

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

PROVISUR TECHNOLOGIES, INC.,

Petitioner,

v.

TEXTOR MASCHINENBAU GMBH,

Patent Owner

Case IPR2024-00235
U.S. Patent No. 8,529,321

**DECLARATION OF PROFESSOR CHARLES REINHOLTZ, Ph.D. IN
SUPPORT OF PATENT OWNER'S RESPONSE TO *INTER PARTES*
REVIEW OF U.S. PATENT NO. 8,529,321**

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I, Charles Reinholtz, declare as follows:

I. INTRODUCTION

1. I am over the age of 21 and am competent to make this declaration. I make this declaration based on facts and matters within my own knowledge and on information provided to me by others, and, if called as a witness, I could and would competently testify to the matters set forth herein.

II. OVERVIEW AND MATERIALS CONSIDERED

2. I have relied upon my education, knowledge, and experience as well as the other materials as discussed in this declaration in forming my opinions.

3. For this work, I have been asked to analyze and opine on certain issues related to U.S. Patent No. 8,529,321 (“the ’321 Patent”) (Ex. 1001) and Provisur’s Petition for *Inter Partes* Review (“IPR”) of the ’321 Patent. In developing my opinions set forth herein, I have considered the materials cited or discussed in Provisur’s IPR Petition as well as the following additional materials:

- Deposition Transcript of Dr. John Collins (Ex. 2006)
- Light-emitting Diodes: A Primer (Ex. 2008)
- Principles of Physics (Ex. 2009)
- An aluminium nitride light-emitting diode with a wavelength of 210 nanometres (Ex. 2010)

4. I have considered these materials from the viewpoint of a POSITA as of the priority date of the ’321 Patent. For the purposes of this declaration, I have been asked to assume that the priority date of the ’321 Patent is October 24, 2007. I

note that my opinions provided in this declaration are made from the perspective of a POSITA as of this priority date of the '321 Patent, unless expressly stated otherwise.

III. QUALIFICATIONS

5. A copy of my curriculum vitae is attached as Appendix A. Below I provide a brief summary of qualifications relevant to my opinions set forth in this Declaration.

6. I earned my bachelor's degree in 1976, my master's degree in 1980, and my Ph.D. in 1983. All my degrees are in mechanical engineering from the University of Florida.

7. One key aspect of my graduate research was the design and analysis of mechanisms for the creation and conversion of motion and forces. My Ph.D. dissertation, entitled "Optimization of Spatial Mechanisms," presented a new approach for synthesizing mechanisms to produce complex three-dimensional motion while meeting specific practical constraints. This dissertation represented one of the earliest efforts to use computer-programmed numerical optimization tools for the design of three-dimensional mechanisms.

8. As reflected in my CV, in addition to my industry work, I have extensive experience as an academic. For example, I previously held positions at Virginia Tech as an assistant professor (1983-1988 (Tenured)), associate professor

(1988-1993), professor (August 1993), W.S. White Chair for Innovation in Engineering Education (Aug. 1996 to Aug. 1999), Assistant Department Head and ABET Review Chair (1996-2002), and Alumni Distinguished Professor (2002-2007). I am the recipient of the Virginia Tech Wine Award and Alumni Teaching Award, two of the highest honors awarded for teaching excellence at Virginia Tech. I also served as Chair of the Virginia Tech Academy of Teaching Excellence.

9. I am currently Emeritus Professor of Mechanical Engineering at Embry-Riddle Aeronautical University (ERAU) in Daytona Beach, Florida. From 2007 to 2017, I also served as Professor and Chair of the Mechanical Engineering Department at ERAU. In that capacity, I grew the department from an initial enrollment of 29 Bachelor of Science students to a department with an enrollment of over 400 students granting Bachelor's, Master's, and Ph.D. degrees.

10. My teaching and research have generally been focused on the design and analysis of machines, mechanisms, electro-mechanical systems, and robotics. My teaching has included courses on mechanisms and kinematics, mechanical design, controls, electro-mechanical systems, robotics, and project-based capstone design. Among the topics I routinely teach are the design and analysis of linkages, gears, gear trains, screws, clutches, escapements, and rotary-to-linear and linear-to-rotary motion mechanisms. I am also familiar with and teach the strategies used to control electromechanical systems and how to implement such strategies in

software. I have authored over 125 journal and conference papers in the areas of mechanisms, kinematics, robotics, and mechanical design. I also have co-founded three companies in the area of robotics and unmanned vehicle systems.

