first locking pin and swinging the leg to the desired position, removing a second locking pin and rotating the jacking column and crawler track to the desired position, reinserting the second locking pin, and recalibrating the turn limits of the crawler track. [Ex. 1005 (CIII), 79-80, 193-195.] CIII discloses similar adjustments for the four-track configuration that involve removing or manually adjusting turnbuckles on each of the four swing legs and then manually calibrating the steering cylinders for each of the four crawler tracks, which requires setting the left turn limit, the center, and the right turn limit for each steering cylinder. [Ex. 1005 (CIII), 193-195, 209-211, 253.] A POSITA would have recognized that requiring manual adjustments to heavy machinery like CIII's swing legs risks the safety of operators, as well as damage to the machine and work site. When discussing the three-track configuration, CIII warns of a serious risk that "THE MACHINE MAY TIP OVER TO THE LEFT," if the legs are not positioned correctly when the swing leg is pivoted. [Ex. 1005 (CIII), 80.] A POSITA would have also recognized that these manual adjustments add cost and time to paving operations. Accordingly, a POSITA would have been motivated to eliminate the manual adjustments described above.

83. Rio solves these adjustment problems. Its control system includes controller 32 that receives signals from pivot sensor 83 and rotation sensor 75 and counter-rotates the track so it remains oriented in a particular direction even as actuator 42 pivots the swing leg. [Ex. 1006 (Rio), 6:65-66, 7:11-13, 8:31-59.] Rio discloses steering the tracks both before and after swing-leg movements without the need for manual recalibration of the track position. [Ex. 1006 (Rio), 8:31-9:42.] A POSITA would have been motivated to implement Rio's control system in the CIII machine to automate rotation of the swing leg and the crawler track, eliminating the manual adjustments described in CIII above. CIII already discloses a feedback system like Rio's for steering the slipform paver, where a controller receives signals from a steering sensor and a feedback pot and rotates the tracks to a desired position based on those signals. [Ex. 1005 (CIII), 407-408.] A POSITA would have thus found it obvious to use the feedback system described in Rio to simultaneously control the angles of the swing legs and crawler tracks in the CIII machine.

84. In view of modifying CIII's leg assemblies to include a rotary actuator, a POSITA would have found it obvious to implement Rio's rotation sensor to measure the rotation of the crawler track relative to the jacking column. [Ex. 1006 (Rio), 6:6-11.] This would have been a routine substitution of one known sensor for another—CIII already discloses using a sensor (i.e., CIII's

feedback pot) to measure rotation of the crawler track relative to the outer cylinder of the jacking column. Moreover, Rio discloses that rotation sensor 75 can be "associated with" any "rotating component" driven by rotary actuator 44, which includes the crawler track. [Ex. 1006 (Rio), 6:6-11.] Indeed, it was well known to position a rotation sensor at the bottom of a jacking column and use it to sense rotation of the crawler track. [Ex. 1007 (Littman), 5:34-42, 6:12-26, Figs. 4-6 (disclosing synchro 130 at bottom of second section 70 for sensing angle of wheels 90); Ex. 1008 (Miller), 12:23-46, Fig. 3 (disclosing sensor 506 below extendable support means 62, above tractor 140, and off to the side); Ex. 1009 (Johns), ¶ [0021] (disclosing positional reader 34 attached to steering shaft 33 of wheel 32).]

85. A POSITA would have further known from Rio to implement pivot sensor 83 as a rotary encoder associated with the shaft about which CIII's swing leg pivots. [Ex. 1006 (Rio), 6:22-26; Ex. 1005 (CIII), 79, 85.] The swing leg's pivot sensor and the crawler track's rotation sensor would have allowed CIII's controller to determine the angle of the crawler tracks relative to the frame regardless of the location of the swing leg. [Ex. 1006 (Rio), 8:31-59, 9:15-21; Ex. 1005 (CIII), 407-408.]

86. In view of implementing Rio's control system in CIII, a POSITA would have been motivated to further implement a hydraulic actuator, such as

CIII's swing cylinder or Rio's rotary or linear actuator, allowing an operator to pivot each swing leg about a vertical axis. The use of a hydraulic actuator to pivot each of four swing legs was well known in the art. [Ex. 1011 (Whitaker), 3:56-64, Figs. 1, 3 (disclosing that, for each of four swing legs (arms 23), "a fluid operated piston and rod assembly 25 mounted to said box frame 12 and said arm 23" is used to mechanically pivot the arm 23).] A POSITA would have known that implementing Rio's control system and a hydraulic actuator for pivoting each swing leg would have allowed an operator to automatically orient the associated crawler track in the paving direction or another desired direction without needing to rotate the swing leg and crawler track in separate steps or recalibrate the crawler tracks. [Ex. 1005 (CIII), 34, 79-80, 253-254; Ex. 1006 (Rio), 4:40-44, 4:61-5:7.] It would have been obvious to substitute CIII's locking pin (when using CIII's hinged bracket) and/or CIII's turnbuckles for Rio's automatic anti-swing device 84 to fully automate the rotation of the swing leg "for the convenience of the operator." [Ex. 1006 (Rio), 6:27-37, 8:21-30; Ex. 1005 (CIII), 79-80.] A POSITA would have known that modifying CIII with Rio, as described, would provide manufacturing and operational cost savings, as well as improve the safety of the machine. A POSITA would have known from Rio that implementing Rio's automatic anti-swing device 84 would permit pivotal movement of the swing legs when desired and would lock the swing legs "against unintentional pivotal

movement" relative to the frame when wanting to maintain the same swing-leg orientation. [Ex. 1006 (Rio), 6:27-37.]

87. A POSITA would have had a reasonable expectation of success in combining CIII and Rio as described herein. Implementing Rio's actuators and control system on the CIII machine would have constituted nothing more than a combination of well-known prior-art elements according to known methods to yield predictable results. Rio's actuators and control system already successfully allowed an operator to move a swing leg while orienting the associated crawler track in the travel direction. Additionally, a POSITA would have reasonably expected from Rio's teachings about steering and the use of similar designs known in the prior art that the design may be implemented as described above with a rotary actuator having sufficient torque. And while a POSITA would have reasonably expected that Rio's rotary actuators with a worm-gear design would support the necessary weight when positioned between the jacking column and crawler track, [*see* Ex. 1013 (Swasey), ¶¶ [0041], [0044]-[0045] (disclosing a rotary actuator with a worm-gear design, like Rio, that includes the ability to "drive and steer simultaneously . . . while bearing a very large load and providing a significant amount of torque relative to the overall size of the unit"); Ex. 1009 (Johns), ¶ [0020], Fig. 2; Ex. 1008 (Miller), 7:35-53, Fig. 20; Ex. 1011 (Whitaker), 4:1-16, Figs. 1, 3], a POSITA would have known how to design a housing for the

rotary actuator to help support the weight, if desired. Thus, a POSITA would have recognized that Rio's actuators and control system when implemented on CIII's paver would function in the same manner as they functioned on Rio's machine.

**b. Combining the Modified CIII-Rio Paver and Files**

88. It would have been obvious further in view of Files to incorporate hinged brackets to removably couple each of CIII's four swing legs in its four-track configuration to its module frame. CIII already discloses a hinged bracket in its three-track configuration that removably connects the one swing leg to the frame, but does not explicitly describe using this hinged bracket in its four-track configuration. [Ex. 1005 (CIII), 76, 79-80, 85.] As discussed further in Section VII.A.7.d ([1C]), Files teaches a machine similar to the four-track configuration in CIII, where Files discloses connecting all four of the swing legs to a surface of the frame via a hinged bracket, and a POSITA would have found it obvious to likewise connect each of the swing legs in CIII's four-track configuration to a surface of the modular frame via a hinged bracket.

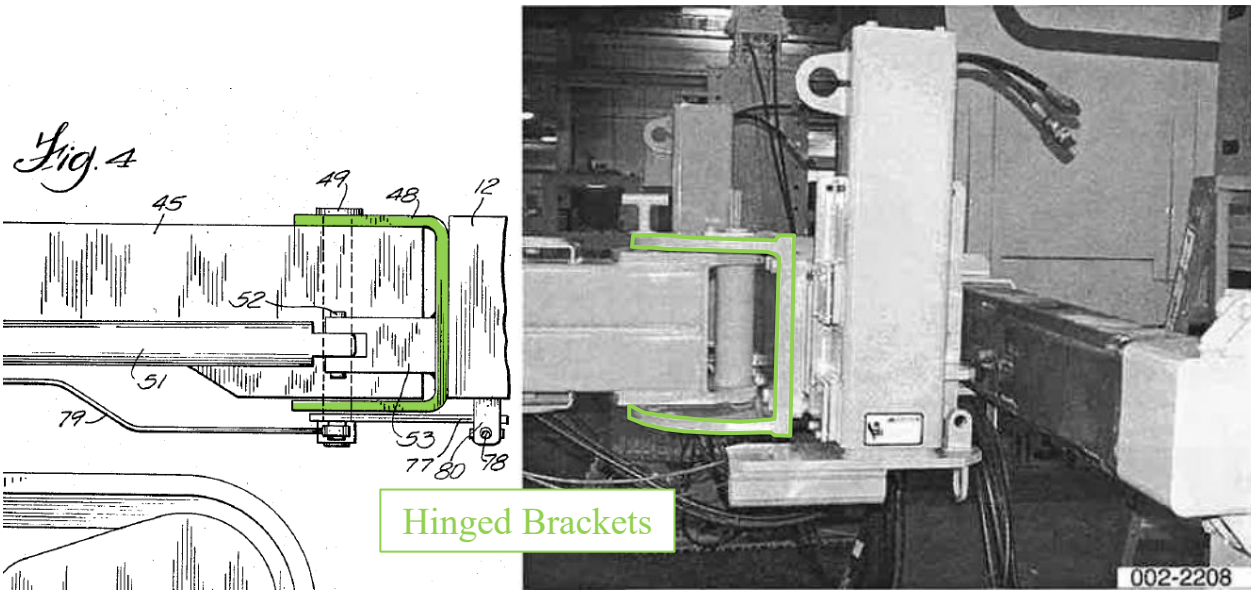
89. A POSITA would have understood from Files that, where a paver has multiple swing legs, such as CIII's four-track configuration, connecting each swing leg to a surface of the paver's frame with a hinged bracket allows each swing-leg assembly to be easily attached/detached and would have been motivated to do so to achieve the benefits of easy attachment/detachment of the swing-leg assemblies. A

POSITA would have recognized that this design permits easy attachment and removal of each swing-leg assembly and that the ability to quickly attach and remove each swing-leg assembly facilitates swing-leg maintenance, allows greater flexibility in paving configurations, and allows faster changes between configurations.

90. For example, CIII discloses a "Minimum Clearance Setup," in which the four-track configuration can be operated "without the left rear leg attached to the machine frame." [Ex. 1005 (CIII), 255.] To setup this configuration, CIII discloses removing "the left rear leg," which includes the jacking column, steering cylinder, and crawler track, "from the machine frame," and then removing "the left rear leg swinging pivot, i.e., the swing leg, "to reduce the weight hanging on the left rear corner of the machine frame." [Ex. 1005 (CIII), 255.] By combining the CIII-Rio paver with Files to implement a hinged bracket between the swing leg and frame for each swing-leg assembly, these separate steps would have been reduced into a single step—detaching the entire swing-leg assembly from the machine frame by detaching the hinged bracket from the frame.

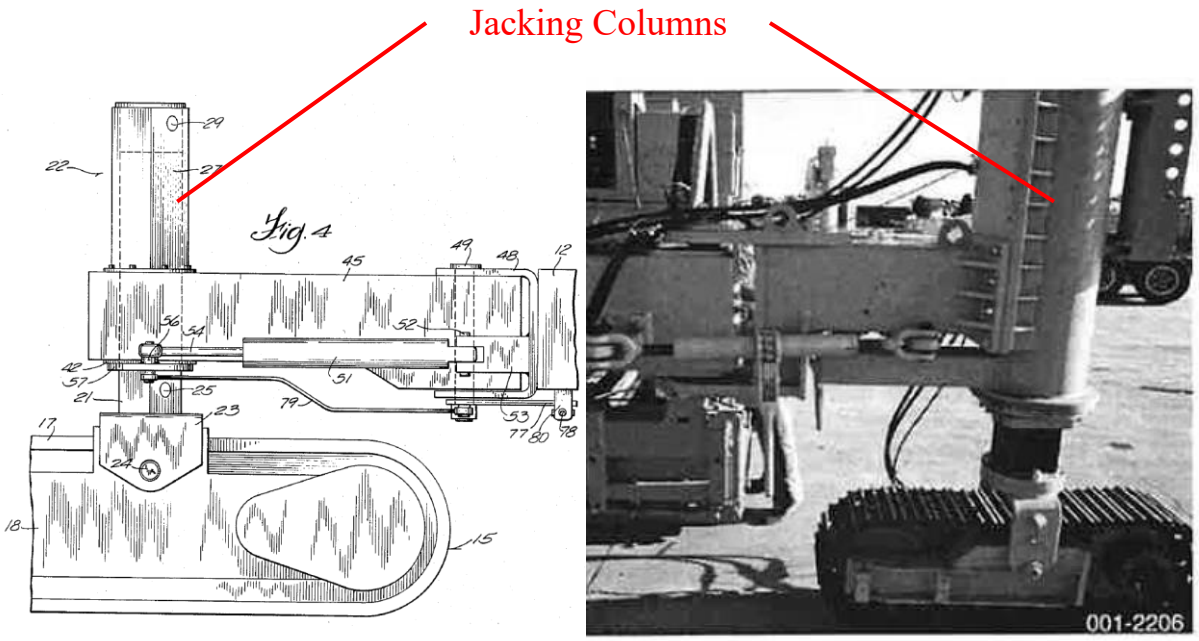
91. A POSITA would have had a reasonable expectation of success in such a modification, as this would have simply been a combination of familiar elements according to known methods to yield predictable results. Indeed, CIII discloses that this hinged bracket works well with the three-track configuration,

and a POSITA would have likewise expected it to work in the four-track configuration, as confirmed by Files' disclosure of a hinged bracket similar to CIII's for attaching each of its four swing legs to the frame. [Ex. 1012 (Files), 2:57-63, Fig. 2.] The similarity of Files' hinged bracket and CIII's is shown in the figures below.




[Ex. 1012 (Files), Fig. 4 (cropped, annotated); Ex. 1005 (CIII), 85 (annotated).]

92. Additionally, CIII and Files disclose similar jacking column designs, shown below, in which two guide tubes are rotationally fixed but can telescope axially relative to each other in response to a hydraulic lift cylinder extending or retracting. [*Infra* Section VII.A.7.h ([1G]).]




[Ex. 1012 (Files), Fig. 4 (annotated, left); Ex. 1005 (CIII), 209 (annotated, right).]

93. As discussed in Section VII.A.7.h ([1G]), Files' hydraulic lift cylinder is vertically oriented, extends along the upright axis, and is operable within the upper and lower guide tubes. To the extent not disclosed in CIII, it would have been obvious in view of Files to similarly design CIII's lift cylinders as vertically oriented, located along the upright axis, and operable within the upper and lower guide tubes.

94. Given the similarity between CIII's and Files' jacking columns, a POSITA would have looked to Files for implementation details on how to arrange CIII's lift cylinders and would have been motivated to arrange them such that they are vertically oriented, located along the upright axis, and operable within the upper and lower guide tubes, like Files. Such a design was typical of jacking

columns at the time and would have been seen as a combination of familiar elements according to known methods to yield predictable results. [*See* Ex. 1006 (Rio), 5:32-53 (disclosing similar design).]

95. To further improve CIII's guide-tube design, it likewise would have been obvious to add a second set of axial bearings axially spaced apart from CIII's bearings "on the bottom of the legs" that align the tubes, limit rotational backlash, and facilitate the relative axial movement in view of Files' disclosures of spaced-apart shim bearings to keep the tubes aligned and limit backlash. I explain why this would have been obvious in Sections VII.A.7.i ([1H]), VII.A.8 ([2]).

**7. Independent Claim 1**

**a. [1pre]: "A paving machine comprising:"**

96. If the preamble is limiting, CIII discloses this feature. The Board found that CIII discloses a substantially similar limitation in claim 17 of the '749 patent. [Ex. 1033, 23:54-57 ("A paving machine . . . comprising"); '749 FWD at 95-96. CIII discloses a "Slipform Paver," which is a paving machine that includes both a three-track configuration and a four-track configuration. [Ex. 1005 (CIII), 4, 42, 194, 240-253.] The paving machine in its four-track configuration is depicted below:



Concrete spread evenly in front of machine

[Ex. 1005 (CIII), 242.]

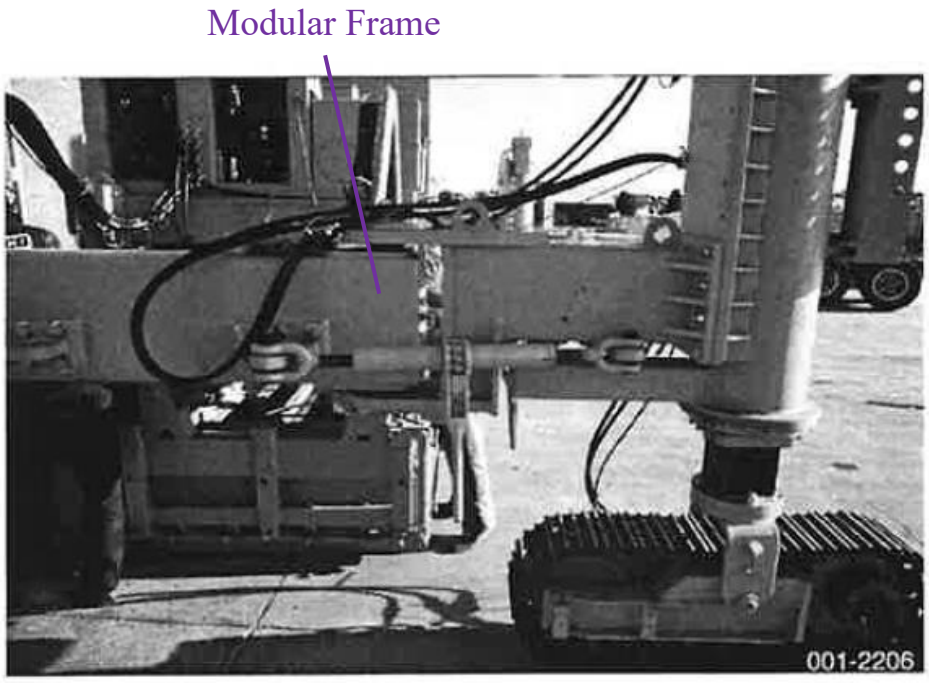
**b. [1A]: "a modular frame;"**

97. CIII discloses this feature. The Board found that CIII discloses a substantially similar limitation in claim 17 of the '749 patent. [Ex. 1033, 24:1 ("a module frame"); '749 FWD at 95-96. CIII discloses a "4-track frame" ("modular frame") for its four-track configuration. [Ex. 1005 (CIII), 202, 253-254, 263.] This frame is modular, for example, because CIII discloses that the width of the frame can be modified via "frame extensions" that may be installed into the frame to "allow the machine frame to clear the width of a form that exceeds 16 ft."

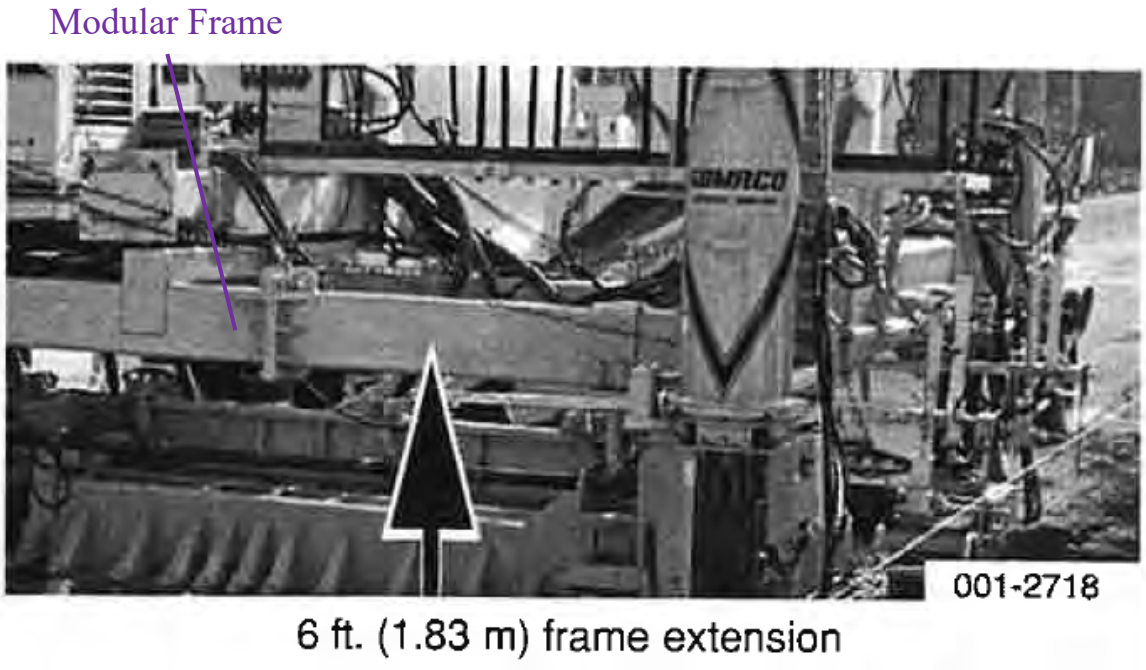
[Ex. 1005 (CIII), 34, 202, 208, 219-220.] The ability to add pieces (or "modules") to the frame to achieve the desired configuration for paving makes it modular. The photographs below from CIII show the modular frame.




[Ex. 1005 (CIII), 253 (annotated).]



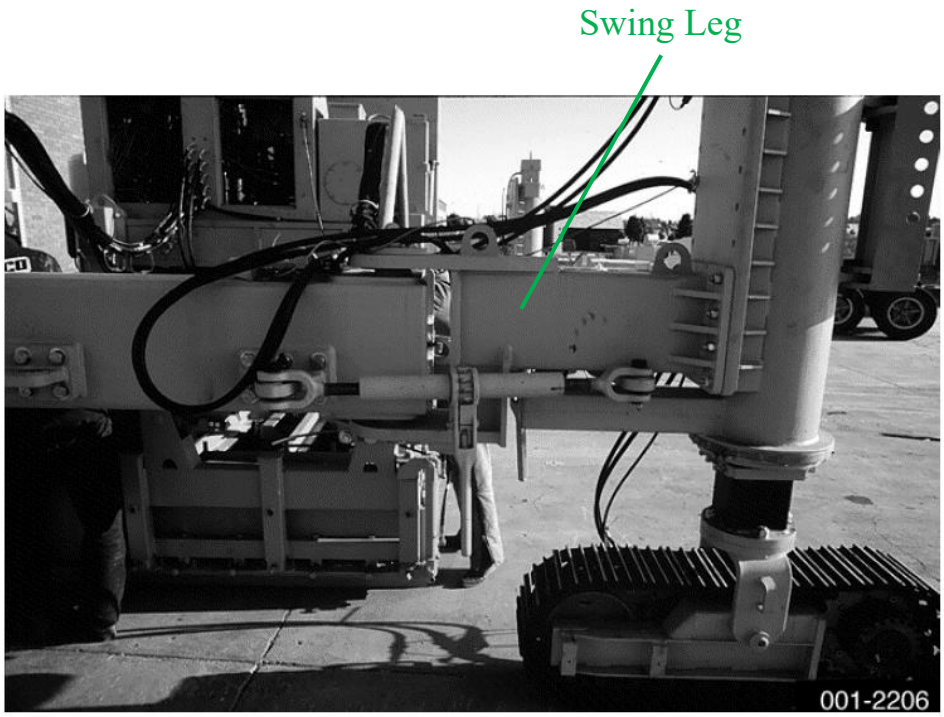

[Ex. 1005 (CIII), 209 (annotated).]