11. I am the co-author of *Mechanisms and Dynamics of Machinery*, a popular textbook published in 1987 by John Wiley. This textbook is focused on the design and analysis of mechanical devices and systems for the creation and transmission of forces and motion. Devices such as cams, linkages, gears, gear trains, screws, and intermittent-motion devices are discussed and analyzed in detail in the text. The text also includes software to implement many of the analytic approaches described in the text.

12. I am a Fellow in the American Society of Mechanical Engineers (ASME) and have held numerous other positions within that organization, including Associate Technical Editor, ASME Journal of Mechanical Design, and Paper Review Chairman and Proceeding Editor for the ASME Mechanisms Conference. I am also a member of Tau Beta Pi, Pi Tau Sigma, Sigma Xi, Epsilon Lambda Chi, and the Association for Unmanned Vehicle Systems International (AUVSI). I have received numerous honors and awards during my career in mechanical engineering, including receiving the Applied Mechanisms Conference Procter and Gamble Best Paper Award on two separate occasions and being awarded the National Applied Mechanism Conference South-Pointing Chariot Award for lifetime contributions to

the mechanisms community. Numerous other awards and recognitions are summarized in my CV. I have worked on over 65 funded research projects that have received grants totaling more than \$15 million.

13. I have served as an expert as identified in Appendix B, which lists my consulting work and prior testimony over the past 4 years. In addition to my broad mechanical design experience, I have twice served as an expert in the food processing industry. From 2000 through 2001 I worked on a case involving the clam processing and canning equipment. From 2020 through 2022 I served as an expert on two separate cases involving Weber food-processing equipment.

14. I am a named inventor on two patents: U.S. Patent 5,699,695 entitled "Spatial, Parallel-Architecture, Robotic Carpal Wrist," which issued on December 23, 1997; and U.S. Patent 4,998,942, entitled "Snubber Profile," which issued on March 12, 1991.

15. My education, work, teaching and research have helped me develop a broad base of knowledge regarding machine design and mechanical systems design including a broad understanding of mechanical systems that include conveyor systems, food-slicing equipment, motor-belt drives, weighing systems and weigh conveyors and load cells. My knowledge encompasses machines in general, as well as their structural members, components, control algorithms and software. This background qualifies me to evaluate the intellectual property involved in this case

from the perspective of a person of ordinary skill in the art ("POSITA") including under the qualifications identified in Section III of Provisur's Petition.

16. In the past four years, I have been deposed or testified at trial, ITC, and IPR proceedings in a number of cases representing both plaintiffs and defendants. These prior proceedings are detailed in Appendix B, attached to this declaration.

IV. RELEVANT LEGAL PRINCIPLES

17. I am not a lawyer, and I will not provide any legal opinions. Although I am not a lawyer, I have been advised certain legal standards are to be applied by technical experts in forming opinions regarding the meaning and validity of patent claims.

18. I understand that a patent claim is invalid if it is anticipated or obvious in view of the prior art, and that a claim can be unpatentable even if all of the requirements of the claim cannot be found in a single prior-art reference. I further understand that invalidity of a claim requires that the claim be anticipated or obvious from the perspective of a person of ordinary skill in the art at the time the invention was made.

19. I have been informed that a patent claim is invalid if it would have been obvious to a person of ordinary skill in the art. In analyzing the obviousness of a claim, I understand the following factors may be taken into account: (1) the scope and content of the prior art; (2) the differences between the prior art and the claims;

(3) the level of ordinary skill in the art; and (4) any so called “secondary considerations” of nonobviousness if they are present.