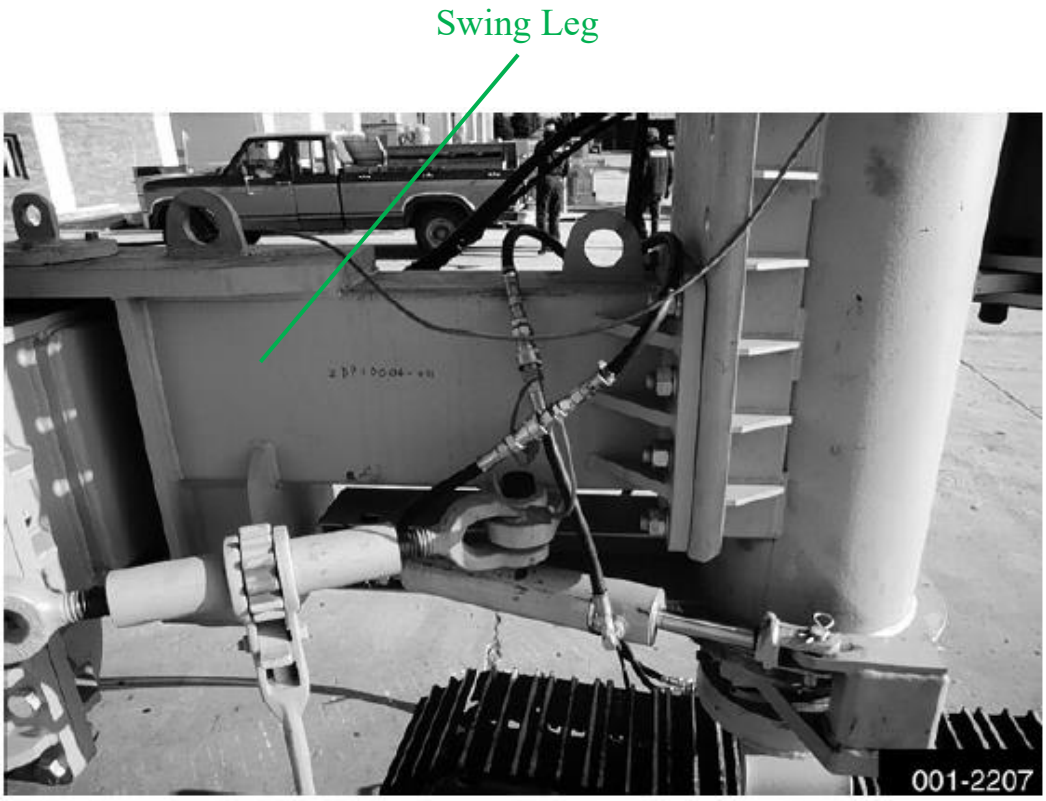

[Ex. 1005 (CIII), 202 (annotated).]

**c. [1B]: "a plurality of swing legs,"**

98. CIII discloses this feature. The Board found that CIII disclosed a substantially similar limitation in claim 17 of the '749 patent. [Ex. 1033, 24:2-4 ("two or more swing leg assemblies, each swing leg assembly comprising: a swing leg"); '749 FWD at 95-96.] CIII discloses four swing legs that are coupled to the paving machine in its four-track configuration, two of which are shown in the images below. [Ex. 1005 (CIII), 204-206, 209, 253-254, 265.] For example, CIII discloses "[s]wing[ing] the swinging legs into position and attach[ing] the turnbuckles on either side of each leg," adjusting the angular orientation of each swing leg "to the left or right of an in-line position with the end frames to bypass obstacles or for narrow clearances" by loosening or tightening the turnbuckles, and adjusting the angular orientation of each swing leg to change from the paving mode to the transport mode by removing the turnbuckles and pivoting each leg "around to the end of the 4-track frame" about its axis. [Ex. 1005 (CIII), 209, 253-254.]




[Ex. 1005 (CIII), 209 (annotated).]

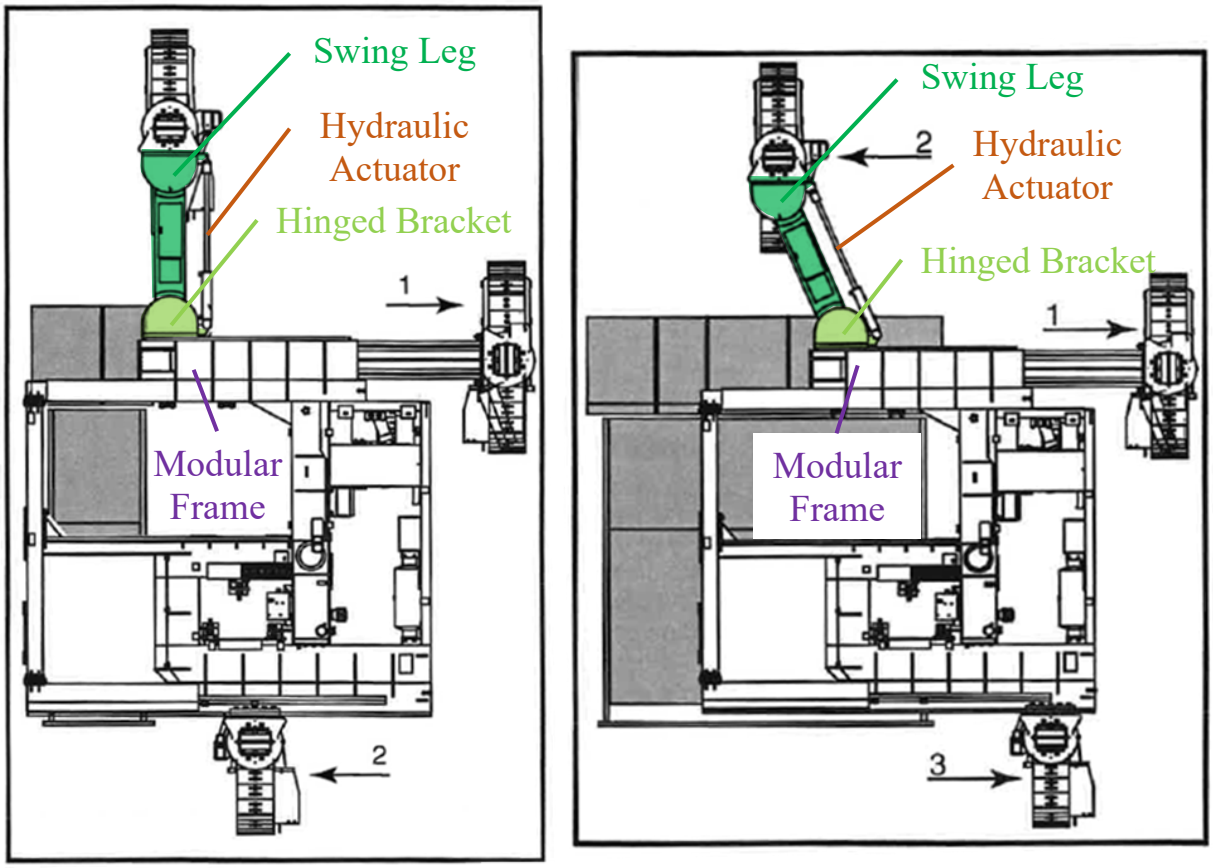


[Ex. 1005 (CIII), 265 (annotated).]

**d. [1C]: "each swing leg coupled to a surface of the modular frame via a hinged bracket and hydraulically actuated to pivot the swing leg about a vertical axis,"**

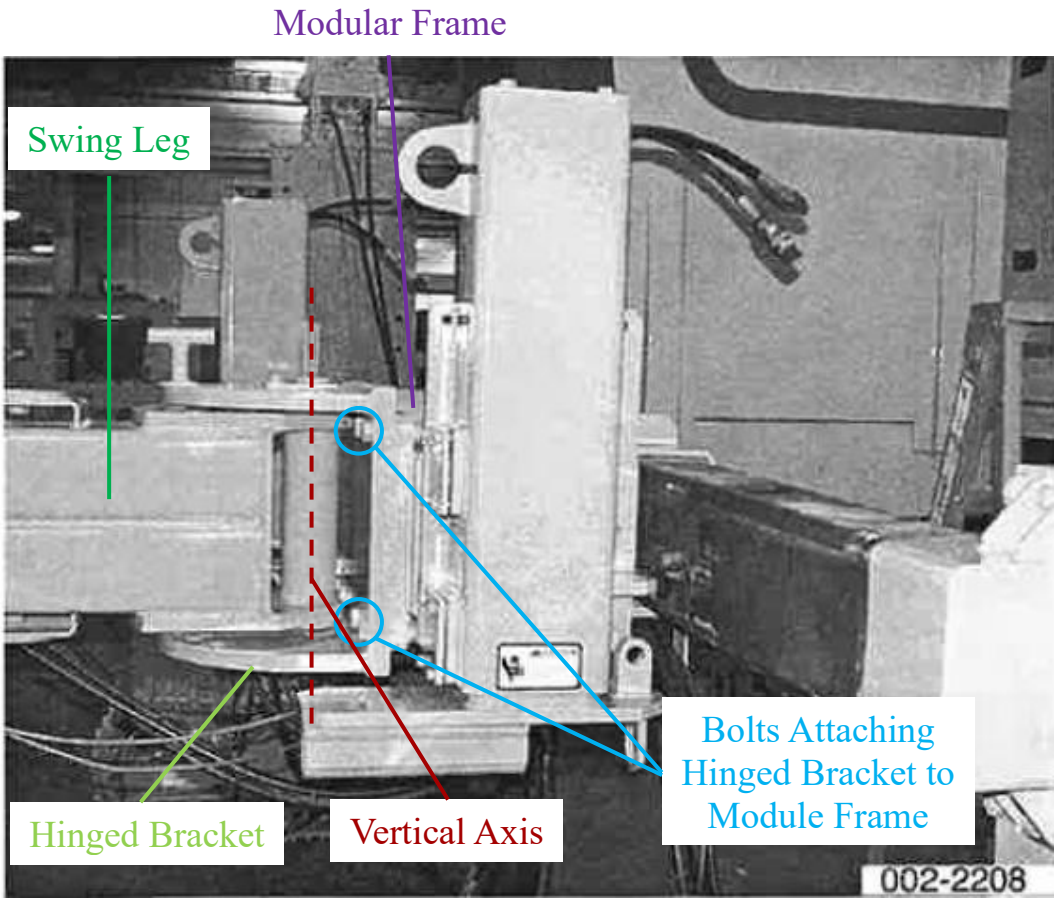
99. CIII alone or in view of Rio and Files renders obvious this feature. The Board found that CIII discloses substantially similar limitations in claims 2-4 of the '749 patent and rendered obvious these same limitations in claim 18 in view of Rio and another reference used for the same purpose as Files here. [Ex. 1033, 23:2-14, 24:36-47 (both, "a hinge bracket arranged to be interposed between the swing leg and the surface of the module frame"; "wherein the hinge bracket . . . permits pivotal movements of the swing leg . . . about a second upright axis"; "a hydraulic actuator . . . permitting the swing leg to pivot relative to the module frame"); '749 FWD at 96-97, 105-106.]

100. As depicted in the overhead views below, in its three-track configuration, CIII discloses a swing leg coupled to a surface of the modular frame via a hinged bracket and hydraulically actuated to pivot the swing leg about a vertical axis. [Ex. 1005 (CIII), 76, 79-80, 85.]




[Ex. 1005 (CIII), 76 (annotated).]

101. For example, CIII discloses pivoting the swing leg about a vertical axis of the hinged bracket attached to the frame by removing the locking pin from the hinged bracket and "mov[ing] the swing control switch to extend the swing cylinder." [Ex. 1005 (CIII), 80.] As depicted below, this vertical axis runs through a pivot pin of the hinged bracket. [Ex. 1005 (CIII), 85, 175.]



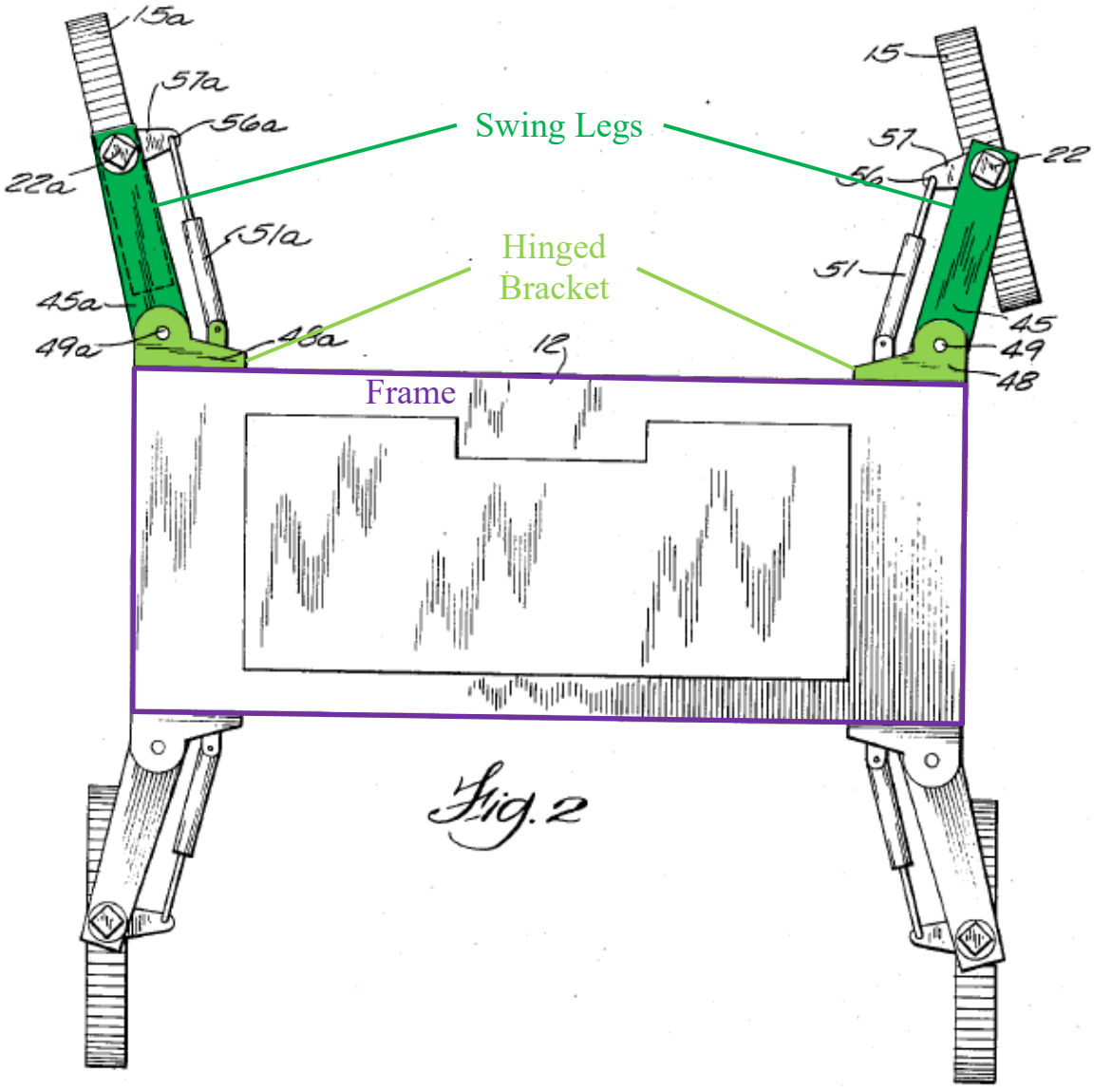

[Ex. 1005 (CIII), 85 (annotated).]

102. A POSITA would have recognized that this hinged bracket provides an easy-to-assemble/disassemble bracket that can be attached/removed from the frame, allowing for removal of the entire swing-leg assembly. [Ex. 1005 (CIII), 204.] A POSITA would have been motivated to use this hinged bracket to attach each swing leg to a surface of the modular frame in the four-track configuration. [*Supra* Section VII.A.7.c ([1B])]. A POSITA would have recognized that this design permits easy attachment and removal of each swing-leg assembly and that the ability to quickly attach and remove each swing-leg assembly facilitates swing-

leg maintenance, allows greater flexibility in paving configurations, and allows faster changes between configurations.

103. Moreover, a POSITA would have been motivated to modify CIII in this way because it would have reduced manufacturing costs. For example, CIII discloses a swing leg in its three-track configuration that, when the machine is changed to its four-track configuration, is not used. [Ex. 1005 (CIII), 204 ("Set the left front leg pivot off to the side of the work area as it will not be used.").] By incorporating CIII's hinged bracket into the modified swing-leg assemblies of the four-track configuration, it would have allowed one of the four-track swing legs to be used in both configurations, thereby reducing the need to manufacture separate swing legs for each configuration.

104. Additionally, a design with a hinged bracket removably attaching each of the four swing legs to the frame is further obvious in view of Files. As shown below, Files discloses four swing legs, each of which "fits between the upper and lower plates of the bracket 48 and is secured thereto by the vertical pin 49 which allows the projecting end of the leg to pivot laterally for the lateral positioning of the traction unit." [Ex. 1012 (Files), 2:57-61.] The bracket 48 is a "hinged bracket" that is "removably secure[d]" to the frame. [Ex. 1012 (Files), 2:61-63.]




[Ex. 1012 (Files), Fig. 2 (annotated).]

105. A POSITA would have been motivated to combine the modified CIII-Rio paver with Files to include a hinged bracket coupling each swing leg to the modular frame, and would have had a reasonable expectation of success in doing

so, for the reasons explained in Section VII.A.6.b (Combining the Modified CIII-Rio Paver and Files).

106. Moreover, it would have been obvious to use CIII's hydraulic swing cylinder or Rio's hydraulic actuator 42 to pivot the swing legs instead of the turnbuckles in CIII's four-track configuration. [Ex. 1005 (CIII), 76, 79-80, 209; Ex. 1006 (Rio), Figs. 3-4, Claims 1, 12, 4:38-44, 4:61-5:7.] In its four-track configuration, CIII discloses turnbuckles that, to pivot the swing leg, must be either manually loosened/tightened or removed entirely. [Ex. 1005 (CIII), 209, 253.] CIII also discloses a need to pivot the swing legs "left or right of an in-line position with the end frames to bypass obstacles or for narrow clearances." [Ex. 1005 (CIII), 209.]

107. A POSITA would have been motivated to replace these turnbuckles with a hydraulic actuator, as disclosed in CIII's three-track configuration and in Rio, to facilitate the pivoting of the swing leg, improving usability and the speed of changing swing-leg positions. [*Supra* Section VII.A.6.a (Combining CIII and Rio).] Doing so would have replaced the time-consuming manual adjustments to a turnbuckle with the quicker, less labor-intensive press of a button. [Ex. 1005 (CIII), 79-80.] Moreover, the use of a hydraulic actuator to pivot each of four swing legs was well known in the art. [Ex. 1011 (Whitaker), 3:56-64, Figs. 1, 3 (disclosing that, for each of four swing legs (arms 23), "a fluid operated piston and

rod assembly 25 mounted to said box frame 12 and said arm 23" is used to mechanically pivot the arm 23).] A POSITA would have understood that mounting the hydraulic actuator to the hinged bracket and the swing leg would have allowed the swing legs to be more easily attached and removed because removing the hinged bracket from the frame of the paving machine would detach essentially the entire swing-leg assembly (except for any electrical/hydraulic lines between the swing-leg assembly and the frame), thereby improving the speed with which the paving machine can change configurations.

108. Rio further discloses an "anti-swing device 84" that "locks the swing arm 76 against unintentional pivotal movement." [Ex. 1006 (Rio), 6:27-37.] A POSITA would have recognized that replacing the turnbuckles on CIII's swing legs with hydraulic actuators and replacing CIII's locking pins in its hinged brackets with actuated locking pins, which would have automated the locking/unlocking of the swing legs, would have improved CIII's swing legs. [Ex. 1005 (CIII), 76, 79-80, 209; Ex. 1006 (Rio), Figs. 3-4, Claims 1, 12, 4:61-5:7; *supra* Section VII.A.6.a (Combining CIII and Rio).] Hydraulic actuators such as CIII's swing cylinder or Rio's hydraulic actuator 42 would have allowed automatic pivoting without needing to manually adjust turnbuckles, and an actuated locked pin like Rio's anti-swing device 84 would have allowed automated swing-leg locking. [Ex. 1005 (CIII), 76, 79-80, 209; Ex. 1006 (Rio), Figs. 3-4, Claims 1, 12,

4:61-5:7; *supra* Section VII.A.6.a (Combining CIII and Rio).] Such a modification would have been a combination of familiar elements according to known methods to yield predictable results, as CIII's hinged bracket is already designed to accommodate a hydraulic actuator that pivots the swing leg.

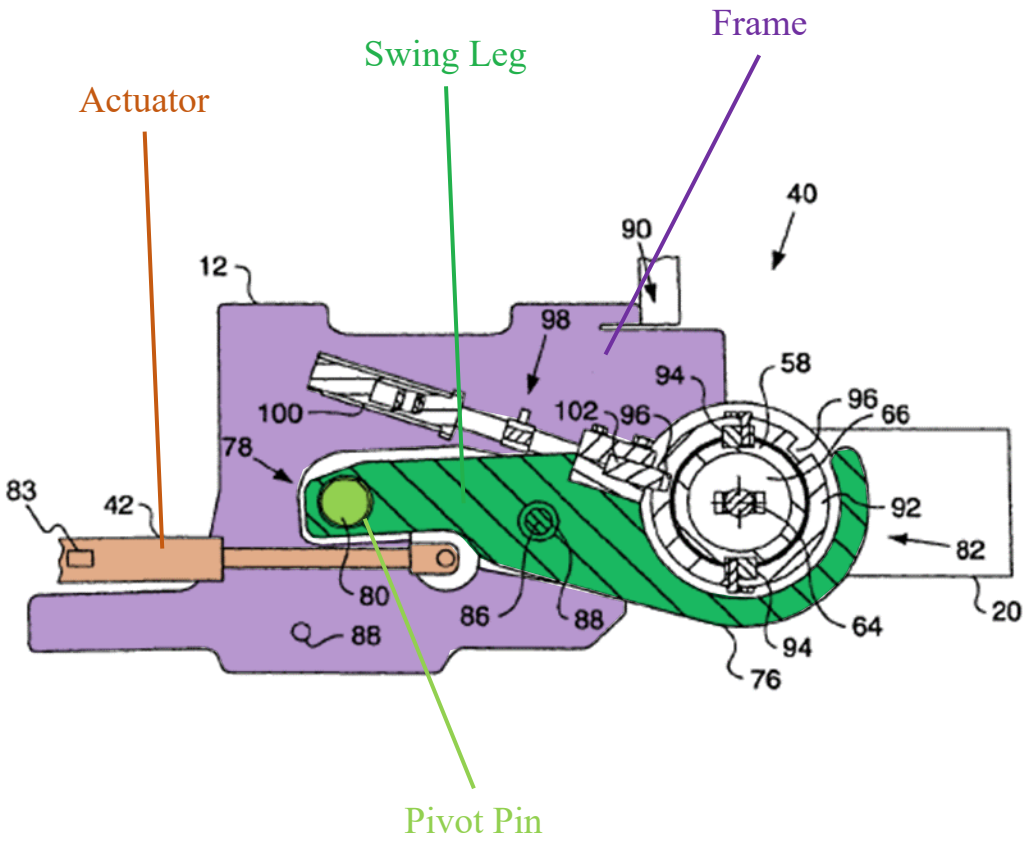
**e. [1D]: "wherein a first angular position transducer is disposed on the modular frame or the swing leg to measure an angular position between the swing leg and the modular frame and further emit a first signal indicative of the measured angular position to an onboard computer or processor;"**

109. CIII and Rio render obvious this feature. The Board previously found that CIII and Rio render obvious a feature of the '749 patent that is substantially similar except for the "disposed on" portion of this feature. [Ex. 1033, 24:17-21 ("a second angular position transducer between the swing leg and the module frame, configured to emit a second signal which is indicative of an angular orientation of the swing leg relative to the module frame"), 24:26-27 ("a processor operable to receive the first and second signals"); '749 FWD at 65-68, 95-96.] Although numbered differently, both the "second angular position transducer" in the '749 patent and the "first angular position transducer" here emit a signal indicative of the angular orientation of the swing leg relative to the frame.

110. Rio discloses a pivot sensor 83 ("first angular position transducer") that measures the angular position between the swing arm 76 ("swing leg") and the

machine frame 12 ("to measure an angular position between the swing leg and the modular frame"). [Ex. 1006 (Rio), 6:22-26, 7:19-23, 8:32-34.] That sensor emits a pivot position signal 122 ("further emit a first signal") "indicating the instantaneous angular position of the swing arm 76 relative to the machine frame 12" ("indicative of the measured angular position" "between the swing leg and the modular frame") to controller 32 ("to an onboard computer or processor"). [Ex. 1006 (Rio), 6:22-26, 7:19-23, 8:32-34.]

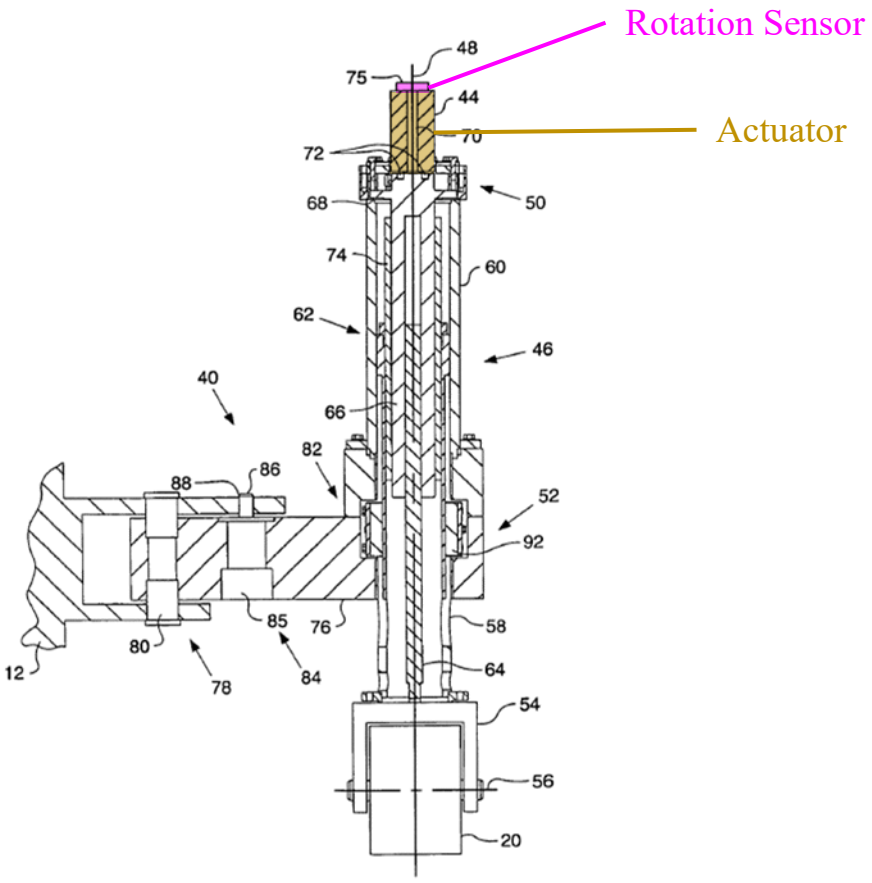
111. While annotated Figure 3 below depicts an embodiment in which pivot sensor 83 is "associated with the first actuator 42," Rio discloses another embodiment (not pictured) in which pivot sensor 83 is a "rotary encoder associated with the pivot pin 80." [Ex. 1006 (Rio), 6:22-26.]




[Ex. 1006 (Rio), Fig. 3 (annotated).]

112. Rotary encoders measure the amount of rotation of one component relative to another by converting angular motion about the pivot point into a signal. For example, Figure 2 of Rio, below, depicts rotation sensor 75 as a rotary encoder "associated with the second actuator 44." [Ex. 1006 (Rio), 6:6-11, Fig. 2.] This rotation sensor 75 is disposed on second actuator 44 and measures the rotation of actuator's rotor 70 relative to its housing. [Ex. 1006 (Rio), 5:54-56 ("[T]he housing of the second actuator 44 is connected, for example by bolts, to the top of the outer tubular member 60."), 5:56-61 (stating that rotation of "rotor 70 of the second

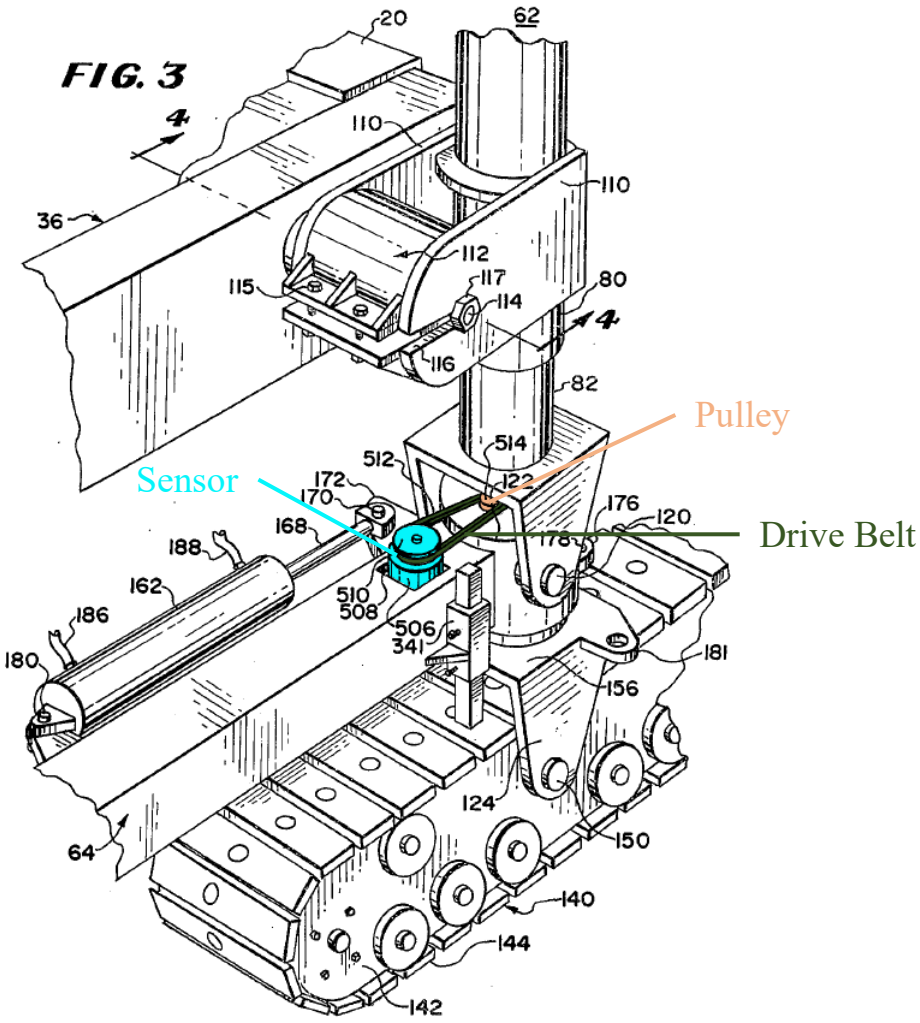
actuator 44" "causes the cylinder 66 to rotate as the cylinder flange 68 slides on the outer tubular member 60"), 6:6-11, Fig. 2.]




[Ex. 1006 (Rio), Fig. 2 (annotated).]

113. A POSITA would also have been familiar with other ways to associate a rotary encoder with a pivot point. Miller provides an example, depicted below, where the sensor 506 is disposed on a walking beam 64 next to the pivot point and is "connected by means of the drive belt 512 to the pulley 514 that rotates with bogey-mount 124 thereunder." [Ex. 1008 (Miller), 12:23-46.] "When any one track turns, the pulley 514 is rotated in relation to the walking beam which

moves the belt 512 and turns the sensor wheel 510 off the null point." [Ex. 1008 (Miller), 12:40-43.]

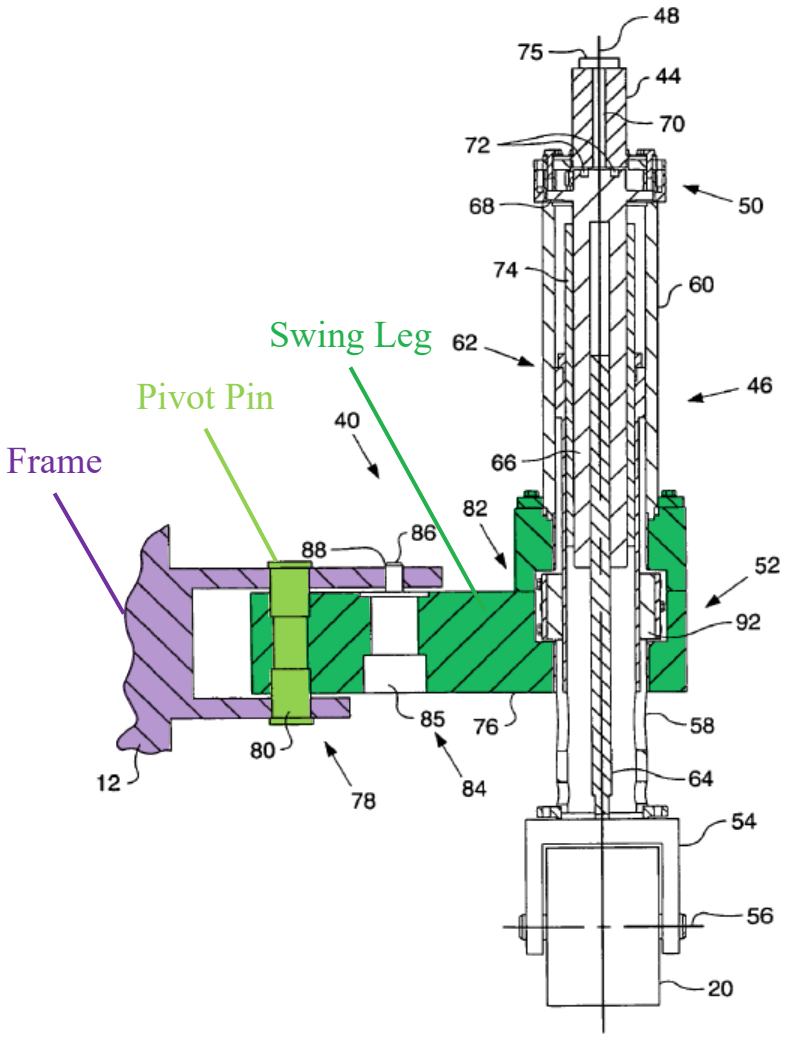



[Ex. 1008 (Miller), Fig. 3 (annotated).]

114. Rio discloses that pivot pin 80 pivotally connects the swing leg (swing arm 76) to the frame (machine frame 12) and that the swing leg pivots "about the pivot pin 80." [Ex. 1006 (Rio), 6:12-22.] Accordingly, for Rio's pivot sensor 83 that is "associated with the pivot pin 80," [Ex. 1006 (Rio), 6:19-26], a POSITA

would have known to dispose pivot sensor 83 on the frame, the pivot pin, and/or the swing leg to measure the relative rotation about the pivot pin. Figure 2, below, depicts the relationship between the frame, the pivot pin, and the swing leg.

Fig. 2.




[Ex. 1006, Fig. 2 (annotated).]

115. If the pivot pin is designed to rotate with the swing arm, a POSITA would have known to dispose Rio's pivot sensor 83 on its frame and measure the relative angular movement about the pivot pin. [Ex. 1006 (Rio), 6:19-26.] If instead the pivot pin is designed to be rotationally fixed to the frame and allow the swing arm to rotate around it, a POSITA would have known to dispose Rio's pivot sensor 83 on its swing arm and measure the relative angular movement about the pivot pin. [Ex. 1006 (Rio), 6:19-26.]

116. For the reasons explained in Section VII.A.6.a (Combining CIII and Rio), it would have been obvious to implement Rio's pivot sensor 83 such that it is disposed on CIII's modular frame or swing leg to measure an angular position between the swing leg and the modular frame and emit a first signal indicative of the measured angular position to an onboard computer or processor. For example, as explained in Section VII.A.7.d ([1C]), each swing leg is configured to pivot about a vertical axis of a pivot pin within the hinged bracket, similar to Rio's swing arm rotating about pivot pin 80. [Ex. 1005 (CIII), 85, 175; Ex. 1006 (Rio), 6:12-15.] In view of Rio's disclosure that the pivot sensor 83 can be "a rotary encoder associated with the pivot pin 80" and a POSITA's understanding of rotary encoders and how to position them to measure relative rotation, a POSITA would have found it obvious to dispose a rotary encoder on CIII's modular frame or swing leg to measure the relative angular rotation about the axis of the pivot pin of

the hinged bracket. [Ex. 1006 (Rio), 6:22-26; *supra* Section VII.A.6.a (Combining CIII and Rio).]

117. Such a configuration would have been a routine way to implement Rio's rotary encoder, as a POSITA would have understood that the rotary encoder would need to be connected to both a reference point and a pivot point to measure the angular position of the swing leg relative to the modular frame. [Ex. 1008 (Miller), 12:23-46, Fig. 3.] For example, if the pivot pin pivots with the swing leg, it would have been obvious to dispose the rotary encoder on the modular frame and measure the angular position of the pivot pin, and therefore, the swing leg, relative to the modular frame. The modular frame would have been close to the pivot pin and one of a finite number of convenient options to use as a reference point, so a POSITA would have found such a configuration obvious, or at least obvious to try.

118. If, instead, the pivot pin was rotationally fixed to the modular frame, it would have been obvious to dispose the rotary encoder on the swing leg and measure the angular position of the pivot pin, thereby measuring the angular position of the swing leg relative to the modular frame. In this design, the swing leg would have been the nearest reference point to measure relative movement, and therefore, would have been a convenient and obvious design choice.

119. Additionally, if Patent Owner incorrectly contends that disposing a first angular position transducer on the "pivot shaft" of the '723 patent's "hinge

bracket" discloses disposing a first angular position transducer on either the swing leg or the modular frame, [Ex. 1001 ('723 patent), 7:42-46; *infra* Section VII.C (Claims 1-7 Lack Written-Description Support)], it would have similarly been obvious to dispose the rotary encoder on the pivot pin of the hinged bracket in the modified CIII-Rio paver for the same reasons explained above. As I explained above, disposing Rio's pivot sensor 83 on the pivot pin was one known way to implement Rio's disclosure that Rio's pivot sensor 83 is "associated with the pivot pin 80," in addition to disposing it on the frame or swing leg. [Ex. 1006 (Rio), 6:19-26].

120. Such design choices would have been well within the knowledge of a POSITA. And given the finite number of options and a POSITA's knowledge that the rotary encoder would need to be connected to both a fixed portion and a rotating portion, such design choices at least would have been obvious to try.

121. Additionally, it would have been obvious to combine CIII and Rio such that the control system includes a processor configured to receive the signal from the pivot sensor. [*Supra* Section VII.A.6.a (Combining CIII and Rio).] In particular, CIII discloses a controller that receives a steer signal and a signal corresponding to the position of each crawler track. [Ex. 1005 (CIII), 407-408.] Based on a comparison of these signals, CIII's controller generates and emits a corrective signal that causes the crawler track to rotate until the crawler-track

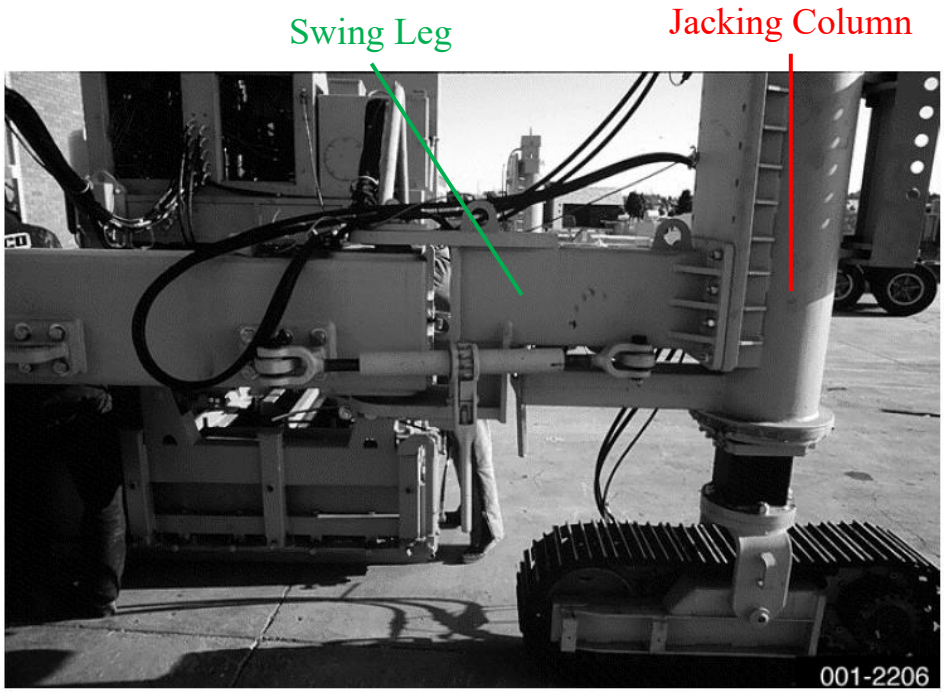
signal matches the steer signal. [Ex. 1005 (CIII), 407-408.] However, before this can occur, CIII discloses that each crawler track must be manually aligned to the frame of the paver via time-consuming measurements to calibrate CIII's steering system. [Ex. 1005 (CIII), 193-194; *Supra* Section VII.A.6.a (Combining CIII and Rio).]

122. Rio discloses a control system that eliminates the need for this alignment procedure after pivoting a swing leg. [Ex. 1006 (Rio), 8:31-9:14.] Rio's control system includes a controller 32, such as "a programmed computer logic unit and associated memory," that receives signals from the sensors and coordinates movements of the swing leg and crawler track via signals to the actuators. [Ex. 1006 (Rio), 4:16-20, 4:47-50, 6:56-7:42, Fig. 5.] Rio's controller discloses a processor configured to receive signals from the pivot sensor 83. As explained in Section VII.A.6.a (Combining CIII and Rio), it would have been obvious to implement Rio's actuators and control system in CIII to improve CIII.

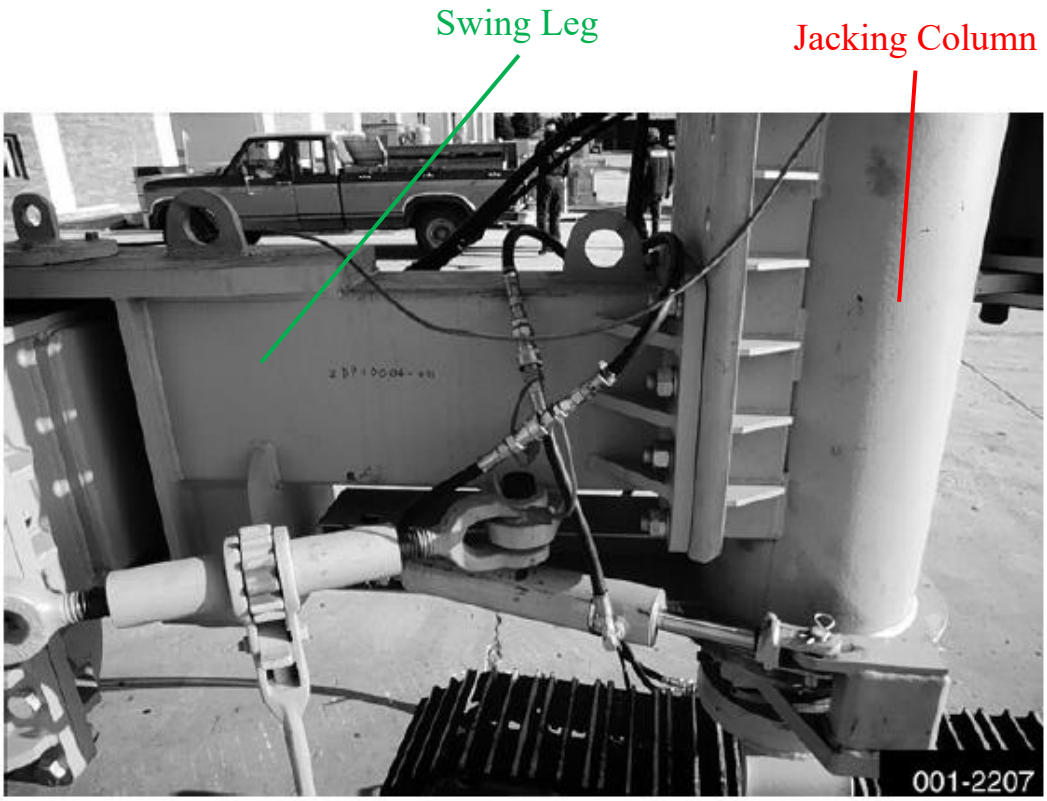
**f. [1E]: "a jacking column secured to each swing leg, the jacking column comprising:"**

123. CIII discloses this feature. The Board previously found that CIII discloses a similar limitation of the '749 patent. [Ex. 1033, 24:7 ("an upright jacking column secured to the swing leg"); '749 FWD at 64-65, 95-96.] CIII discloses a jacking column that can raise/lower the crawler track or the machine

frame. [Ex. 1005 (CIII), 38-39, 44, 74, 79.] CIII discloses that the same jacking columns are used in both the three-track and four-track configurations, with the jacking columns secured to the swing legs in the four-track configuration, as shown in the images below. [Ex. 1005 (CIII), 204-206, 209, 265.]



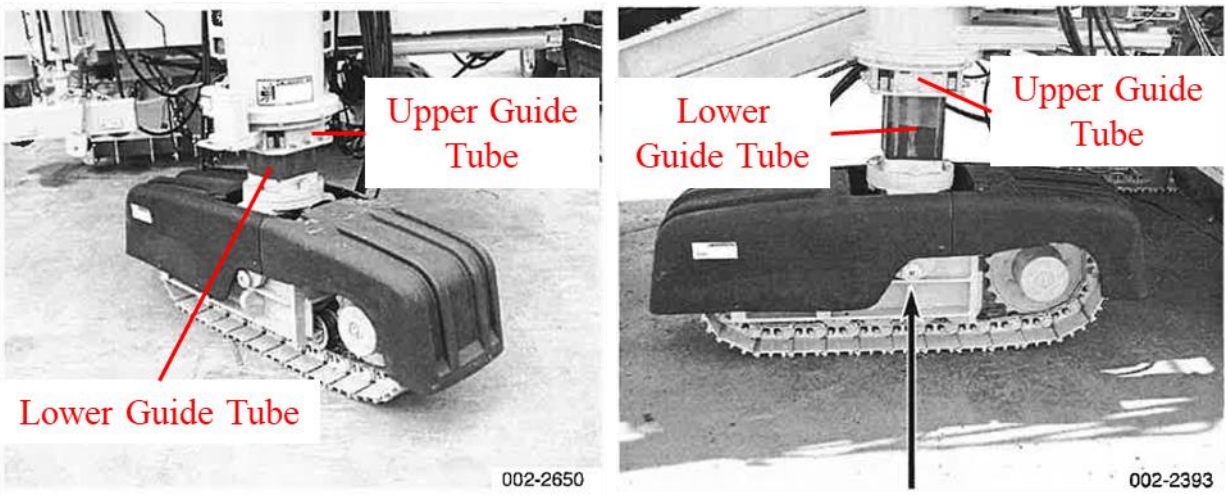

[Ex. 1005 (CIII), 209 (annotated).]