20. I have been informed that a claim can be obvious in light of a single prior art reference or multiple prior art references. I understand that to prove that prior art or a combination of prior art renders a patent obvious, it is necessary to:

- Identify the particular references that, singly or in combination, make the patent obvious;
- Specifically identify which elements of the patent claim appear in each of the asserted references; and
- Explain why a person of ordinary skill in the art would have combined the references, and how they would have done so, to create the inventions claimed in the patent. I further understand that exemplary rationales that may support a conclusion of obviousness include:
 - Combining prior art elements according to known methods to yield predictable results;
 - Simple substitution of known element for another to obtain predictable results;
 - Use of known technique(s) to improve similar devices (methods or products) in the same way;

- Applying a known technique to a known device (method or product) ready for improvement to yield predictable results;
- “Obvious to try” – choosing from a finite number of identified, predictable solutions with a reasonable expectation of success;
- Known work in one field of endeavor may prompt variations of the work for use in either the same field or a different field based on design;
- Incentives or other market forces if the variations are predicable to a person of ordinary skill in the art; and
- Some teaching, suggestion, or motivation in the prior art that would have led a person of ordinary skill in the art to modify the prior art reference or to combine the prior art reference teachings to arrive at the claimed invention.

21. I have been informed that, in considering obviousness, hindsight reasoning derived from the patent-at-issue may not be used.

22. I am informed that it is improper to combine references where the references teach away from their combination. I am informed that a reference may be said to teach away when a person of ordinary skill in the relevant art, upon reading the reference, would be discouraged from following the path set out in the reference, or would be led in a direction divergent from the path that was taken by the patent

applicant. In general, a reference will teach away if it suggests that the line of development flowing from the reference's disclosure is unlikely to be productive of the result sought by the patentee. I am informed that a reference teaches away, for example, if (1) the combination would produce a seemingly inoperative device, or (2) the references leave the impression that the product would not have the property sought by the patentee. I also am informed, however, that a reference does not teach away if it merely expresses a general preference for an alternative invention but does not criticize, discredit, or otherwise discourage investigation into the invention claimed.

23. I am informed that even if a *prima facie* case of obviousness is established, the final determination of obviousness must also consider "secondary considerations" if presented. In most instances, the patentee raises these secondary considerations of non-obviousness. In that context, the patentee argues an invention would not have been obvious in view of these considerations, which include: (a) commercial success of a product due to the merits of the claimed invention; (b) a long-felt, but unsatisfied need for the invention; (c) failure of others to find the solution provided by the claimed invention; (d) deliberate copying of the invention by others; (e) unexpected results achieved by the invention; (f) praise of the invention by others skilled in the art; (g) lack of independent simultaneous invention

within a comparatively short space of time; and (h) teaching away from the invention in the prior art.

V. BRIEF OVERVIEW OF THE '321 PATENT

24. The '321 Patent presents a novel apparatus for separating at least a portion of a fat cover from a flesh component of a meat product in an automated process that overcomes many of the drawbacks of conventional systems with “significantly lower economic effort.” Ex. 1001 at Abstract, 2:19-37. A meat product generally comprises three components: rind, fat, and flesh. *Id.* at 1:14-17. To remove portions of the fat cover, i.e., the rind and fat, the '321 Patent explains that conventional systems measured the thickness of the fat cover with an insertable probe that detected changes in brightness of different tissues. *Id.* at 1:18-36. In these systems, the “meat product is damaged by the insertion of the sensor,” particularly when one or more sensors have to be “inserted at multiple sites of the product for a reliable” fat thickness determination. *Id.* The non-contact measurements in the '321 Patent's invention determine “the thickness of a fat cover of a meat product without damaging the meat product[.]” *Id.* at 1:37-2:5 (describing exemplary optical non-contact measurements using light detectors and a CCD camera), 4:18-5:6.

25. The measured thickness of the fat cover is then “transferred from the evaluation unit of the measurement device” to a control unit of a cutting device. *Id.* at 5:24-28. This control unit “determines the anatomy of the meat product [] from

the measurement result” and then selects a stored “travel profile”—which are “[p]roduct-dependent or anatomy-dependent” profiles that “effect a change in the setting of the cutter bar in dependence on the feed of the meat product [] to be processed[.]” *Id.* at 5:24-43. In this way, the cutting device includes a cutting blade whose position “is variable relative to a product support” such that the “cutting blade position can be adapted to differently thick fat covers or the thickness can be set” for separation of a portion of the fat cover. *Id.* at 2:46-52.