[Ex. 1005 (CIII), 265 (annotated).]

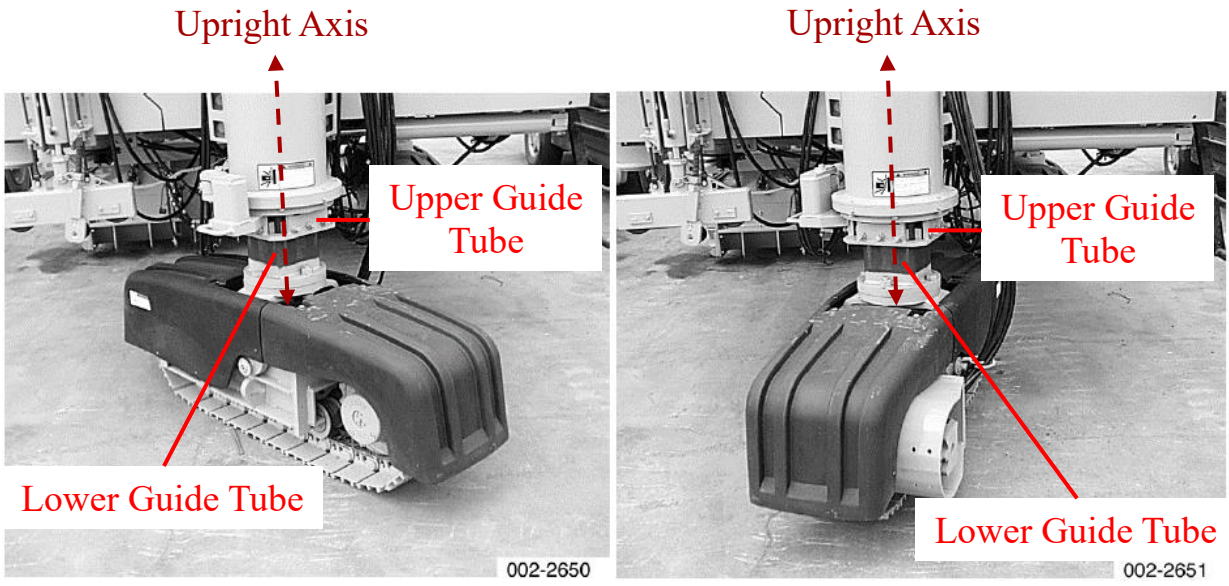
**g. [1F]: "telescoping outer and inner tubes with an upright axis,"**

124. CIII discloses this feature. As depicted in the annotated images below, the jacking columns each include a lower guide tube ("inner tubes") that telescopes in and out of the upper guide tube ("outer tubes"). [Ex. 1005 (CIII), 79, 173; *supra* Section VII.A.1 (Summary of CIII).]




[Ex. 1005 (CIII), 193, 175 (showing lower guide tube telescoped at different heights).]

125. These guide tubes have an upright axis, about which they rotate, as shown in the images below depicting the rotation of the track and guide tubes.

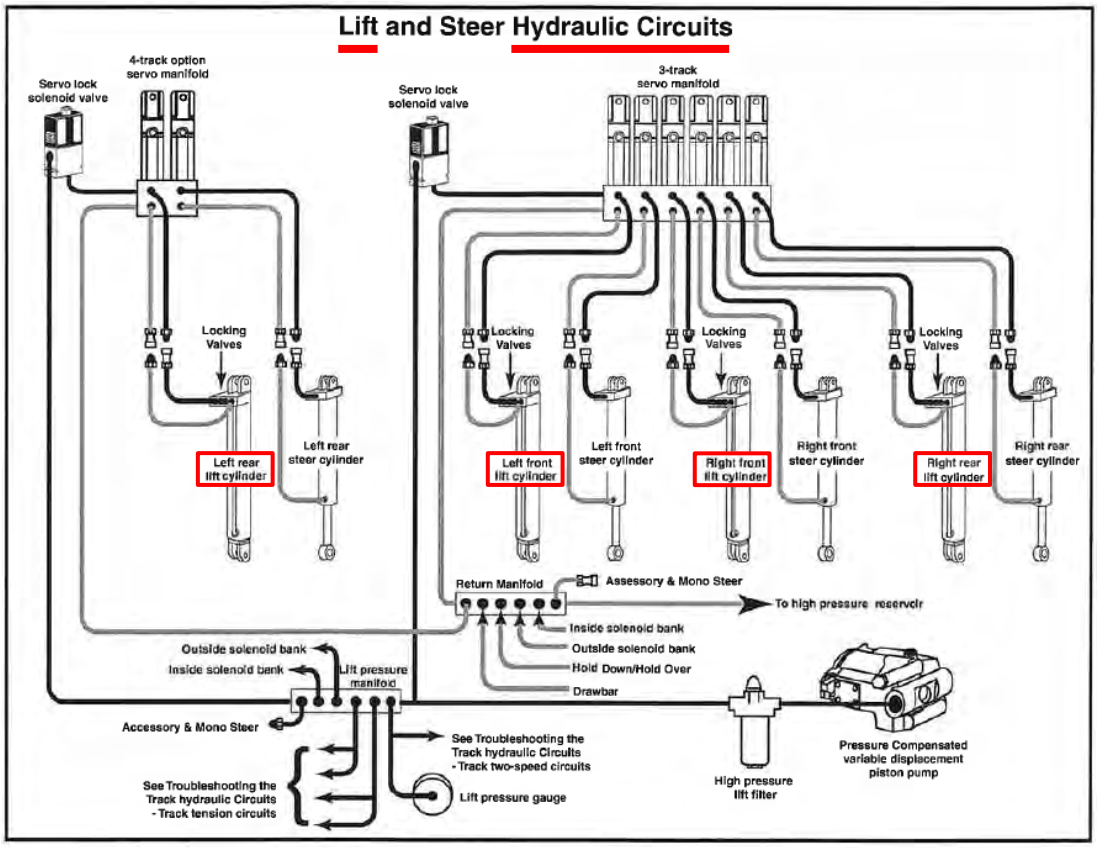



[Ex. 1005 (CIII), 193, 195 (annotated).]

**h. [1G]: "a vertically oriented hydraulic actuator located along the upright axis, the hydraulic actuator comprising a cylinder and a piston operable within the outer and inner tubes, and"**

126. CIII alone or in view of Files renders obvious this feature. CIII discloses that each jacking column includes a hydraulic "grade cylinder," also called a "lift cylinder," which is a hydraulic actuator, that is vertically oriented to extend and retract the lower guide tube relative to the upper guide tube. [Ex. 1005 (CIII), 73-75, 129, 204-206, 373-374.] By vertically extending and retracting the lower guide tube relative to the upper guide tube, a POSITA would have understood that each hydraulic actuator is vertically oriented and located along the upright axis and operable within the outer and inner tubes of each respective jacking column.

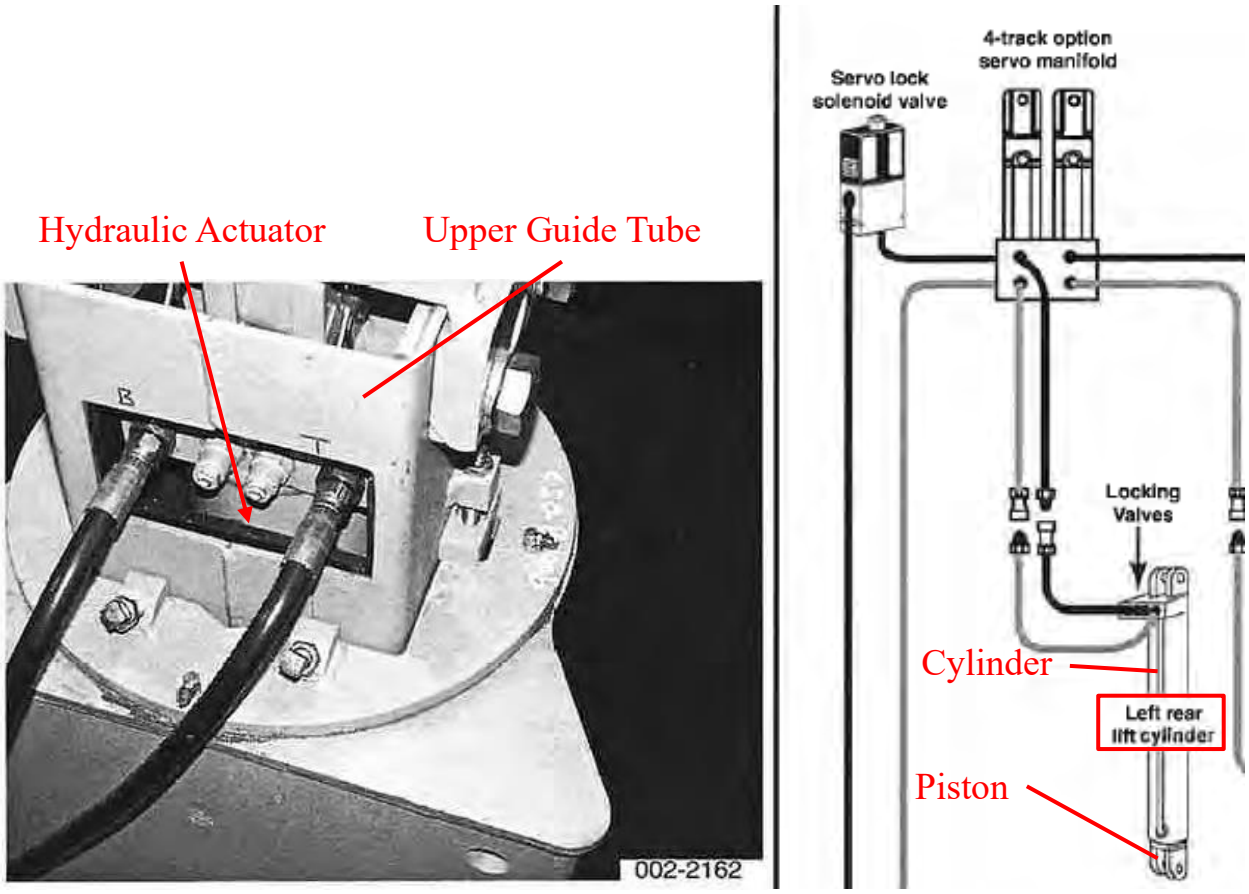
127. This grade cylinder includes an "[i]nternal cylinder piston" within the upper and lower guide tubes, which a POSITA would have understood discloses a cylinder and a piston operable within the upper and lower guide tubes. [Ex. 1005 (CIII), 264-265, 373-374, 378-379.] For example, CIII discloses that hydraulic oil flows into either "the piston (top) end of the cylinder" or into "the rod (bottom) end of the cylinder," causing it to begin to extend or retract, respectively. [Ex. 1005 (CIII), 374.] CIII discloses the hydraulic circuits for the four lift cylinders in the image below.




[Ex. 1005 (CIII), 373 (annotated).]

128. In this hydraulic circuit diagram, a cropped and zoomed version of which is reproduced below and right, the two hoses depicted at the top of each lift cylinder that permit flow of oil to either the piston end or the rod end of the cylinder correspond to the two hoses entering the upper guide tube in the image below and left. [Ex. 1005 (CIII), 373-375.] The orientation of these hoses in the images below, their depiction as connecting to the hydraulic actuator within the upper guide tube, and CIII's description of the lift cylinders moving the lower guide tube vertically relative to the upper guide tube confirm to a POSITA that the

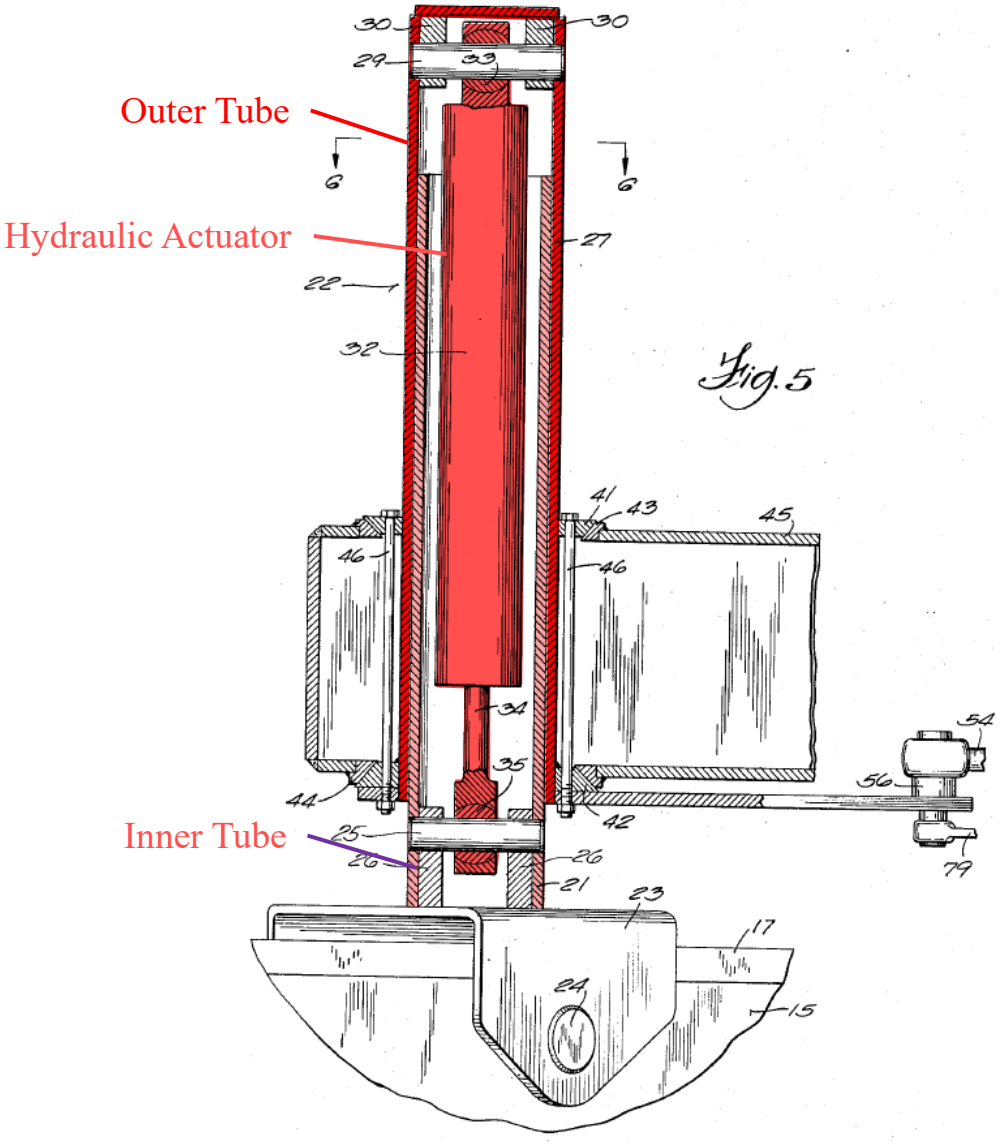
lift cylinder is vertically oriented, located along the upright axis, and operable within the upper and lower guide tube.




[Ex. 1005 (CIII), 379, 373 (cropped and zoomed).]

129. To the extent CIII does not disclose this feature, it would have been obvious in view of Files. Like CIII, Files discloses a jacking column comprising an "inner tube 21" that telescopes relative to "outer tube 27." [Ex. 1012 (Files), 2:21-35.] This inner tube is "vertically slidable but rotationally fixed with respect to the outer tube," like the telescoping tubes in CIII. [Ex. 1012 (Files), 5:63-64.] Files discloses that a hydraulic actuator comprising hydraulic cylinder 32 and piston rod

34 is connected to the top of the outer tube via cross-pin 29 and to the bottom of the inner tube via cross-pin 25, as shown below, "whereby operation of cylinder 32 either lifts or lowers outer tube 27 in sliding relation on tube 21." [Ex. 1012 (Files), 2:26-35, Fig. 5.] A POSITA would have understood that piston rod 34, depicted in annotated Figure 5 below, discloses the piston portion of the hydraulic actuator.




[Ex. 1012 (Files), Fig. 5 (annotated).]

130. Given the similarity between CIII's and Files' jacking columns, a POSITA would have looked to Files for implementation details on how to arrange CIII's lift cylinders and would have been motivated to arrange them such that they are vertically oriented, located along the upright axis, and operable within the upper and lower guide tubes, like Files. Such a design was typical of jacking columns at the time and would have been seen as a combination of familiar elements according to known methods to yield predictable results. [*See* Ex. 1006 (Rio), 5:32-53 (disclosing similar design).]

**i. [1H]: "spaced apart axial bearings coupled to the outer tube and/or the inner tube; and"**

131. CIII discloses or, in view of Files, renders obvious this feature. CIII discloses wear pads, elsewhere referred to as "wear bars" or "wear plates,"[6] "on the bottom of the outer guide tube on each leg." [Ex. 1005 (CIII), 194, 173-174, 376, 378.] These wear pads are axial bearings, as they facilitate axial sliding movement between the outer and inner tubes. [*E.g.*, Ex. 1005 (CIII), 173-175, 378; *supra* Section VII.A.7.g ([1F]).] This type of bearing was well known in the art. [U.S.

[6] Unless I am quoting from CIII, I use the term "wear pad" throughout, as this is the more conventional term for this type of bearing used frequently in telescoping components.

Patent Publication No. 2006/0042131 ("Pinther"; Ex. 1014), ¶¶ [0030]-[0031] (describing similar wear pads "disposed between and in contact with both the inner and outer members" and "acting as contact bearings between the members that allow one member to easily move relative to the other"); U.S. Patent Publication No. 2003/0152454 ("Albright"; Ex. 1020) ¶¶ [0003], [0008], [0009], [0029], [0066] (describing wear pads as "sliding bearings" or "linear bearings").]

132. It was well understood that several different types of bearings exist. One of the simplest bearing designs is a "plain bearing," which "is formed by any two materials rubbing on one another, whether a sleeve around a shaft or a flat surface under a slider." [Norton, Robert L, "Machine Design: An Integrated Approach" (3d ed. 2006) ("Machine Design"; Ex. 1018), 577.] One type of plain bearing is called a "guide" bearing. [Oberg, Erik et al., "Machinery's Handbook" (25th ed. 1996), 2104 ("Machinery's Handbook"; Ex. 1019).] Guide bearings are sometimes also referred to as contact bearings or slipper bearings. Guide bearings "guide moving parts in a straight line" and are "generally used as a positioning device or as a guide to linear motion such as in machine tools." [Ex. 1019 (Machinery's Handbook), 2104, 2149.] These types of bearings do not require any type of rolling component like roller bearings. Rather:

> The relative motions between the parts of plain bearings may take place: (1) As pure sliding without the benefit of a liquid or gaseous

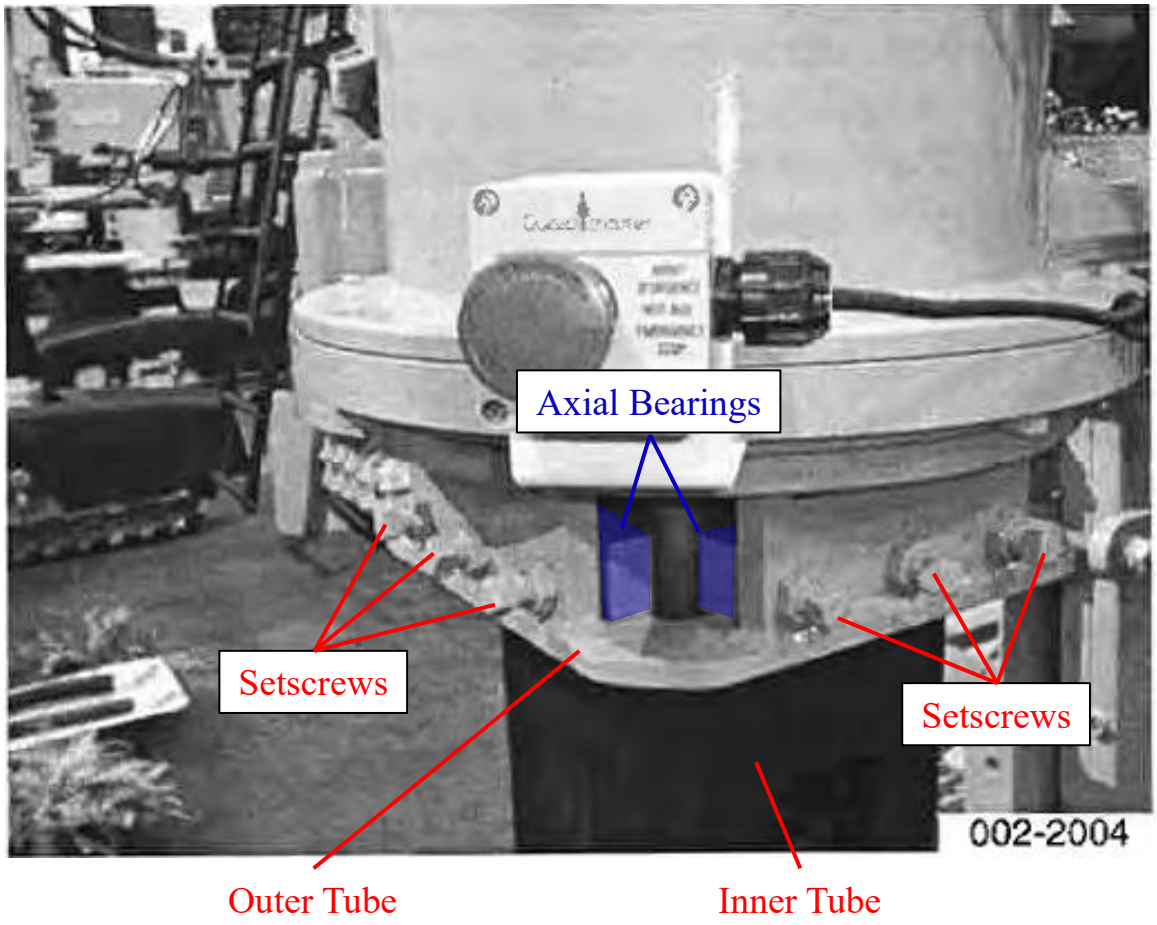
> lubricating medium between the moving surfaces such as with the dry operation of nylon or Teflon; (2) with hydrodynamic lubrication in which a wedge or film buildup of lubricating medium is produced, with either whole or partial separation of the bearing surfaces; (3) with hydrostatic lubrication in which a lubricating medium is introduced under pressure between the mating surfaces causing a force opposite to the applied load and a lifting or separation of these surfaces; and (4) with a hybrid form or combination of hydrodynamic and hydrostatic lubrication.

[Ex. 1019 (Machinery's Handbook), 2104.]

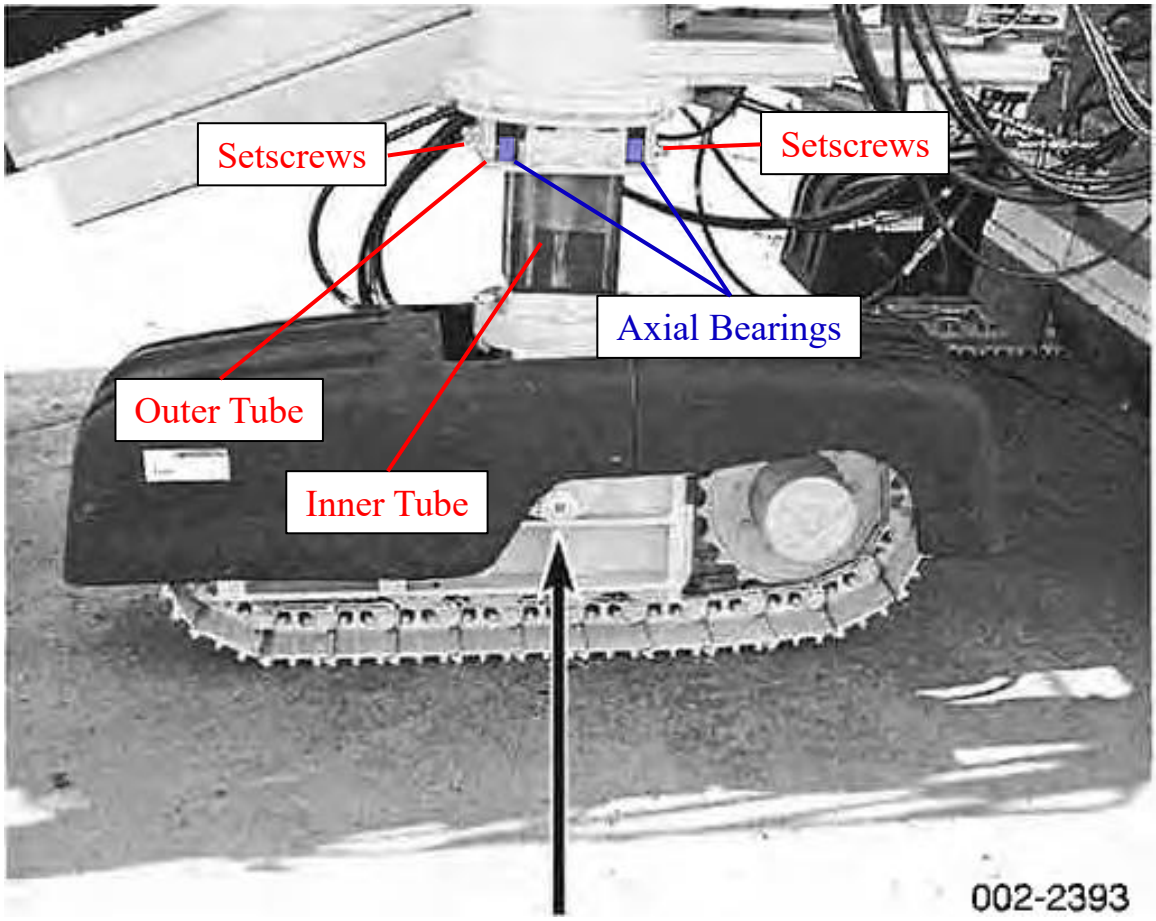
133. A POSITA would have known that CIII's wear pads are a type of guide bearing and were commonly used for telescoping mechanisms like CIII's guide tubes. [*See* Ex. 1014 (Pinther).] Plain bearings like CIII's wear pads had advantages over complex bearings, like roller bearings, for this type of application because their flat surfaces spread the load out over a greater surface area, making bearing failure less likely. Additionally, debris entering the space between the guide tubes would have less of an impact on bearings like wear pads than bearings that relied on rolling surfaces. Paving machines like CIII's were designed to operate in environments with high amounts of debris in the air, making wear pads the better choice over roller bearings. While roller bearings in ideal conditions generally have a lower coefficient of friction than guide bearings, the coefficient of

friction of a bearing is less important than its durability for jacking columns, which typically move slowly and relatively infrequently.

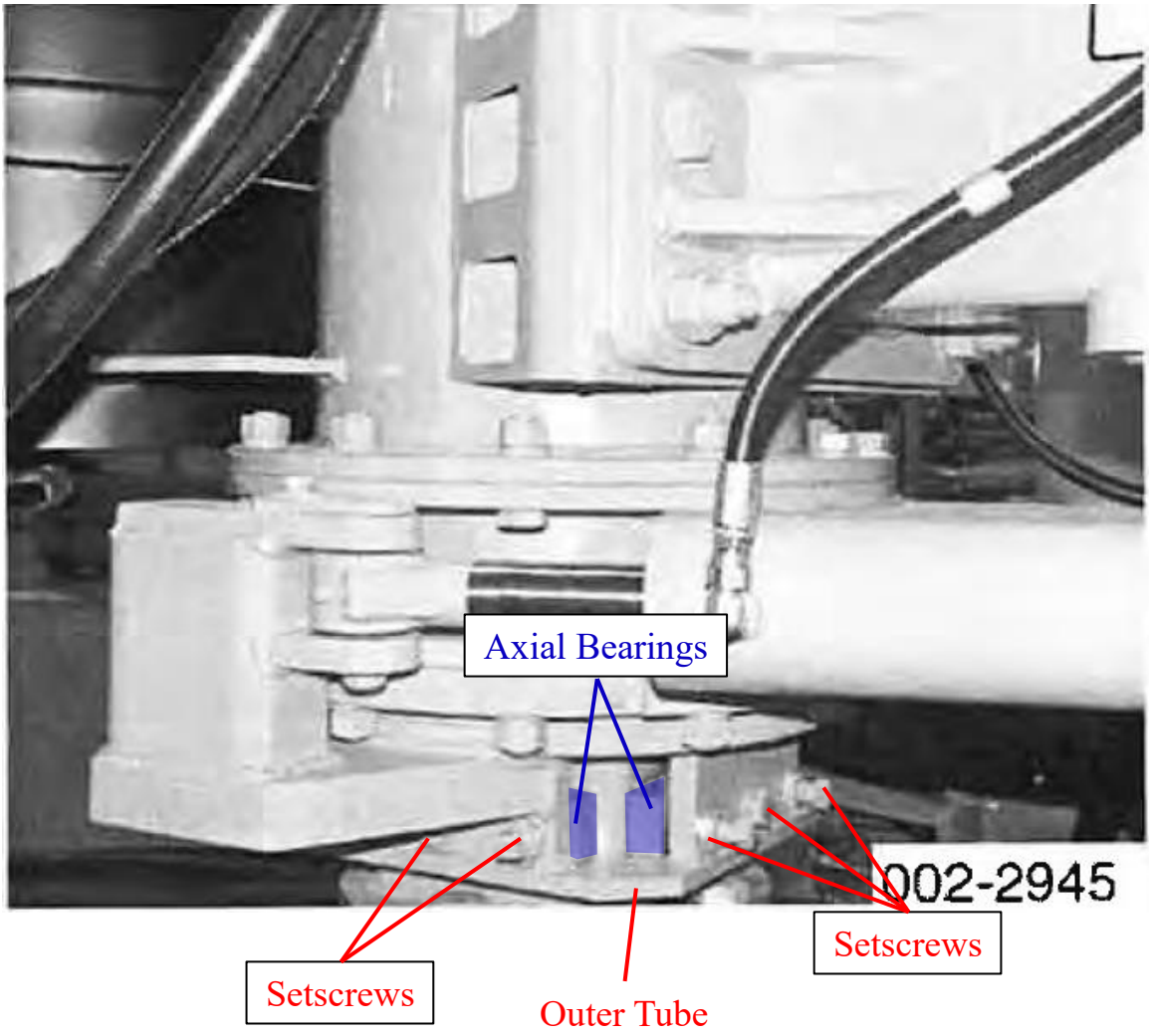
134. CIII's wear pads also serve to limit backlash, as CIII discloses making "certain the setscrews are snug against the wear bar on the bottom of the outer guide tube on each leg to eliminate any looseness between the inner and outer guide tubes." [Ex. 1005 (CIII), 194, 174, 378.] If too much "cylinder stroke is required to begin turning the track in either direction," CIII discloses adjusting "the wear pad tension." [Ex. 1005 (CIII), 378.] The tight clearances achieved by making the wear pads snug against the guide tube are what the '723 patent says minimizes backlash. [Ex. 1001 ('723 patent), 11:34-37.] As depicted in the images below and described in CIII, these axial bearings in CIII are spaced apart radially around the guide tubes, with one on each of the four sides of the tubes. Also pictured are the setscrews on the lower power of the outer tube that are tightened to eliminate any looseness between the inner and outer tubes. [Ex. 1005 (CIII), 194, 174, 378.]




[Ex. 1005 (CIII), 353 (annotated).]



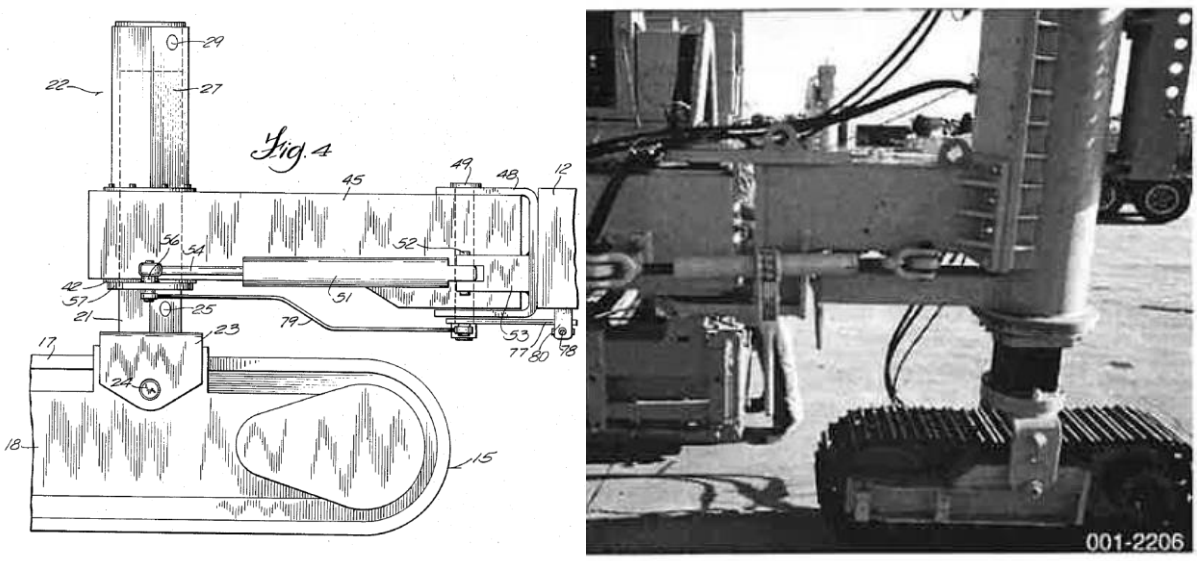

[Ex. 1005 (CIII), 175 (annotated).]




[Ex. 1005 (CIII), 205 (annotated).]

135. From the three setscrews shown extending across each side of the outer tube in CIII as well as the various images showing visible ends of the wear pads regardless of whether shown from the left or the right, a POSITA would have understood that each of the wear pads extends across the setscrews on each side of the outer tube in CIII.

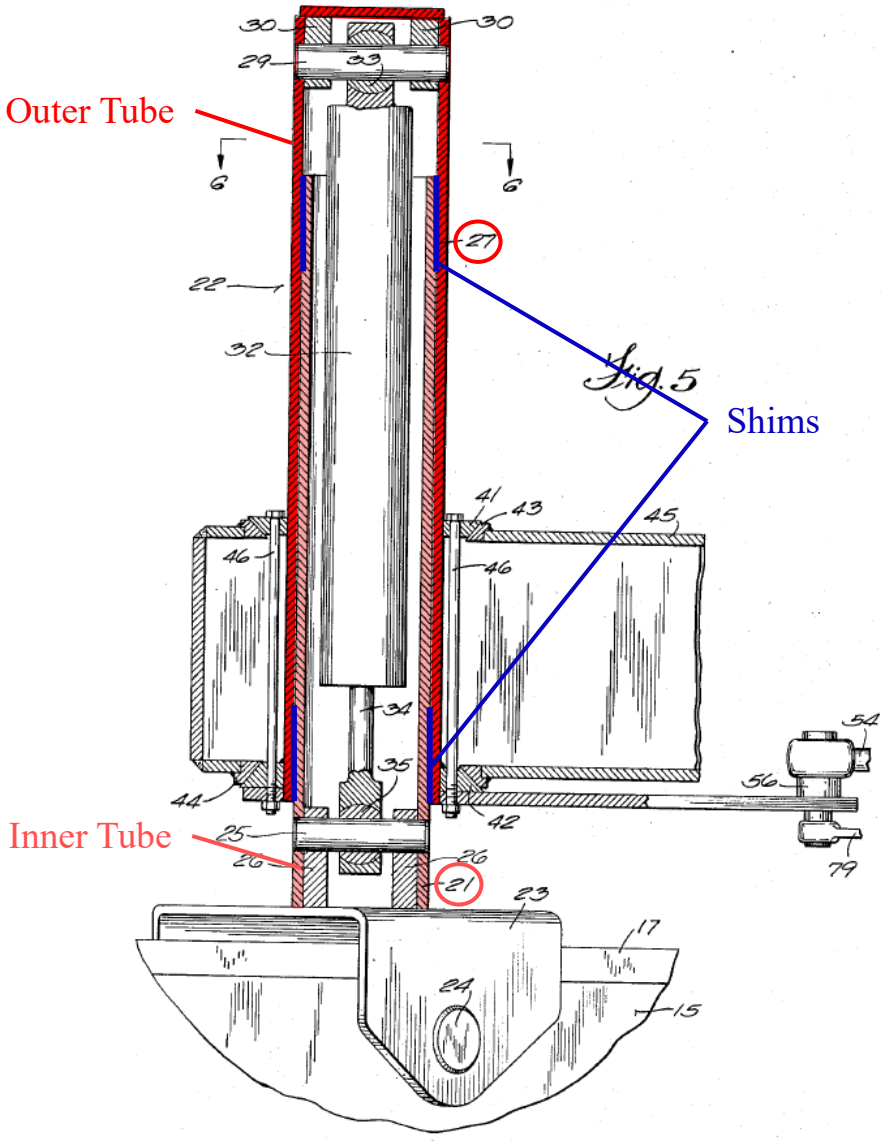
136. To the extent CIII does not disclose spaced-apart axial bearings, it would have been obvious in view of Files to add a second set of axial bearings spaced *vertically* from these radially-spaced bearings and coupled to the outer tube to further facilitate the telescopic movement between these guide tubes. Files discloses a similar jacking column and crawler track design as CIII, as shown in the figures below. [*See* Ex. 1012 (Files), Fig. 4, 2:16-3:4.]




[Ex. 1012 (Files), Fig. 4; Ex. 1005 (CIII), 209.]

137. For example, Files discloses a hydraulic power system, where "operation of cylinder 32 either lifts or lowers outer tube 27 in sliding relation on tube 21." [Ex. 1012 (Files), 2:32-35.] Files discloses that tubes 21 and 27 have a square cross-section, like CIII, and that, "[f]or a sliding fit[,] the ***lower*** inner end of tube 27 and the ***upper*** outer end of tube 21 may be fitted with shims." [Ex. 1012 (Files), 2:48-56 (emphases added).] In annotated Figure 5 of Files below, I have

shown where these shims would appear. These shims are vertically spaced-apart axial bearings that provide a sliding fit.




[Ex. 1012 (Files), Fig. 5 (annotated).]

138. These shims function the same as CIII's wear pads. A POSITA would have understood that the shims are axially spaced apart because they are at different vertical heights. Furthermore, they are coupled to either the outer tube or

inner tube, and they reduce the friction between the tubes 21 and 27 to facilitate axial movement of the inner tube relative to the outer tube while simultaneously preventing relative rotational movement of the inner tube relative to the outer tube.

139. Like CIII's wear pads, a POSITA would have understood Files' shims are plain bearings that allows one surface to slide relative to another. Shims are simply flat pieces of materials that are durable and have a relatively low coefficient of friction. Shims can either be standalone bearings similar to CIII's wear pads or additional material added to existing wear pads to ensure a snug fit of the bearing against the opposing surface. A POSITA would have understood Files to be using the term "shims" to refer to standalone guide bearings because it discloses that the tubes 21 and 27 of Files "may be fitted with shims" for a sliding fit. [Ex. 1012 (Files), 2:52-56.] These shims act as guide bearings to keep the tubes aligned, while permitting relative axial movement.

140. A POSITA would have been motivated to combine CIII and Files such that CIII's jacking columns include spaced-apart axial bearings coupled to the outer tube and/or the inner tube. CIII already discloses axial bearings on the bottom of the outer guide tubes that facilitate axial movement and limit rotational backlash. But over time, "the thickness of the wear pads decreases because of wear," which can introduce unwanted play. [Ex. 1014 (Pinther), ¶ [0003].] And once loose, "vibration of the machine induces further wear." [Ex. 1012 (Files),

1:16-17.] A POSITA would have been motivated to add a second set of axial bearings (e.g., CIII's wear pads or Files' shims) spaced apart vertically—one set on the lower end of the outer tube and one on the upper end of the inner tube—to improve the alignment of the guide tubes and reduce the load on CIII's axial bearings, thereby increasing the life of each bearing and reducing wear.

141. For example, evidence from the state of the art, such as disclosed in U.S. Patent No. 6,226,809 ("Davies"; Ex. 1015), teaches a hydraulic lift cylinder assembly in which "two plain sliding bearings 45 and 46" are spaced apart vertically and located between the outer surface of cylinder 30 and inner surface of sleeve 42 to "prevent[] lateral movement" and "provide support . . . against lateral forces." [Ex. 1015 (Davies), 1:5-6, 2:53-59, 3:13-15, Figs. 2, 4.]

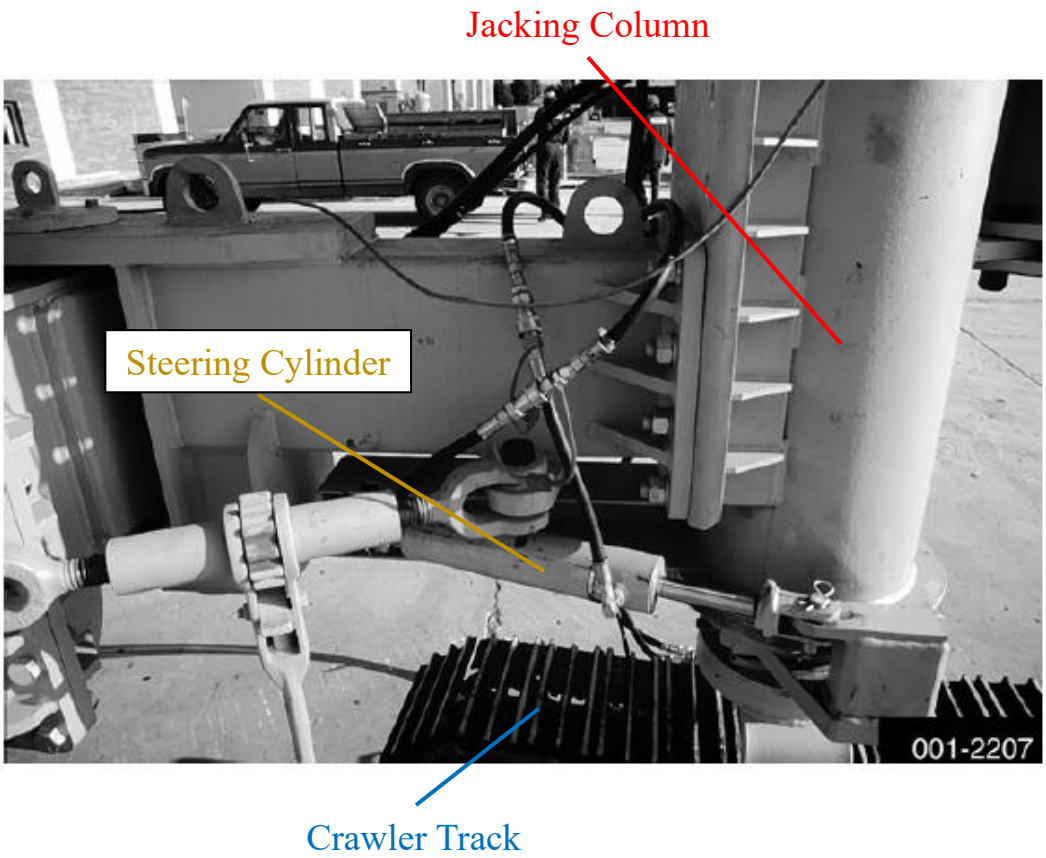
142. By designing bearings in this way in the modified CIII-Rio-Files paver, this arrangement would have facilitated smoother relative axial movement between the tubes, prevented wear on the surfaces of the tubes, and lowered the amount of energy required to perform axial movement. A POSITA would have understood a shim used in this way to be a type of linear sliding bearing.

143. A POSITA would have had a reasonable expectation of success in such a combination, as axial bearings were well known to provide such benefits, and such a design would have been a combination of familiar elements according

to known methods to yield predictable results. Additionally, CIII already discloses wear pads similar to Files' shims.

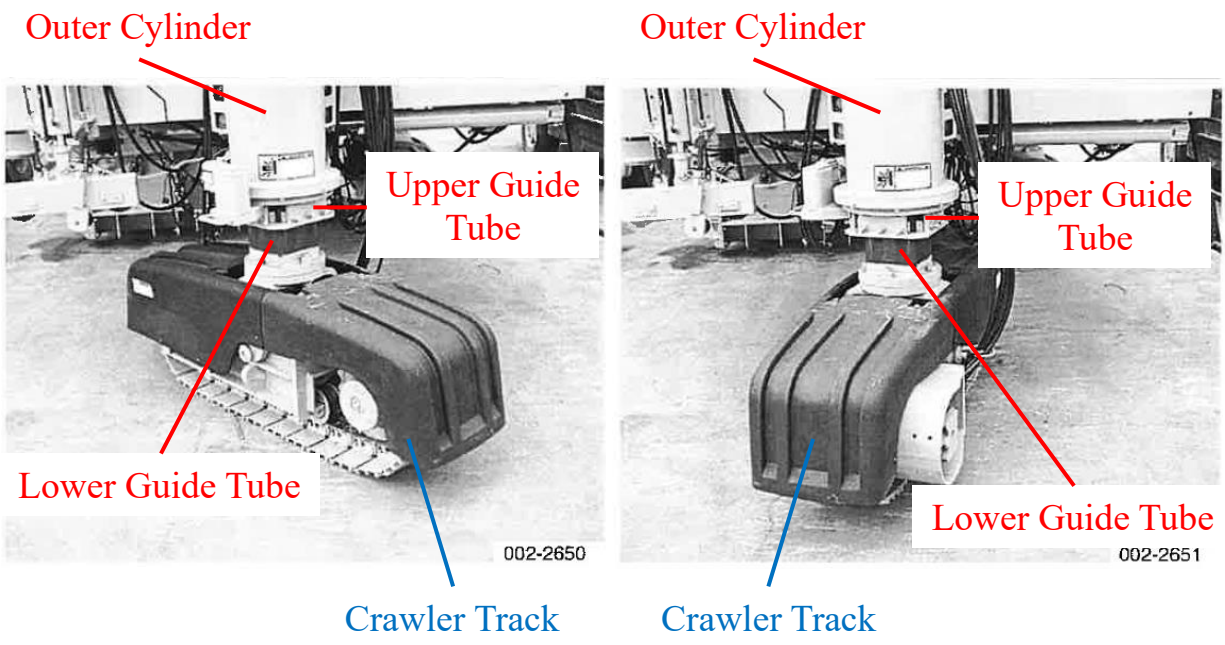
**j. [1I]: "a crawler track coupled to a yoke which is rotatably coupled to the jacking column;"**

144. CIII and Rio render obvious this feature. The Board previously found that CIII and Rio render obvious a similar feature of the '749 patent. [Ex. 1033, 24:6 ("a crawler track"), 24:8-11 ("a rotary connection between the jacking column and the crawler track permitting relative rotational movements of the crawler track and the jacking column about a first upright axis"); '749 FWD at 64-66, 95-96.] CIII discloses four crawler tracks in its four-track configuration, each of which is rotated about a vertical axis of its associated jacking column relative to the jacking column's outer cylinder via a hydraulic steering cylinder that extends and retracts. [Ex. 1005 (CIII), 165, 193, 195, 204-206, 373-374; *supra* Section VII.A.1 (Summary of CIII).] The hydraulic steering cylinder, jacking column, and crawler track are shown in the image below.