26. In other words, the claimed invention measures the thickness of the fat cover and then removes portions of the fat cover based on this measurement. Both independent claims expressly recite this process. Independent Claim 1 recites “a measurement device for automatic *determination of the thickness of the fat cover*¹,” a “cutting device . . . for automatic separation of the fat cover from the flesh component *in dependence on the thickness determined by the measurement device*, wherein . . . a control unit [] *control[s] the position of the cutting blade in dependence on the thickness determined by the measurement device*[.]” Independent Claim 14 similarly recites “*determining the thickness of the fat cover* . . . [and] *setting a position of a cutting blade in dependence on the determined thickness* of the fat cover[.]”

¹ All emphases added unless indicated otherwise.

VI. THE ALLEGED PRIOR ART

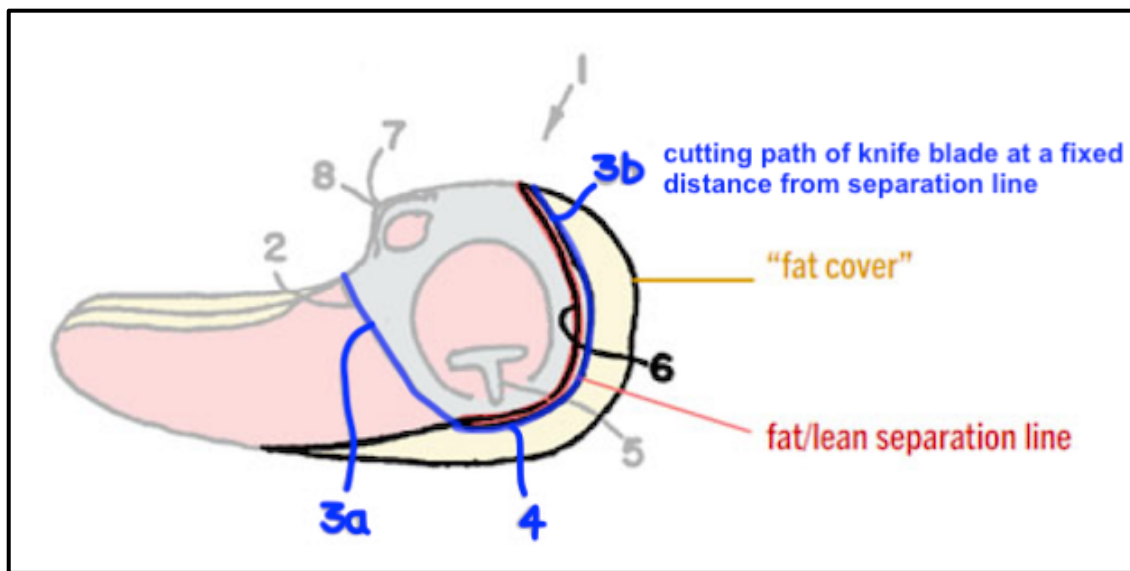
A. Young (Ex. 1004)

27. *Young* discloses a loin separation apparatus that simulates the motions of a human operator by addressing the problems of prior art systems by increasing control over its cutting actions. *Young*, Abstract, 2:55-58. *Young* performs its loin separation through the use of a control system including a loin knife assembly possessing a U-shaped knife blade with moving means to direct the cutting of the U-shaped blade in vertical and lateral directions. *Id.*, 4:17-25. *Young*'s embodiments all use imaging to determine or locate "a fat/lean separation line" on the side of meat; such that "the U-shaped knife blade" follows "*a preset distance from the fat/lean separation line*["*Id.*, 3:60-4:61.

28. *Young* describes multiple cameras, including fat/lean separation camera 198, which "provide[s] dynamic (real time) image data of the fat/lean separation line for the pork side proximate the backbone." *Id.*, 18:33-56. The fat/lean separation camera 198 permits the system to "make real-time adjustments to the profile of the loin knife assembly," to error correct and ensure "no data conflicts will occur" between the earlier generated "loin knife assembly profile." *Id.*, 21:62-22:2, 26:41-27:7.

29. In controlling the loin knife blade 121, *Young* consistently and repeatedly teaches that the *fat/lean separation line* serves as the reference point

guiding its knife blade. *Id.*, 20:60-63 (“The left side 121b of **knife blade 121** preferably follows line 3b, which is a fixed distance (preferably 0.1 inch) from fat/lean separation line 6, and which generally follows the contour thereof.”). The annotated figure 10c below is exemplary of the meat product cut by *Young*, featuring the fat cover (annotated yellow), fat/lean separation line 6 (annotated red), line 3a, 4, 3b (annotated blue) showing the cutting path of *Young*'s knife blade cutting (1) at a fixed distance from line 6 in 3b, (4) below bone 5 proximate the fat/lean separation line, and (2) following the scribe cut of the scribe saw:



Young, Fig. 10c (annotated); *id.*, 20:55-21:2 (describing the same).

30. Throughout its disclosure, *Young* makes clear that two variables define the cutting profile: the lean/fat separation line and the user-defined preset distance from the lean/fat separation line, which defines how much fat cover remains after cutting. *Id.*, 4:5-13 (“The controller includes image processing means for

determining backbone and fat/lean separation lines from the top plan image, profile calculating means for generating profiles for the vertical moving means and the first and second lateral moving means to control ... the second side of the U-shaped knife blade to follow *a preset distance from the fat/lean separation line*"); 4:36-38 ("the second side of the U-shaped knife blade *follows a preset distance from the fat/lean separation line*"); 4:57-59 ("the second side of the U-shaped knife blade to *follow a preset distance from the fat/lean separation line*"); 20:50-53 ("At the entry point into the pork side, the right side of the knife blade 121 enters at the scribe cut, and *the left side of the blade preferably enters 0.1 inches from the fat/lean separation line.*"); 25:17-24 ("Moreover, it is preferable to control servos 152, 154, 156 and 157 to locate the right side of the loin knife blade along the scribe cut, *locate the left side of the loin knife blade 0.1 inch from the corner point of the fat/lean separation line generated in routine 240, and locate the bottom of the loin knife blade 0.1 inch from the end fat/lean separation line generated in routine 240.*"); 25:65-26:2 ("The profiles of the right and left sides of the *knife blade are selected to follow fixed distances from* the backbone line and the *fat/lean separation line*, respectively, and the profile data for servos 152, 154, 156 and 157 are generated accordingly."); 26:13-16 ("During this period, however, the left side of the *knife blade is still controlled to follow the fixed distance from the fat/lean separation line* throughout the remainder of the loin pulling process."); 26:36-40 ("Returning

to block 216 in FIG. 11, the profile data for servos 152, 154, 156 and 157 are preferably dynamically modified to control the left side of the *knife blade to better follow a fixed separation from the fat/lean separation line* of the pork side.”).

B. Norrie (Ex. 1005)

31. *Norrie* describes an “[a]pparatus for the separation of back fat from a loin portion of a carcass” and “a device for sensing the thickness of back fat on the loin portion.” *Norrie*, Abstract. *Norrie* measures the thickness of the back fat on the loin using “a video camera and a light source indicated generally as 54[.]” *Id.*, 3:51-53. “[T]he camera [] will observe the thickness of fat on the underside of the loin lying on the conveyor” and “will then send appropriate fat signals to the computer.” *Id.*, 4:27-29. The computer then determines whether to adjust the position of blade 34 upward or downward from the conveyor by signaling blade solenoid 41. *Id.*, 4:28-33, 4:46-52. In other words, *Norrie* uses a basic camera system to move a single blade up or down, depending on the measured fat thickness.

C. Johnson (Ex. 1006)

32. *Johnson* discloses an “[a]pparatus and method for a meat cut classification and fat trimming for sensing the thickness of a layer of fat of a cut of meat and the various contours thereof” and “providing the fat thickness or classification information to a downstream system for performing a fat trimming operation.” *Johnson*, Abstract. *Johnson*’s apparatus and method for sensing the

thickness of fat is based on “a multi-probe mechanism assembly” used “to penetrate the meat cut for measuring the fat thickness.” *Id.*, 1:65-2:2. These probes possess “a somewhat pointed end portion such that when it is pressed against the meat cut penetration occurs into the fat layer and extends through the fat to lean transition.” *Id.*, 2:15-18. They “can be instrumented with a sensor that can determine when the probe extends through the fat to lean interface as well as instrumented with a linear encoder for sensing the amount of extension of the probe or the fat layer depth.” *Id.*, 2:18-22. These probes are “further operable to ***send a signal representative of the fat thickness or the location of the fat to lean interface.***” *Id.*, 2:22-24. *Johnson* teaches that its probes include sensors for detecting the fat/lean interface:

The probe also has a sensor assembly 252 emitting and receiving sensor signals. The sensor assembly emits a signal through a window of the pointed end of the probe and receives a reflected signal from the meat cut for sensing the fat to [lean] interface. Optical Technology or infrared sensor technology can be utilized or any other appropriate sensor technology.