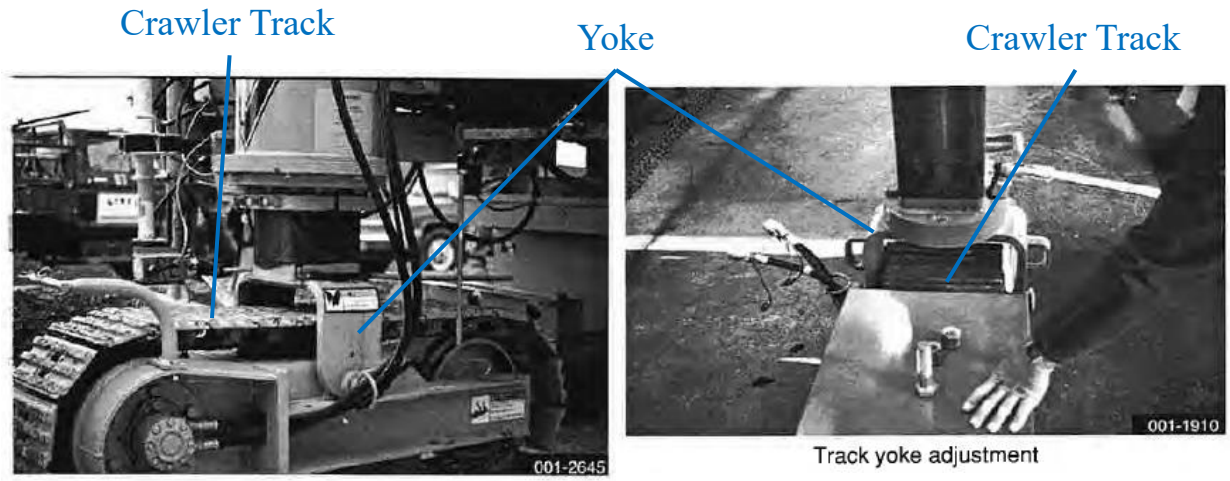

[Ex. 1005 (CIII), 265 (annotated).]

145. The rotation of the track and guide tubes relative to the outer cylinder of the jacking column is shown below.



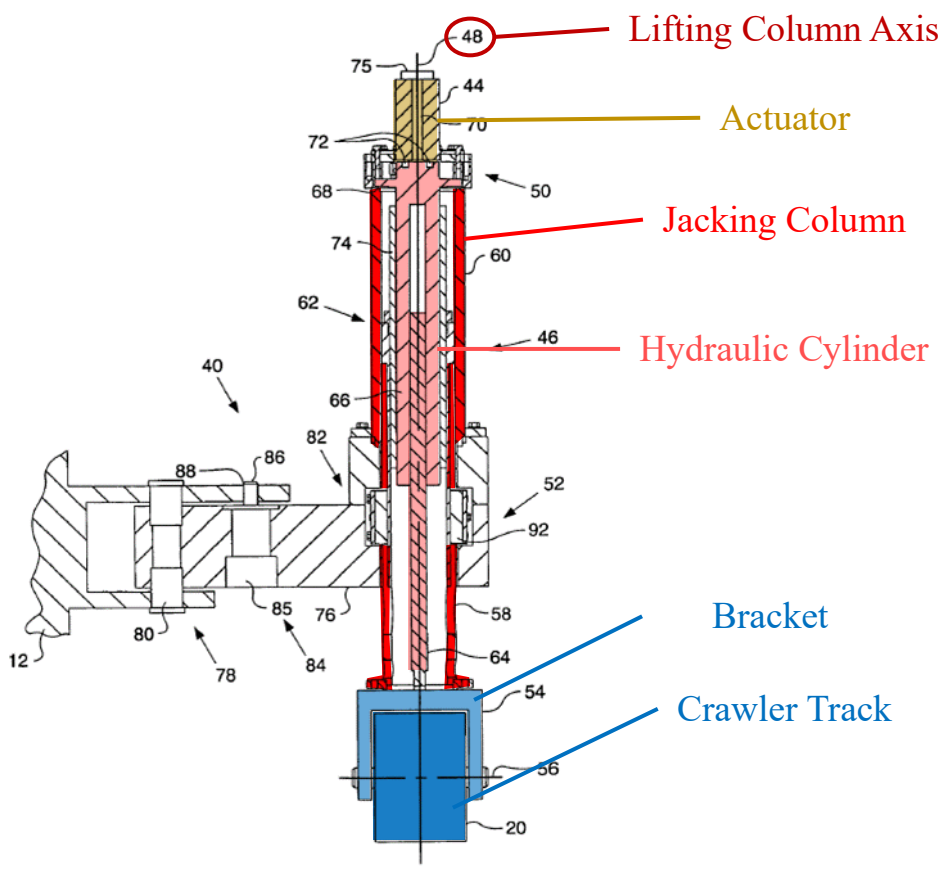

[Ex. 1005 (CIII), 193, 195 (annotated).]

146. CIII also discloses that each crawler track is coupled to a yoke, referred to as a "track yoke," which is coupled to the lower guide tube. [Ex. 1005 (CIII), 204-206, 209-210.] For example, CIII discloses that "[e]ach inner leg tube is bolted to the track yoke," as shown in the images below. [Ex. 1005 (CIII), 209.] Each yoke for each crawler track includes a "track pivot yoke pin" that allows the track to pivot up and down relative to the yoke. [Ex. 1005 (CIII), 175.]




[Ex. 1005 (CIII), 102, 209 (annotated).]

147. It would have been obvious in view of Rio to modify CIII such that the yoke is rotatably coupled to the entire jacking column and not just the outer cylinder. Rio discloses a rotary actuator 44 positioned "along the lifting column axis 48" (a "second axis") that moves the crawler track "rotationally about the lifting column axis 48." [Ex. 1006 (Rio), 4:56-5:16, 5:32-34, 6:2-6.] In the embodiment depicted in Figure 2, below, rotary actuator 44 "moves" the "ground engaging unit 20 rotationally about the lifting column axis 48" via connections between cylinder 66, inner tubular member 58, and bracket 54. [Ex. 1006 (Rio), 5:54-6:6, 5:25-29, 5:34-35.]




[Ex. 1006 (Rio), Fig. 2 (annotated); *supra* Section VII.A.2 (Summary of Rio).]

148. For the reasons explained in Section VII.A.6.a (Combining CIII and Rio), it would have been obvious to modify CIII's leg assembly by positioning Rio's rotary actuator 44 between the bottom of the jacking column and the top of the yoke associated with each crawler track and using that rotary actuator to rotate CIII's crawler track relative to the entire jacking column, rather than just its outer cylinder. This design was well known in the art. [*Supra* Section VII.A.6.a (Combining CIII and Rio); Ex. 1007 (Littman), 5:14-59, Figs. 4-5 (disclosing rotary actuator at bottom of jacking column that rotates crawler track relative to the

jacking column); Ex. 1008 (Miller), 7:35-58, Fig. 7 (same); Ex. 1011 (Whitaker), 4:7-16, Fig. 3 (same); Ex. 1009 (Johns), ¶ [0020], Fig. 2.] Rio also provides disclosure and motivation for this modification. [Ex. 1006 (Rio), 5:8-11 (explaining that the rotary actuator 44 can be "positioned on the lifting column 46" anywhere "along the lifting column axis 48").]

**k. [1J]: "a slew gear drive secured at a lower end of the inner tube and to a top of the yoke to translate relative rotational movements between the jacking column and the crawler track about the upright axis, wherein the slew gear drive is capable of steering the crawler track under load without lifting the crawler track; and"**

149. CIII and Rio render obvious this feature. The Board previously found that CIII and Rio render obvious a similar feature of the '749 patent. [Ex. 1033, 24:22-25 ("a power drive between the jacking column and the crawler track, configured for translating relative rotational movements between the jacking column and the crawler track"), 23:37-38 ("the power drive comprises a slew gear drive"); '749 FWD at 68-79, 95-96, 102.] Additionally, the Board found that "Rio discloses that sufficient torque can be generated to rotate the crawler track . . . when engaged with the ground." ['749 FWD at 59-60.]

150. As described in Sections VII.A.6.a (Combining CIII and Rio) and VII.A.7.j ([1I]), it would have been obvious to modify CIII's leg assembly by substituting its steering cylinder that rotates the crawler track relative to the outer

cylinder of the jacking column for Rio's rotary actuator 44 positioned between the bottom of the jacking column and the top of the yoke associated with each crawler track, such that the rotary actuator translates relative rotational movements between the jacking column and the crawler track about the upright axis.

151. Rio discloses that rotary actuator 44 can use a worm-gear design—a "well-known mechanical implementation[]"—"with good result." [Ex. 1006 (Rio), 4:61-5:3.] Rio discloses that such a worm-gear rotary actuator was preferred over linear actuators like CIII's steering cylinder because it provides "fine rotary steering control" and "a compact apparatus to achieve rotary motion without the need for complicated and bulky linkages." [Ex. 1006 (Rio), 5:3-7.] A POSITA would have understood that a worm-gear rotary actuator is a slew drive. Indeed, Patent Owner's expert represented that a slew gear drive can be "a drive that comprises a worm gear." [Ex. 1032, 84:12-86:17; *see also* Ex. 1001 ('723 patent), 11:42-63 (describing a ring gear "with two oppositely arranged worm drives" as a slew drive).]

152. Rio discloses positioning its rotary actuator 44 "on the lifting column 46 . . . along the lifting column axis 48," and using the rotary actuator to cause the crawler track to rotate "about the lifting column axis 48." [Ex. 1006 (Rio), 5:8-11, 6:2-6.] For the reasons explained in Section VII.A.6.a (Combining CIII and Rio) and VII.A.7.j ([1I]), it would have been obvious to modify CIII's leg assembly by

coupling Rio's worm-gear rotary actuator 44 to the bottom of each jacking column's lower guide tube and the top of the yoke associated with each crawler track, such that actuating the worm-gear rotary actuator causes the associated crawler track to rotate relative to the entire jacking column, rather than just its outer cylinder.

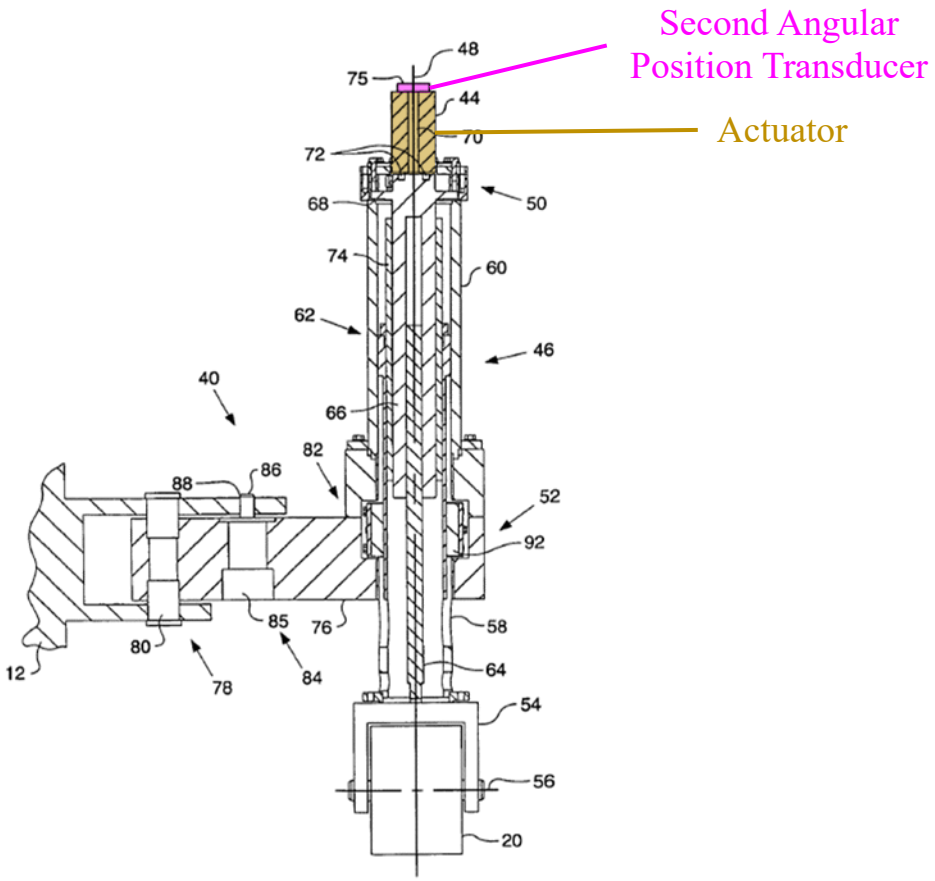
153. Moreover, Rio discloses that its slew drive is capable of steering the crawler track under load without lifting the crawler track. For example, Rio discloses that rotary actuator 44 is capable of "steering the one ground engaging unit 20" while it is on the ground and that both rear ground engaging units 18, 20 may be steered simultaneously via their own rotary actuator 44. [Ex. 1006 (Rio), 9:15-36.] By disclosing steering the units in order to avoid "dragging the unit, especially if it is a track section, across the ground or pavement surface," a POSITA would have understood that Rio discloses steering the units while they are on the ground and under load. [Ex. 1006 (Rio), 9:15-36.] Rio discloses that "with the mere addition of sufficient rotation sensors and actuators[,] it is possible for a programmed controller 32 to rotate and steer each wheel or track section either independently or in coordination with each other, both when the one wheel or track segment 20 is in the retracted position," i.e., pulled close to the frame, "and when it is in the projecting position," i.e., pivoted out from the frame. [Ex. 1006 (Rio), 9:37-42.]

154. Moreover, a POSITA would have had a reasonable expectation that Rio's worm-gear rotary actuator could provide sufficient torque to rotate each of CIII's crawler tracks while they are under load. [*Supra* Section VII.A.6.a (Combining CIII and Rio).] Indeed, the '723 patent acknowledges that worm-gear drives were "commercially available" and provided sufficient torque. [Ex. 1001 ('723 patent), 11:42-63.]

**l. [1K]: "a second angular position transducer configured to measure an angular position of the crawler track and yoke relative to the jacking column and further emit a second signal indicative of the measured angular position via a lead to an onboard computer or processor."**

155. CIII and Rio render obvious this feature. The Board previously found that CIII and Rio render obvious a similar feature of the '749 patent. [Ex. 1033, 24:12-16 ("a first angular position transducer between the jacking column and the crawler track, configured to emit a first signal which is indicative of an angular orientation of the crawler track relative to the jacking column"), 24:26-27 ("a processor operable to receive the first and second signals"); '749 FWD at 65-68, 95-96.] Although numbered differently, both the "first angular position transducer" in the '749 patent and the "second angular position transducer" here emit a signal indicative of the angular orientation of the crawler track relative to the jacking column.

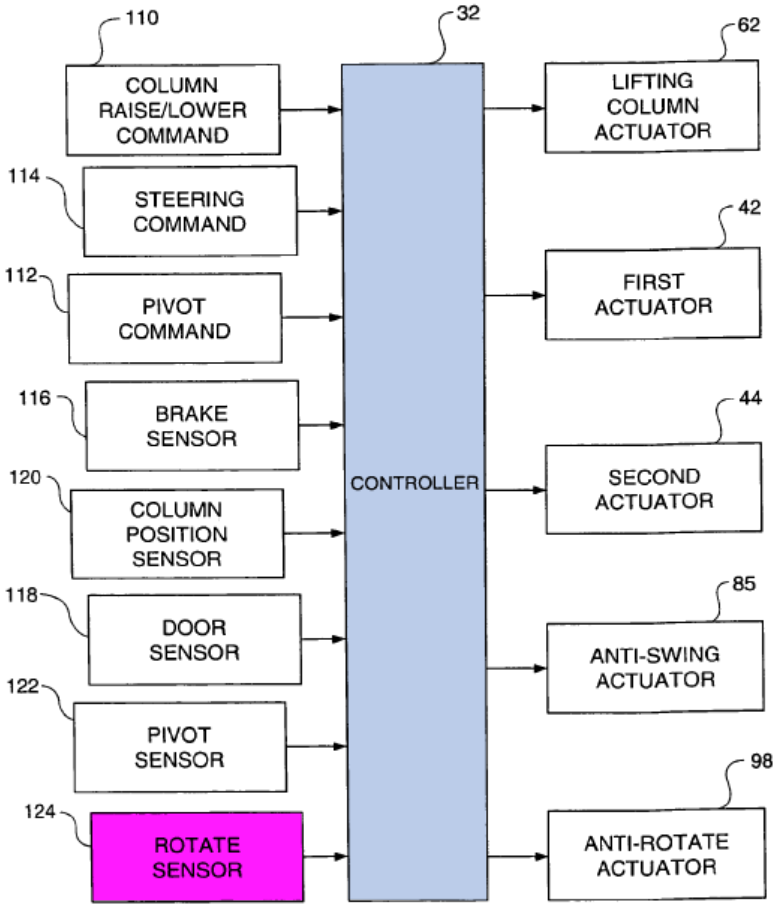
156. As shown below in Figure 2, Rio discloses a rotation sensor 75 ("second angular position transducer") associated with rotary actuator 44 or a "connected rotating component" that measures an angular position of the ground engaging unit 20 and bracket 54 relative to the outer surface of the lifting column. [Ex. 1006 (Rio), 5:25-29, 6:6-11, 7:23-27, 8:38-39.] This sensor emits "rotation position signals 124" via a lead to the onboard controller 32, "deliver[ing] signals representing the rotation angle of the one ground engaging unit 20 relative to the machine frame 12." [Ex. 1006 (Rio), 5:25-29, 6:6-11, 6:65-7:13, 7:23-27, 8:38-39.]




[Ex. 1006 (Rio), Fig. 2 (annotated).]

157. Annotated Figure 5 of Rio below represents this lead as an arrow going from the "ROTATE SENSOR" to the "CONTROLLER." [Ex. 1006 (Rio), Fig. 5.]

Fig. 5




[Ex. 1006 (Rio), Fig. 5 (annotated).]

158. Because Rio describes sensor 75 as "a rotary encoder" "associated with the second actuator 44" that rotates about lifting column axis 48, a POSITA would have understood that sensor 75's rotation position signal 124 indicates the

measured angular orientation of the crawler track and bracket 54 relative to the outer tubular member 60 of lifting column 46 ("a second signal indicative of the measured angular position"). [Ex. 1006 (Rio), 6:6-11, 8:39-47, Fig. 2.] This is apparent from at least Rio's depiction of sensor 75 in Figure 2, shown above, which shows sensor 75 coupled to a fixed portion of the rotary actuator 44, which is attached to outer tubular member 60, and its rotating rotor. [Ex. 1006 (Rio), 5:54-56, 6:6-11, Fig. 2.] In this configuration, the sensor would determine the relative rotation between those two components.

159. While Rio discloses that the rotational position signal 124 indicates "the instantaneous rotation angle of the one ground engaging unit 20 relative to the machine frame 20," a POSITA would have understood this disclosure as meaning that the controller 32 uses the pivot position signal 122 and rotational position signal 124 to determine the angular orientation of the one ground engaging unit 20 relative to the machine frame to "coordinate the actuators 42, 44" such that "the one ground engaging unit 20 remain[s] parallel to the machine frame 12 at all points in the pivot arc." [Ex. 1006 (Rio), 7:23-27, 8:38-47.]

160. To the extent Patent Owner argues that Rio's sensor 75 does not emit a signal corresponding to an angular position of the crawler track and yoke relative to the outer surface of the lifting column, it would have been obvious to have it do so, given the configuration depicted in Rio's Figure 2. A POSITA would have

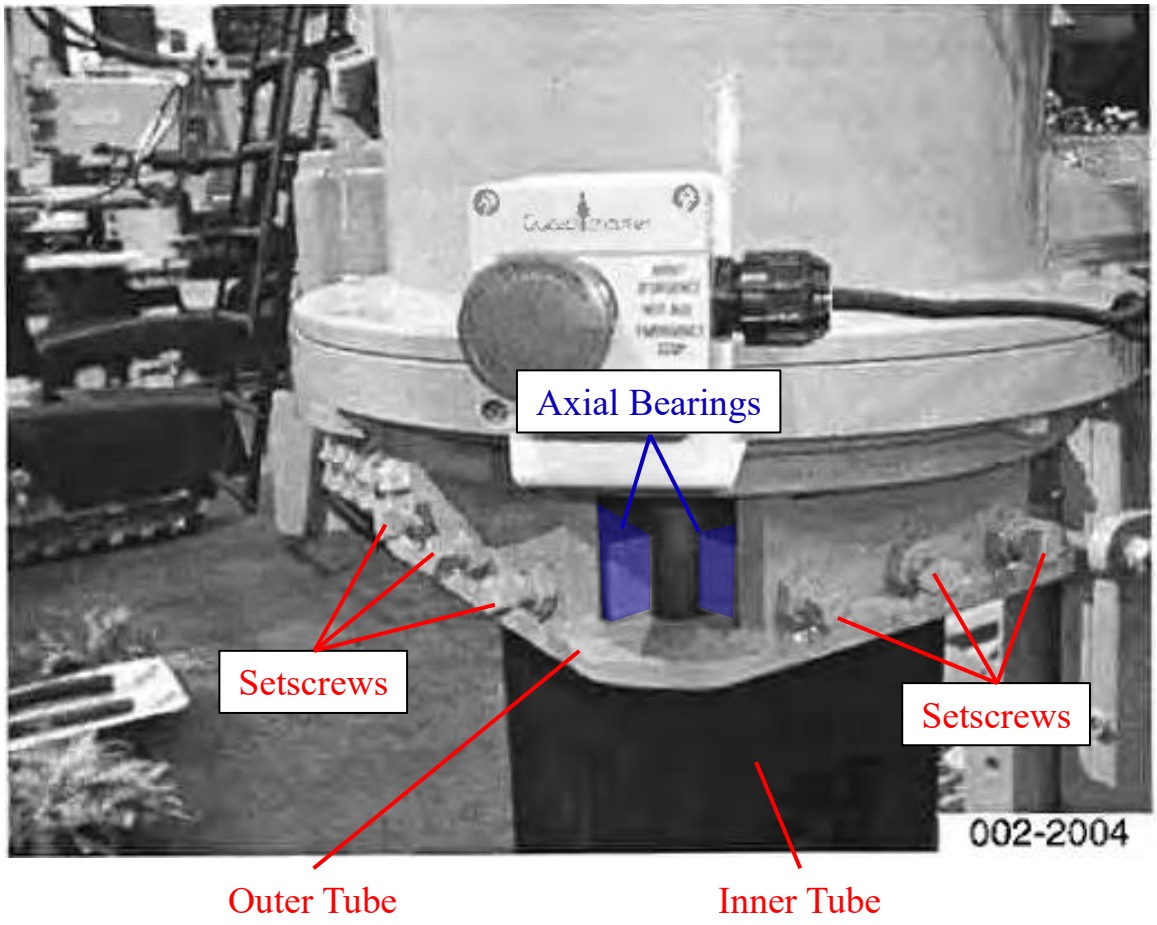
understood that, with the signal representing the angular orientation of the swing arm relative to the frame (e.g., pivot position signal 122 from sensor 83, the "first angular position transducer") and a signal representing the angular orientation of the crawler track and yoke relative to the outer surface of the lifting column, the controller may determine the angular orientation of the crawler track relative to the machine frame through simple geometry. A POSITA would have been motivated to have sensor 75 emit a signal representing the angular position of the crawler track and yoke relative to the outer surface of the lifting column because this would have been a simpler design typical of how rotary encoders were used at the time. Moreover, CIII already discloses a sensor-based steering cylinder, which measures the crawler track's rotational position and sends continuous position signals to the S2X controller. [Ex. 1005 (CIII), 408, 412.] A POSITA would have found it obvious to similarly design sensor 75 to emit such a signal.