Id., 7:58-67.

33. *Johnson* discloses that the “multiple probe penetrations into the meat cut ... gather[s] data to map the lean to fat interface contour[,]” further noting that “[t]he probes can then communicate the data representative of the lean to fat interface to a controller which is operable to interpret the information and generate

a signal responsive to the data or map of the contour that will vary the attack angle or angle of approach of the cutting blade to follow the contour of the lean to fat interface.” *Id.*, 4:51-59. Based on a signal of the fat to lean interface, the controller “will control the blade assembly to variably position the blade to follow the contour of the lean to fat interface.” *Id.*, 5:20-30.

D. Belk (Ex. 1007)

34. *Belk* discloses “[a]n image analysis (IA) system for scoring characteristics predictive of palatability and yield of a meat animal carcass or cut.” *Belk*, Abstract. This “IA system uses an imaging device [and] a data processing unit for processing image data” where the “results are identified with a particular piece of meat for further grading, sortation and processing.” *Id.* *Belk*’s image analysis system can use this imaging data to classify the subject meat product in different ways:

Image data can be used in subsequent calculation of the values of characteristics, the values being predictive of palatability, the characteristics including color and color variability of lean tissue, color and color variability of fat tissue, extent of marbling, average number and variance of marbling flecks per unit area, average size of marbling and the variance of average marbling size, average texture of marbling and lean tissue, firmness of lean tissue, density of lean tissue, density of fat tissue, and density of connective tissue.

Id., 4:26-35; *see also id.*, 9:59-10:1.

35. Belk teaches that its imaging device is “preferably a color video IA system.” *Id.*, 3:54-61. “Where the imaging device 12 is a visible light device such as a color camera, the image data can be analyzed for color scale parameters. If it is desired to conform to international standard, the image data can be analyzed for the color scale parameters L*, a*, and b*, as defined by the Commission Internationale d'Eclairage (CIE).” *Id.*, 8:25-30. Nearly the entirety of Belk's description of classifying product focuses on this color-based analysis. *See, e.g., id.*, 1:11-17 (“***The field of the present invention is prediction of meat palatability and yield.*** More specifically, the present invention relates to the prediction of meat palatability and yield ***by use of image analysis (IA) to determine the color parameters*** L* (psychometric lightness), a* (red vs. green), and b* (yellow vs. blue) or the tissue density of the lean and fat portions of a meat animal carcass or cut.”); 8:25-9:51 (describing classifications based on color data). Relevant to Ground 3, color data is used in Belk's system to characterize and distinguish between lean and fat. *Id.*, 9:2-6 (noting that certain “L*, a*, and b* scores [are] suggestive of . . . fat” and can be ignored when attempting to classify lean meat).

36. In addition to the color image information for classifying tissue types, Belk teaches that density information can be ascertained using imaging in the form of sound waves, tomographic imagers, etc. *Id.*, 9:9:53-58. Neither Petitioner nor its

expert discusses these alternative technologies with respect to any claim limitation, focusing their mapping exclusively on the camera-based embodiment.