161. For these reasons, and the reasons explained in Section VII.A.6.a (Combining CIII and Rio), it would have been obvious to implement Rio's rotation sensor 75 in CIII's swing-leg assembly such that it measures an angular position of CIII's crawler track and yoke relative to the jacking column and further emits a second signal indicative of the measured angular position via a lead to an onboard computer or processor.

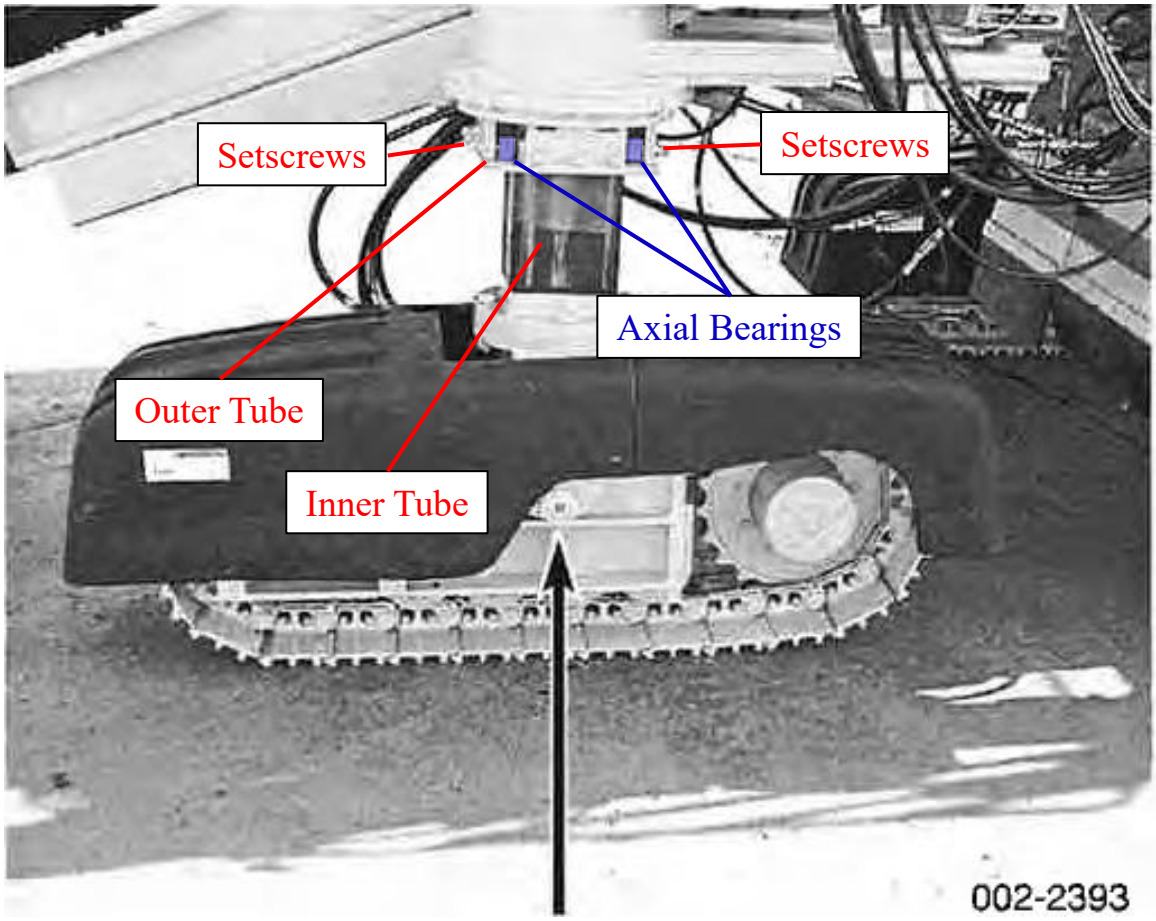
162. Accordingly, for the reasons stated above, a POSITA would have understood claim 1 to be obvious.

**8. Claim 2: "The paving machine of claim 1, wherein the axial bearings are configured to limit rotational backlash between the inner and the outer tubes of the jacking column, while keeping the tubes aligned and allowing them to slide against each other."**

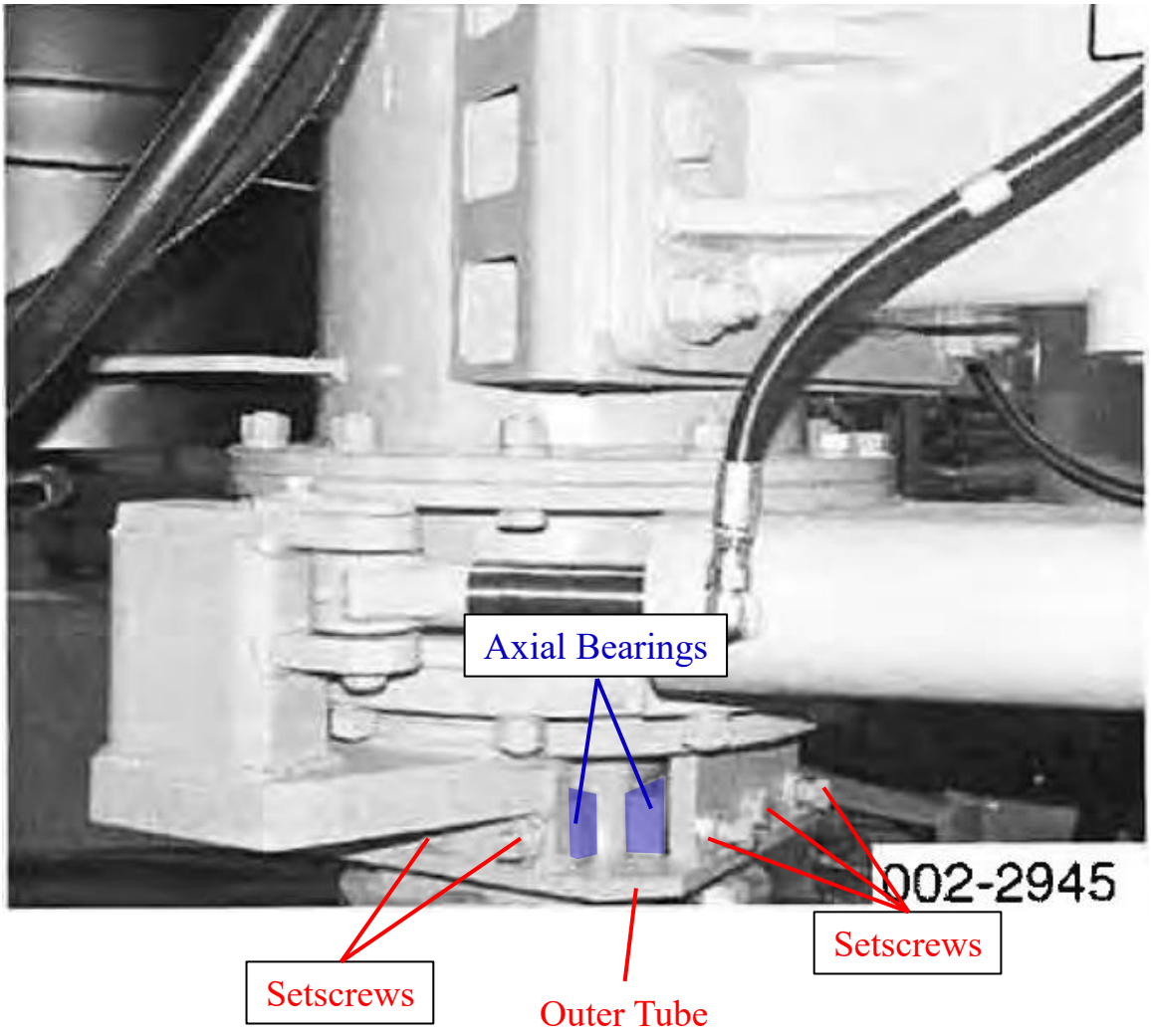
163. CIII discloses or, in view of Files, renders obvious this feature for the reasons discussed in Section VII.A.7.i ([1H]). For example, CIII discloses that the setscrews should be "snug against the wear bar on the bottom of the outer guide tube on each leg to eliminate any looseness between the inner and outer guide tubes" and that, if necessary, tension can be added to reduce excessive backlash. [Ex. 1005 (CIII), 174, 194, 378.] CIII's wear pads and Files' shims keep the tubes aligned by filling the gap between the outer surface of the inner tube and the inner surface of the outer tube. CIII depicts this in the images below, where each wear pad has setscrews that allow the operator to tighten each wear pad against the inner guide tube and remove any lateral play between the guide tubes.




[Ex. 1005 (CIII), 353 (annotated).]




[Ex. 1005 (CIII), 175 (annotated).]




[Ex. 1005 (CIII), 205 (annotated).]

164. By filling this gap, the wear pads/shims also limit the rotational backlash because they ensure a tight rotational fit between the tubes. In fact, CIII specifically states that if the backlash is more than 1 inch of cylinder stroke, then it is necessary to adjust the wear pad. [Ex. 1005, 378.]

165. Designing axial bearings in this way was known to a POSITA. For example, a POSITA would have understood that CIII's wear pads and Files' shims

are axial bearings because they function the same as "sliding bearings" known in the state of the art, which "serve a mechanical purpose of preventing lateral movement" of the inner cylinder relative to the outer cylinder and allowing "one member to easily move relative to the other." [Ex. 1015 (Davies), 2:53-59, 3:13-15, Figs. 2-5; Ex. 1014 (Pinther), ¶¶ [0030]-[0031].] Accordingly, because the inner surface of CIII's outer tube and outer surface of CIII's inner tube have square cross-sections, providing spaced-apart sliding bearings that prevent lateral movement of the lower guide tube would have limited rotational backlash between the upper and lower guide tubes, while keeping the tubes aligned and allowing them to slide against each other.

166. Moreover, a POSITA would have been motivated to make such a design because limiting the rotational backlash would have ensured a more precise steering system and, therefore, improved the quality of the paving. If, for example, the axial bearings permitted large amounts of backlash between the tubes, then the second angular position transducer, [*supra* Section VII.A.7.l ([1K])], may not provide an accurate measurement of the crawler track angle to the controller, thereby producing a steering signal that is less precise. Furthermore, the backlash could lead to deadzones that cause jittery steering effects. Deadzones refer to periods where actuation of the actuator does not translate to rotation of the crawler track. If, for example, 10° of backlash between the outer and inner tubes exists, the

outer tube may have to rotate up to 15° just to get the inner tube and crawler track to rotate 5° leading to jittery steering effects and potentially inaccurate angular position signals. By factoring in Files' teaching of shims that keep the tubes aligned and limit backlash, a POSITA would have ensured that the second angular position transducer accurately measured the crawler track angle, leading to more accurate steering signals. In fact, limiting backlash is a fundamental problem in engineering that a POSITA would have known needed to be reduced, as reflected in CIII's disclosure of tensioning the wear pads to eliminate excessive backlash. [Ex. 1005 (CIII), 378.]

### 9. Claim 3: "The paving machine of claim 1, wherein rotational movement of the crawler track ranges between 180 degrees on either side the upright axis."

167. For the purposes of this proceeding, I am interpreting "rotational movement of the crawler track ranges between 180 degrees on either side the upright axis" as being satisfied if a crawler track is capable of rotating 180 degrees both clockwise and counterclockwise about the upright axis from a given position. CIII and Rio render obvious this feature. For the reasons described in Sections VII.A.6.a (Combining CIII and Rio) and VII.A.7.k ([1J]), it would have been obvious to modify CIII's leg assembly by substituting its steering cylinder for Rio's worm-gear rotary actuator 44 positioned between the bottom of the jacking column and the top of the yoke associated with each crawler track, such that the

rotary actuator translates relative rotational movements between the jacking column and the crawler track. Such worm-gear rotary actuators were well understood to provide rotational movement between 180 degrees on either side of the upright axis. For example, Miller discloses a similar rotary actuator design that provides "360° steering" of the crawler track and discloses turning the crawler tracks both left and right. [Ex. 1008 (Miller), 2:51-53, 7:35-53, 13:47-51, Fig. 7, Abstract.] Additionally, Swasey discloses a worm-gear rotary actuator, like Rio, used in an "omnidirectional drive and steering unit" that allows steering "in full circles . . . while bearing a very large load and providing a significant amount of torque relative to the overall size of the unit." [Ex. 1015 (Davies), ¶¶ [0041], [0044].]

168. A POSITA would have been motivated to ensure that Rio's worm-gear rotary actuator implemented on CIII to steer the crawler tracks could rotate the crawler tracks at least 180° in either direction to improve the maneuverability of the paving machine and to facilitate switching between different modes, such as switching from the paving mode to the transport mode. [Ex. 1005 (CIII), 253-254.] A POSITA would have had a reasonable expectation of success in such a design because worm-gear rotary actuators commonly provided 360° steering. [Ex. 1008 (Miller), 2:51-53, 7:35-53, Fig. 7, Abstract; Ex. 1015 (Davies), ¶¶ [0041], [0044].]

**10. Claim 4: "The paving machine of claim 1, wherein the slew gear drive is configured to steer and/or maintain the crawler track in a preset position under load."**

169. CIII and Rio render obvious this feature. The Board previously found that CIII and Rio render obvious a similar limitation of the '749 patent. [Ex. 1033, 23:25-28 ("a feedback for maintaining the orientation of the crawler track independently of angular inclinations of the crawler track relative to the module frame"); '749 FWD at 99-100.] While claim 7 of the '749 patent does not recite an "under load" requirement like claim 4 of the '723 patent, the Board previously correctly found that "Rio discloses that sufficient torque can be generated to rotate the crawler track, both when engaged with the ground and raised off the ground." ['749 FWD at 59.] For the reasons described in Sections VII.A.6.a (Combining CIII and Rio) and VII.A.7.k ([1J]), it would have been obvious to modify CIII's leg assembly by substituting its steering cylinder for Rio's worm-gear rotary actuator 44 positioned between the bottom of the jacking column and the top of the yoke associated with each crawler track, such that the rotary actuator translates relative rotational movements between the jacking column and the crawler track and is capable of doing so under load.

170. CIII discloses "front and rear steer control systems" that are configured to steer and/or maintain each crawler track in a preset position under load. [Ex. 1005 (CIII), 407-408.] For example, CIII discloses that, while paving, a

controller compares each crawler track's angular-orientation signal to a guideline steer signal and uses feedback to keep each crawler track pointing "straight ahead." [Ex. 1005 (CIII), 407-408.] A POSITA would have understood that, in the modified CIII-Rio-Files paving machine, Rio's worm-gear rotary actuator would be configured to perform this function of steering and/or maintaining each crawler track pointing straight ahead under load. [*Supra* Sections VII.A.6 (Rationale for Combining CIII, Rio, and Files) and VII.A.7.k ([1J]); Ex. 1006 (Rio), 9:15-42 (disclosing that, "with the mere addition of sufficient rotation sensors and actuators[,] it is possible for a programmed controller 32 to rotate and steer each wheel or track section either independently or in coordination with each other" while under load, regardless of the position of the swing arm).]

**11. Claim 5: "The paving machine of claim 1, wherein the slew gear drive is configured for precision movement between the jacking column and the crawler track and to limit backlash to avoid adversely affecting steering accuracy of the crawler track."**

171. CIII and Rio render obvious this feature. For the reasons described in Sections VII.A.6.a (Combining CIII and Rio) and VII.A.7.k ([1J]), it would have been obvious to modify CIII's leg assembly by substituting its steering cylinder for Rio's worm-gear rotary actuator 44 positioned between the bottom of the jacking column and the top of the yoke associated with each crawler track, such that the

rotary actuator translates relative rotational movements between the jacking column and the crawler track.

172. In the modified CIII-Rio-Files paver, Rio's rotary actuator is configured for precision movement between the jacking column and the crawler track because Rio discloses that it provides "fine rotary steering control" and can "precisely offset the rotation caused by the pivoting" so that the crawler track remains parallel to the frame during pivoting. [Ex. 1006 (Rio), 5:1-7, 8:38-47.] Moreover, a POSITA would have understood that such worm-gear rotary actuators, by virtue of their high gear-reduction ratios limit backlash. Indeed, the '723 patent discloses that such worm-gear rotary actuators were "commercially available" and minimize "undesirable play or 'backlash' during steering," regardless of whether it "is activated or deactivated." [Ex. 1001 ('723 patent), 11:42-63.] Accordingly, any advantages that the '723 patent alleges exist with its worm-gear drive likewise exist with Rio's worm-gear rotary actuator. Worm-gear rotary actuators limit backlash to avoid adversely affecting steering accuracy of the crawler track because the high gear-reduction ratios make it very difficult to apply a rotational torque to the worm gear that is large enough to turn the worm.

**12. Claim 6: "The paving machine of claim 1, wherein the swing leg is configured to relocate the jacking column with the crawler track while moving and under load."**

173. CIII and Rio render obvious this feature. For the reasons described in Section VII.A.6.a (Combining CIII and Rio), it would have been obvious to implement Rio's control system to fully automate the rotation of the swing leg. A POSITA would have understood that this modified paving machine is configured to relocate the jacking column and the crawler track while moving and under load. For example, CIII discloses that the crawler tracks can rotate and move the paving machine. [*E.g.*, Ex. 1005 (CIII), 37, 407-408.] And for the reasons discussed in Section VII.A.7.k ([1J]), Rio's worm-gear rotary actuator can steer the crawler tracks under load.

174. A POSITA would have understood that such a configuration would have allowed the swing leg to be rotated, thereby relocating the jacking column with the crawler track, while the paving machine is moving and under load. For example, Littman discloses modes in which a wheel is "positioned perpendicular to the stabilizer legs so as to allow the legs to pivot while the legs are on the ground supporting the prime mover and its load." [Ex. 1007 (Littman), 9:61-64.] In the CIII-Rio-Files modified paving machine, a POSITA would have understood from the state of the art, like Littman, that such a technique for rotating the swing leg to relocate the jacking column with the crawler track while moving and under load

would have been available. For example, CIII discloses that each crawler track can be individually steered and each jacking column and crawler track can be individually relocated. [Ex. 1005 (CIII), 32, 34, 38-39.] Accordingly, this modified paving machine would have allowed the operator to individually steer the crawler tracks at an angle to rotate the swing legs and relocate the jacking columns and crawler tracks while the machine was moving.

175. To the extent this modified paving machine lacks such capability, it would have been obvious to provide the operator with such controls to allow the rotation of the swing legs while the machine was moving and under load. And by rotating the swing legs, the jacking columns and crawler tracks would be relocated relative to the modular frame. A POSITA would have been motivated to provide such controls because it would have shortened the amount of time needed to reposition the swing legs and crawler tracks. For example, CIII discloses the need to switch between a paving mode and a transport mode, which involves swinging each swing leg "around to the end of the 4-track frame." [Ex. 1005 (CIII), 253-254.] Providing the operator with such controls would have improved the paving machine by decreasing the amount of time needed to switch between these modes because multiple swing legs could be rotated at the same time without picking the crawler track off the ground.

**13. Claim 7:**

**a. [7pre]: "The paving machine of claim 1, wherein the processor is configured to:"**

176. CIII and Rio render obvious this feature. The Board previously found that CIII and Rio render obvious a similar feature of the '749 patent. [Ex. 1033, 24:26 ("a processor operable to"); '749 FWD at 67-68, 95-96.] As explained in Sections VII.A.7.d ([1C]) and VII.A.7.j ([1I]), each swing leg and crawler track in CIII's four-track configuration is configured to pivot about a separate axis. CIII discloses a controller that receives a steer signal and a signal corresponding to the position of each crawler track and can control the steering cylinder so that the crawler-track position reaches the desired position. [Ex. 1005 (CIII), 407-408.] However, before this can occur, CIII discloses, each crawler track must be manually aligned to the frame of the paver via time-consuming measurements to calibrate CIII's steering system. [Ex. 1005 (CIII), 193-194; *supra* Section VII.A.6.a (Combining CIII and Rio).] Rio discloses a control system that eliminates the need for this manual alignment procedure after pivoting a swing leg. [Ex. 1006 (Rio), 8:31-9:14.] As explained in Section VII.A.6.a (Combining CIII and Rio), it would have been obvious to implement Rio's actuators and control system in CIII to improve the steering system of CIII.

177. Rio's control system includes a controller 32, such as "a programmed computer logic unit and associated memory," that receives signals from the sensors and coordinates movements of the swing leg and crawler track via signals to the actuators. [Ex. 1006 (Rio), 4:16-20, 4:47-50, 6:56-7:42, Fig. 5.] A POSITA would have understood that Rio's controller discloses a processor configured to perform the actions in the following sections for [7A]-[7D] (Sections VII.A.13.b-VII.A.13.e). It would have been obvious to combine CIII and Rio such that the control system includes a processor configured to perform these actions. [*Supra* Section VII.A.6.a (Combining CIII and Rio).]

**b. [7A]: "receive the first and second signals;"**

178. CIII and Rio render obvious this feature. The Board previously found that CIII and Rio render obvious a similar feature of the '749 patent. [Ex. 1033, 24:26-27 ("receive the first and second signals"); '749 FWD at 67-68, 95-96.] The modified CIII-Rio controller is configured to receive the pivot position signal 122 ("first signal") and the rotational position signal 124 ("second signal"). [Ex. 1006 (Rio), 6:65-66, 7:11-13, 8:34-34, 8:38-39; *supra* Sections VII.A.7.e ([1D]) (identifying the same first signal from Rio), VII.A.7.l ([1K]) (identifying the same second signal from Rio).] For example, Rio discloses that "the controller 32 may receive . . . a ground engaging unit pivot position signal 122[] and a ground engaging unit rotational position signal 124" and uses these signals "to coordinate

activation of the first and second actuators 42, 44." [Ex. 1006 (Rio), 6:65-7:13, 8:38-41, Fig. 5.]

**c. [7B]: "determine a change of the first angular orientation based on the first signal;"**

179. CIII and Rio render obvious this feature. The Board previously found that CIII and Rio render obvious a similar feature. [*Supra* Section VII.A.4 (when comparing [7B] of the '723 patent to the '749 patent, explaining how the Board's findings mean that the Board found [7B] of the '723 patent to be within the scope of [17I] of the '749 patent); '749 FWD at 67-68, 95-96; *see* Ex. 1033, 24:26-33.] The modified CIII-Rio controller is configured to determine a change of the angular orientation of the swing leg relative to the machine frame ("first angular orientation") based on the pivot position signal 122 ("first signal"). [Ex. 1006 (Rio), 6:65-66, 7:11-12, 7:19-23.]

180. For example, Rio discloses that "pivot sensor 83 tracks" the movement of the swing arm 76 "and sends responsive pivot position signals 122 to the controller 32," which uses this signal to counter-rotate the one ground engaging unit 20 "to continuously and precisely offset the rotation caused by the pivoting, resulting in the one ground engaging unit 20 remaining parallel to the machine frame 12 at all points in the pivot arc." [Ex. 1006 (Rio), 8:31-47.] A POSITA

would have understood that this discloses the controller determining a change of the swing leg's angular orientation based on the signal from the pivot sensor 83.

**d. [7C]: "in response to determining the change of the first angular orientation, determine a target second angular orientation based on the determined change of the first angular orientation and the second angular orientation based on the second signal; and"**

181. CIII and Rio render obvious this feature. The Board previously found that CIII and Rio render obvious a similar feature. [*Supra* Section VII.A.4 (when comparing [7C] of the '723 patent to the '749 patent, explaining how the Board's findings mean that the Board found [7C] of the '723 patent to be within the scope of [17I] of the '749 patent); '749 FWD at 67-68, 95-96; *see* Ex. 1033, 24:26-33.] The modified CIII-Rio controller is configured such that, in response to determining the change of the angular orientation of the swing leg relative to the machine frame ("first angular orientation"), it determines a target second angular orientation for the crawler track based on the determined change of the first angular orientation and the angular orientation of the crawler track relative to the swing leg ("second angular orientation") based on the signal from the rotation sensor indicating the angular orientation of the crawler track relative to the swing leg ("second signal"). [Ex. 1006 (Rio), 2:52-57, 3:5-22, 4:47-50, 7:23-36, 8:31-9:14.]