VII. PETITIONER'S PROPOSED GROUNDS DO NOT ANTICIPATE OR RENDER OBVIOUS THE CHALLENGED CLAIMS

A. Ground 1: Young Does Not Anticipate—It Does Not Measure Fat Thickness or Use Fat Thickness to Determine a Cut Line

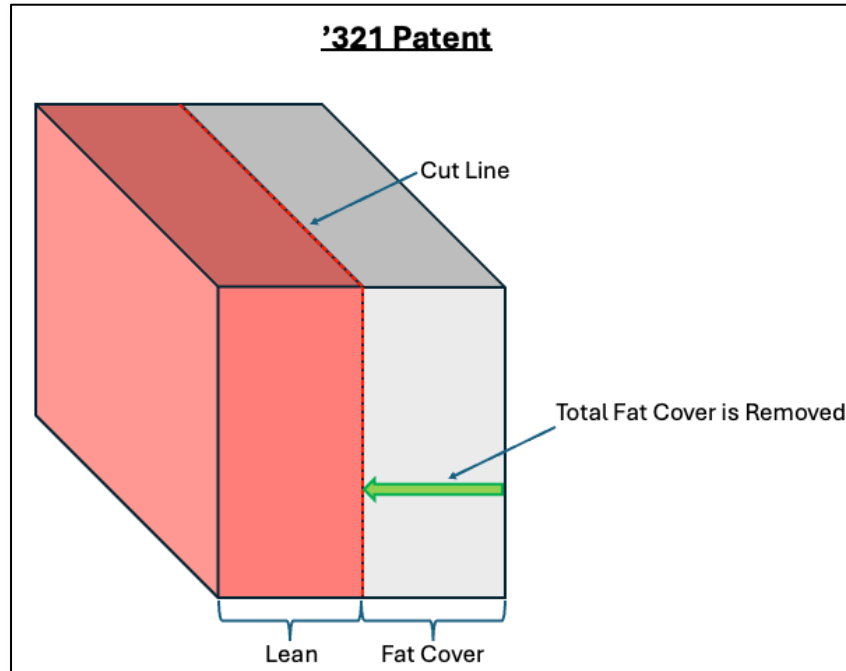
37. Claim 1 of the '321 Patent recites a “measurement device for automatic determination of the *thickness of the fat cover*, wherein the *determination of the thickness* of the fat cover takes place in a contactless manner” (Element 1A²). Ex. 1001 at 6:25-28. A “cutting device” is “coupled to the measurement device for automatic separation of the fat cover from the flesh component *in dependence on the thickness* determined by the measurement device” (Element 1B). *Id.* at 6:29-32. This cutting device is controlled by a “control unit for control of the position of the cutting blade *in dependence on the thickness* determined by the measurement device...” (Element 1D). *Id.* at 6:36-38; *see also* Petition at 10 (identifying commensurate limitations in independent claim 14 which fails for the same reasons herein). The claims on their face openly require (1) the thickness of the fat cover to be determined and (2) the fat to be removed (i.e., cut off) “in dependence on” this determined fat thickness.

² For consistency, I have used Petitioner's element references.

38. A POSITA would understand that *Young's* system, which determines its cut line ***without regard to how much fat cover is removed***, does not satisfy the '321 Patent's requirement that the cutting be made "in dependence on" the determined fat thickness. In other words, *Young's* system does not determine the thickness of the fat cover, nor does it make cut decisions "in dependence on" any fat cover thickness determinations. *Young* determines the cut line without regard to how much fat is removed. This is fundamentally different than the requirements of the '321 Patent claims, which require "determination of the ***thickness of the fat cover***," "automatic separation of the fat cover from the flesh component ***in dependence on the thickness*** determined by the measurement device" and a "control unit for control of the position of the cutting blade ***in dependence on the thickness*** determined by the measurement device..." Ex. 1001 at 6:25-42. The written description supports this understanding:

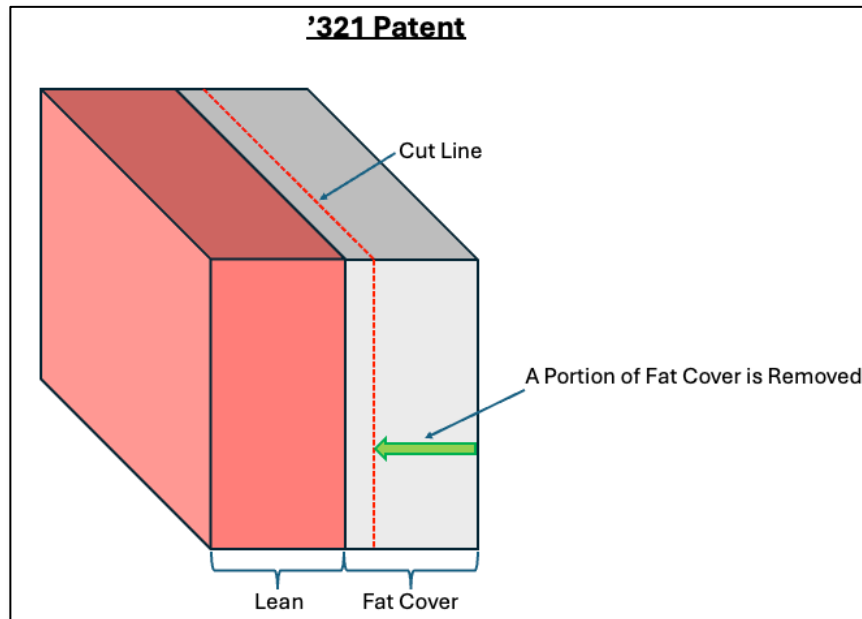
The control device selects a suitable travel profile with respect to the measured result of the determined anatomy of the meat product 12 and the height of the cutter bar is set by said travel profile ***in dependence on the thickness and on the shape of the fat cover*** and in dependence on the product feed so that a fat cover layer of a desired thickness is separated from the meat product 12 or so that a fat cover layer of a desired thickness remains at the flesh component of the meat product 12.