182. For example, Rio discloses that the controller 32 receives signals from the pivot sensor 83 and rotation sensor 75 and "may send control signals to" the first and second actuators 42, 44. [Ex. 1006 (Rio), 7:19-33.] Rio discloses that the controller 32 uses the pivot position signals 122 to determine the change of the swing leg's angular orientation relative to the machine frame and "responsively actuates the second actuator 44 to counter-rotate the one ground engaging unit 20 to maintain it in the same running direction" as the swing leg pivots. [Ex. 1006 (Rio), 8:31-37.] Rio discloses that, "[a]s counter-rotation begins, the rotation sensor 75 sends rotation position signals 124 to the controller 32," which "uses the pivot and rotation signals 122, 124 to coordinate activation of the first and second actuators 42, 44 . . . in a manner to cause the counter-rotation of the one ground engaging unit 20 to continuously and precisely offset the rotation caused by the pivoting, resulting in the one ground engaging unit 20 remaining parallel to the machine frame 12 at all points in the pivot arc." [Ex. 1006 (Rio), 8:38-47.]

183. A POSITA would have understood that this discloses the controller, in response to determining the change of the angular orientation of the swing leg as it moves between different positions, determining a target angular orientation for the crawler track, i.e., an angular orientation that maintains it parallel to the machine frame, based on this determined change of the angular orientation of the swing leg and the second angular orientation based on the second signal.

**e. [7D]: "send a control signal to the slew drive in order to cause the second angular orientation of the crawler track to rotate to the target second angular orientation."**

184. CIII and Rio render obvious this feature. The Board previously found that CIII and Rio render obvious a similar feature of the '749 patent. [Ex. 1033, 24:27-30 ("emit a control signal for activating the power drive and thereby rotationally move the crawler track relative to the jacking column to maintain an orientation of the crawler track"); '749 FWD at 67-68, 95-96.] The modified CIII-Rio controller is configured to send a control signal to the worm-gear rotary actuator 44 ("slew drive") to cause the angular orientation of the crawler track relative to the swing leg ("second angular orientation of the crawler track") to rotate to the target second angular orientation. [Ex. 1006 (Rio), 2:52-57, 3:5-22, 4:47-50, 4:61-5:3, 7:28-36, 8:31-9:14.]

185. For example, Rio discloses that the controller 32 "may send control signals to" the second actuator 44. [Ex. 1006 (Rio), 7:19-33.] Rio discloses that the second actuator 44 is preferably "a rotary actuator" having a worm-gear design. [Ex. 1006 (Rio), 4:61-5:3.] Rio discloses that the controller 32 "responsively actuates the second actuator 44 to counter-rotate the one ground engaging unit 20 to maintain it in the same running direction" as the swing leg pivots. [Ex. 1006 (Rio), 8:31-37.] Specifically, Rio discloses that the controller 32 coordinates

"activation of the first and second actuators 42, 44 . . . in a manner to cause the counter-rotation of the one ground engaging unit 20 to continuously and precisely offset the rotation caused by the pivoting, resulting in the one ground engaging unit 20 remaining parallel to the machine frame 12 at all points in the pivot arc." [Ex. 1006 (Rio), 8:38-47.] A POSITA would have understood that this discloses the controller sending a control signal to the slew drive to cause the second angular orientation of the crawler track to rotate to the target second angular orientation.

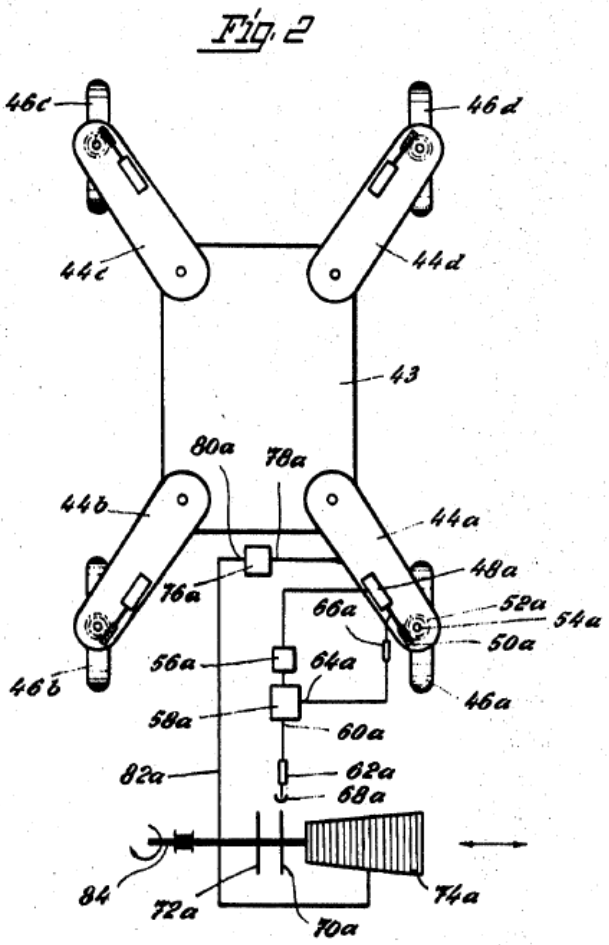
### B. Ground 2: Claim 6 Is Obvious over CIII, Rio, Files, and Tax

186. To the extent it is argued that CIII, Rio, and Files do not render obvious claim 6, this claim would have been obvious in view of the teachings of U.S. Patent No. 3,572,458 ("Tax"; Ex. 1016).

#### 1. Summary of Tax

187. Tax discloses "a steering system for individually steering the several wheels of a heavy vehicle," similar to CIII. [Ex. 1016 (Tax), 1:28-32.] Like CIII's paver, Tax's vehicle includes "four extension arms" that are "pivotally attached to the four corners of the platform," the free ends of which "carry respective wheels . . . so that the track width between the front wheels 46*c*, 46*d* and between the rear wheels 46*a*, 46*b* may be changed by pivoting the arms." [Ex. 1016 (Tax), 4:30-37.] Similar to Rio, Tax discloses steering each wheel by "driv[ing] a worm 50*a* in meshing engagement with a worm gear 52*a* on the upright shaft 54*a*." [Ex. 1016

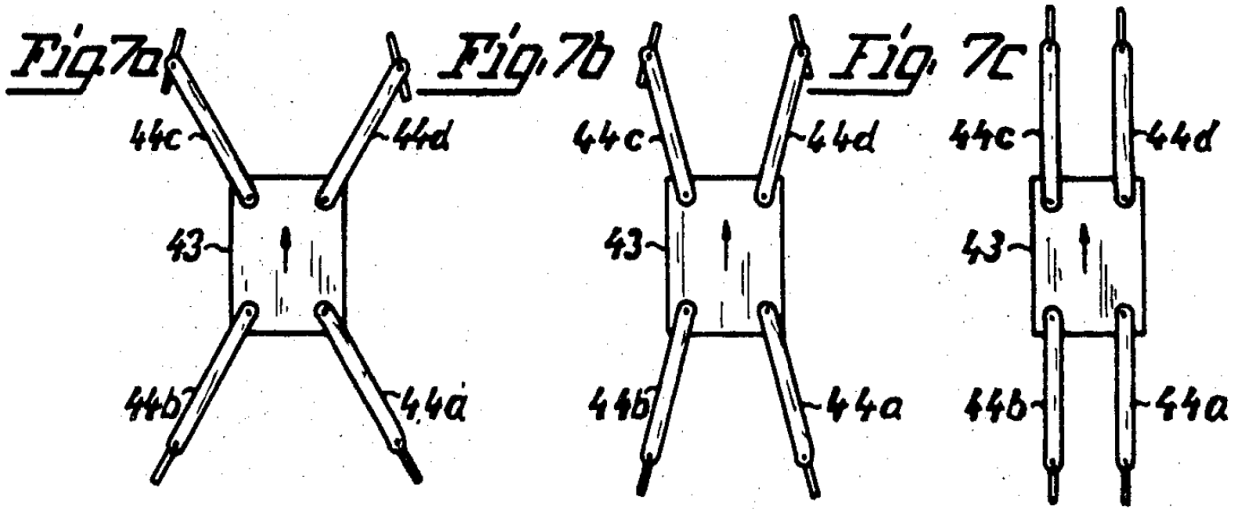
(Tax), 4:45-48.] An overhead view of the four swing arms and wheels of Tax is shown below.




[Ex. 1016 (Tax), Fig. 2.]

188. To narrow the width of the wheels while moving forward, which Tax refers to as narrowing the "track width," Tax discloses steering the wheels to the positions shown in Figure 7*a*, below, and driving forward so that the swing legs "are swung toward the median longitudinal plane of the carriage by friction between the wheels and the ground on which the wheels roll while supporting the

carriage, as is sequentially shown in FIGS. 7*a* and 7*c*," as shown below. [Ex. 1016 (Tax), 5:1-16.] Tax likewise discloses "reversing the angular positions" to increase the width. [Ex. 1016 (Tax), 5:16-18.]

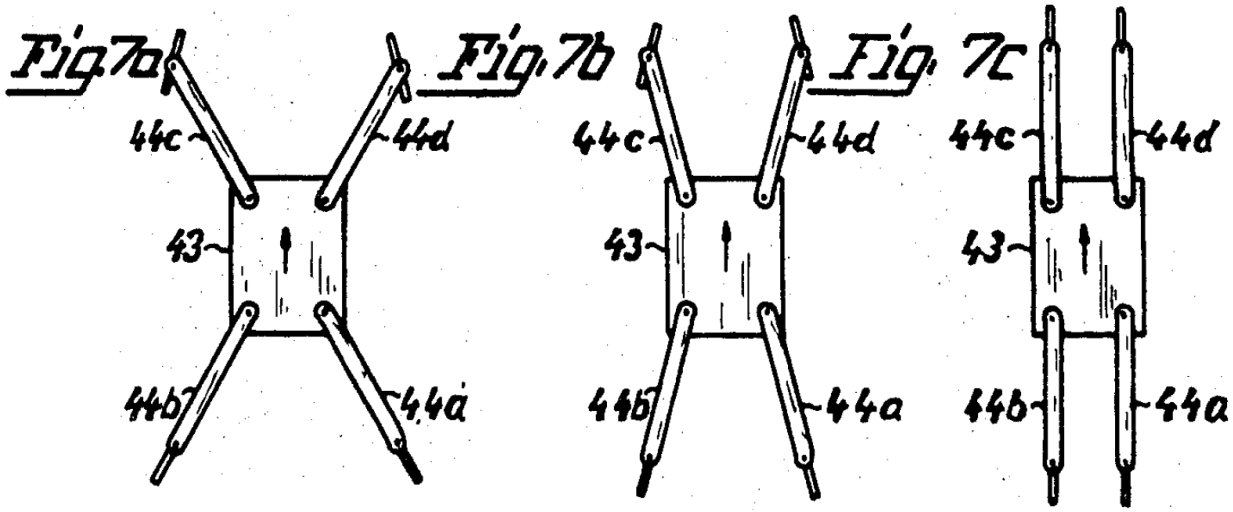



[Ex. 1016 (Tax), Figs. 7*a*-7*c*.]

**2. Claim 6: "The paving machine of claim 1, wherein the swing leg is configured to relocate the jacking column with the crawler track while moving and under load."**

189. CIII, Rio, and Tax render obvious this limitation. Tax discloses a vehicle with four swing legs, similar to CIII, that are configured to relocate the wheels and their corresponding vertical shafts while moving and under load. [Ex. 1016 (Tax), 2:45-53, 5:1-18.] For example, Tax discloses narrowing the "track width"—the spacing between two wheels—by steering the wheels to "the positions shown in FIG. 7*a*" and moving the vehicle forward so that "the arms 44*a*,

44*b*, 44*c*, 44*d* are swung toward the median longitudinal plane of the carriage by friction between the wheels and the ground on which the wheels roll while supporting the carriage, as is sequentially shown in FIGS. 7*a* and 7*c*." [Ex. 1016 (Tax), 5:10-16.] "Conversely, the initially parallel arms can be swung apart by reversing the angular positions of the wheel supports during forward movement." [Ex. 1016 (Tax), 5:16-18.]




[Ex. 1016 (Tax), Figs. 7*a*-7*c*.]

190. It would have been obvious to combine the CIII-Rio-Files paver with Tax to permit relocating the jacking column with the crawler track while moving and under load via the swing legs. Tax is analogous art to the '723 patent, for example, because it discloses a "heavy vehicle" having a steering system that "is light in weight, occupies relatively little space, yet is extremely versatile so as to permit the vehicle to perform complex movements without external auxiliary

devices." [Ex. 1016 (Tax), 1:28-32.] The vehicle includes four swing legs and wheels driven by worm-gear drives, and is concerned with repositioning those swing legs and wheels. [Ex. 1016 (Tax), 2:45-70, 4:30-48, 5:1-18, Figs. 2, 7*a*-7*c*.] It is, therefore, in the same field of endeavor and reasonably pertinent to the problem purportedly solved by the '723 patent.

191. A POSITA would have been motivated to provide the CIII-Rio-Files paver with the ability to similarly allow it to change the width of its crawler tracks while moving forward (and thus "relocat[ing] the jacking column with the crawler track while moving and under load," as claimed), thereby allowing it to avoid obstacles during paving and/or while maneuvering around a job site. For example, Tax discloses that increasing the swing-leg angles to form a "wide base" increases stability, but this orientation "may be too wide for travel . . . through narrow streets, and the track width of the vehicle must be reduced for this purpose." [Ex. 1016 (Tax), 5:1-7.] Additionally, it was known that such functionality would improve the operator's ability to "properly distribute weight on the work vehicle," further improving the CIII-Rio-Files paver. [U.S. Patent No. 6,311,795 ("Skotnikov"; Ex. 1017), 5:1-38.] A POSITA would have had a reasonable expectation of success at least for the reasons discussed in Section VII.A.12 ([6]) and due to the similarity between the CIII-Rio-Files paver and the Tax vehicle.

### C. Ground 3: Claims 1-7 Lack Written-Description Support

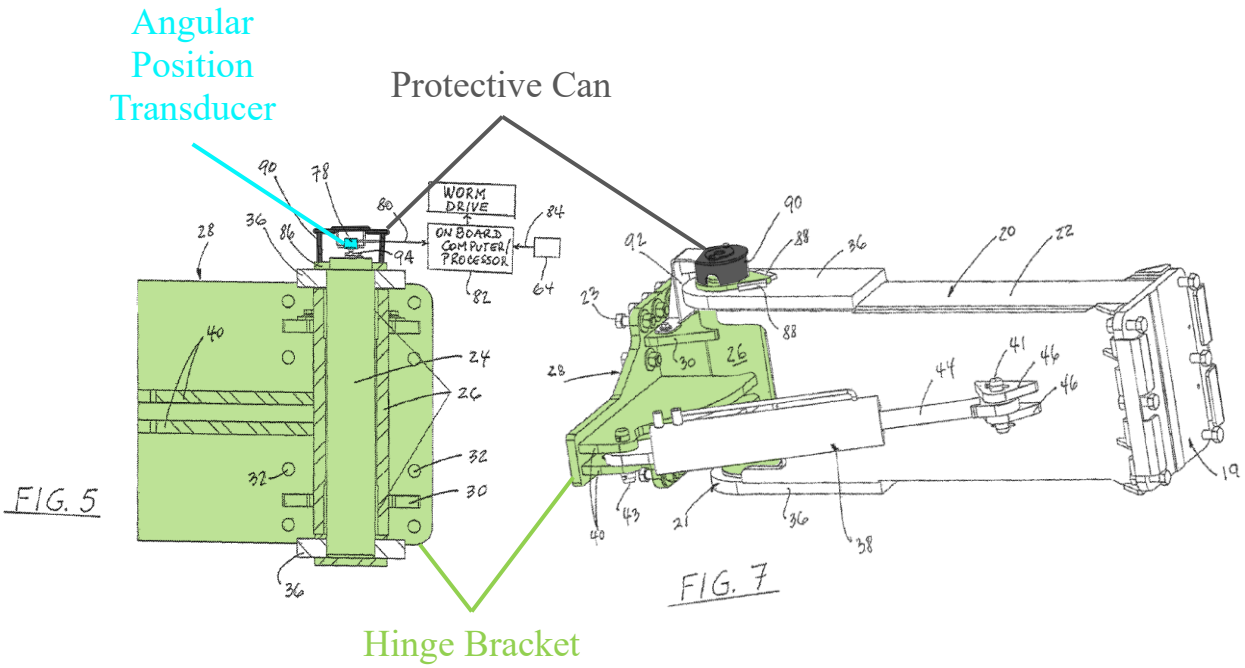
192. Claims 1-7 are unpatentable for lack of written description because the specification fails to describe a first angular position transducer that "is disposed on the modular frame or the swing leg," as recited in claim 1. I have been informed that, to provide adequate written description, the specification must reasonably convey to those skilled in the art that the inventor had possession of the claimed subject matter as of the filing date. I have been informed that a description that merely renders the invention obvious does not satisfy the requirement. I have been told that the written-description test is the same whether the claim element is essential or auxiliary to the invention.

193. Claim 1 recites "a plurality of swing legs, each swing leg coupled to a surface of the modular frame via a hinged bracket . . . , wherein ***a first angular position transducer is disposed on the modular frame or the swing leg*** to measure an angular position between the swing leg and the modular frame and further emit a first signal indicative of the measured angular position to an onboard computer or processor." [Ex. 1001 ('723 patent), 22:44-52 (emphasis added).] Accordingly, claim 1, and by dependency claims 2-7, includes a structural requirement for the first angular position transducer: it must be disposed on either the modular frame or the swing leg. The required support is lacking.

194. In every embodiment of the ’723 patent, the angular position transducer is disposed only on the hinged bracket—a separate component that couples each swing leg to a surface of the modular frame. [*E.g.*, Ex. 1001 (’723 patent), 12:14-39.] For example, the specification describes angular position transducer 78 as “mounted inside a downwardly open protective can 90, . . . which is bolted to hinge bracket 28 via an upright holding arm 92.” [Ex. 1001 (’723 patent), 12:28-30.]

195. The specification also discloses “[a] trigger pin 94 [that] projects upwardly from the top surface of pivot shaft 24 and cooperates with angular position transducer 78 to generate an angular position signal which reflects the angular inclination between the pivot shaft and the hinge bracket.” [Ex. 1001 (’723 patent), 12:31-38.] While the ’723 patent states that angular position transducer 78 “is placed on top of swing leg pivot shaft 24,” [Ex. 1001 (’723 patent), 12:15-17], the ’723 patent elsewhere makes clear that this pivot shaft is separate from the modular frame and the swing leg, [Ex. 1001 (’723 patent), 7:42-46 (describing an “upright pivot shaft that pivotally engages the swing leg” as part of the “hinge bracket”), 12:17-22 (describing “the top of the pivot shaft” as having “a generally drop-shaped head 86 that is engaged by blocks 88” fixed to the swing leg so that the pivot shaft “duplicates the angular movements of swing leg 20”).]

196. Annotated Figures 5 and 7, below, depict how the angular position transducer 78 is "placed on top of," and thus disposed on, the pivot shaft of the hinge bracket, rather than the swing leg or the modular frame. [Ex. 1001 ('723 patent), 7:42-46, 12:15-22, Figs. 5, 7.]




[Ex. 1001 ('723 patent), Figs. 5, 7 (annotated).]

197. Because the pivot shaft "duplicates the angular movements of swing leg 20 about the pivot shaft" and the hinge bracket is bolted to a surface of the frame, angular position transducer 78's "angular position signal which reflects the angular inclination between the pivot shaft and the hinge bracket" is a proxy for the angular inclination between the swing leg and the frame. [Ex. 1001 ('723 patent), 9:40-43, 12:15-22, 12:28-38.] But disposing the angular position

transducer on either "the module frame or the swing leg to measure an angular position between the swing leg and the modular frame and further emit a first signal indicative of the measured angular position," as claimed, is an entirely different configuration not disclosed in the '723 patent.

198. Accordingly, the '723 patent is lacking any description of an angular position transducer that "is disposed on the modular frame or the swing leg," as claimed. While the '723 patent discloses an angular position transducer disposed on a hinge bracket, the "hinged bracket" in claim 1 is a separate component that couples each swing leg to a surface of the modular frame, meaning the hinged bracket is neither the swing leg nor the modular frame. [Ex. 1001 ('723 patent), 22:44-47.]

199. The disclosure of an angular position transducer disposed on a hinge bracket does not provide written description for an angular position transducer disposed on either a modular frame or a swing leg. And even if one were to find that the hinge bracket is part of either the modular frame or swing leg (contrary to the claims and specification treating these all as separate components), the specification would only provide written description for *one* of the claimed alternatives. The claims would still lack written description for the other alternative. Claims 1-7 should, therefore, be found unpatentable for lack of written description.

*  *  *

200. In signing this declaration, I understand that the declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I acknowledge that I may be subject to cross-examination in the case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

201. I declare 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 further, that these statements were made with knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001.

202. I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Date: April 29, 2024

By: 
William Singhose

# APPENDIX A: LIST OF MATERIALS CONSIDERED

| Description |
|---|
| U.S. Patent No. 11,772,723 |
| Prosecution History for U.S. Patent No. 11,772,723 |
| Commander III New Generation Trimmer/Paver Operator/Service Manual G21 Controls ("CIII") |
| U.S. Patent No. 7,523,995 to Rio et al. ("Rio") |
| U.S. Patent No. 4,558,758 to Littman et al. ("Littman") |
| U.S. Patent No. 4,029,165 to Miller et al. ("Miller") |
| U.S. Patent Publication No. 2003/0173130 to Johns ("Johns") |
| GT-3200 Trimmer/Slipform Paver ("GT-3200") |
| U.S. Patent No. 5,127,335 to Whitaker ("Whitaker") |
| U.S. Patent No. 3,792,745 to Files ("Files") |
| U.S. Patent Pub. No. 2010/0181136 to Swasey et al. ("Swasey") |
| U.S. Patent Publication No. 2006/0042131 to Pinther et al. ("Pinther") |
| U.S. Patent No. 6,226,809 to Davies ("Davies") |
| U.S. Patent No. 3,572,458 to Tax ("Tax") |
| U.S. Patent No. 6,311,795 to Skotnikov et al. ("Skotnikov") |
| Robert L. Norton, *Machine Design: An Integrated Approach* (3d ed. 2006) |
| Erik Oberg et al., *Machinery's Handbook 25* (25th ed. 1996) |
| U.S. Patent Publication No. 2003/0152454 ("Albright") |
| Disclosure of Preliminary Claim Constructions and Extrinsic Evidence, *Guntert & Zimmerman Const. Div., Inc. v. GOMACO Corp.*, Case No. 5:20-cv-04007-CJW-KEM (N.D. Iowa Sept. 15, 2020) |
| Deposition Transcript of Kenneth Bryden, Ph.D., *Guntert & Zimmerman Const. Div., Inc. v. GOMACO Corp.*, Case No. 5:20-cv-04007-CJW-KEM (N.D. Iowa Aug. 13, 2020) |
| U.S. Patent No. 10,029,749 |
| *Godbersen-Smith Const. Co. v. Guntert & Zimmerman Const. Div., Inc.*, IPR2020-01698, Paper 80 (Apr. 12, 2022) |
| U.S. Patent No. 11,535,318 |
| U.S. Patent No. 10,589,807 |
| U.S. Patent No. 9,908,571 |
| U.S. Patent No. 9,708,020 |
| U.S. Patent No. 10,029,749 |
| U.S. Patent No. 10,053,167 |
| U.S. Patent No. 10,196,101 |

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|---|
| U.S. Patent No. 8,459,898 |
| Prosecution History for U.S. Patent No. 11,535,318 |
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