Id., 5:35-43. In other words, separating the fat cover or a portion of the fat cover from the meat product depends on the thickness or shape of the fat cover. For example, the claims do not necessarily require removing all fat after the thickness is determined. Rather, the '321 Patent acknowledges that the entirety of the fat cover can be removed or a desired thickness of fat cover can remain after some of the fat cover is removed. *See id.*, 5:40-43 (“a ***fat cover layer of a desired thickness*** is separated from the meat product 12 ***or*** so that ***a fat cover layer of a desired thickness remains*** at the flesh component of the meat product 12.”). In one example consistent with the Challenged Claims, the system determines the fat cover thickness and removes that fat cover in its entirety:



In another example consistent with the Challenged Claims, the system determines the fat cover thickness and removes only a portion of the fat cover, leaving a desired

portion of the fat cover thickness adjacent to the lean meat portion of the meat product.



Whether all or part of the fat cover is removed, the cut line must depend on the determined fat cover thickness. A POSITA would understand that a system that determines its cut line without regard to the thickness or shape of the removed fat cover cannot satisfy the claimed requirement that a fat cover is removed “in dependence on” the determined thickness of that fat cover.

39. Despite the unambiguous claim limitations in the '321 Patent requiring fat removal that depends on determined fat thickness, Petitioner advances an anticipation ground using *Young*—a reference that does not measure the thickness of the fat cover and that is agnostic as to the thickness removed from the meat

product. Petitioner's expert, Dr. Collins, admitted that the cut line in *Young* would not change in response to changes in fat thickness:

Q. If the meat product depicted in Figure 10c had an extra two inches of fat to the right, beyond what we're seeing here in Figure 10c, would the cut line change in Young's system?

...

A. Well, this is an illustration. There are no dimensions here.

Q. If we're just considering the dimensions that we can see in Figure 10c, would the cut line change as a result of additional fat cover thickness?

A. Well, again, this is an illustration. It's not a dimension drawing, so I don't know what the thickness is. But the whole idea here is that you want to remove the layer of fat and leave a certain amount behind. So the amount of fat will increase if the -- if the total amount of the -- ***amount of fat removed is going to increase if there's more fat, but the cut line is relative to the lean piece, and that won't change.***

Ex. 2006, 35:1-20. In other words, Petitioner's expert admits the cut position is ***not*** made "in dependence on" the determined thickness of the fat cover, as claimed. This deficiency is fatal to Petitioner's challenge based on Young.

40. Petitioner relies on Young's "imaging system 190" as the claimed "measurement device for automatic determination of the thickness of the fat cover[.]" Petition, 29-30. Petitioner asserts that this measurement device, through several cameras including "fat line camera 198," determines "a backbone line and a

fat/lean separation line on the side of meat.” Petition, 30-31, 35 (stating camera 198 is “primarily used to provide dynamic (real-time) image data of the fat/lean separation line for the pork side proximate the backbone”). According to Petitioner, “[c]ontroller 172 uses this information to dynamically modify the cutting profile of loin knife assembly 100 so that the assembly follows a fixed distance from the separation line to provide the optimum fat cover for the loin.” Petition, 35 (citing Ex. 1004, 18:33-40).

41. Young does not determine the thickness of the fat cover as required by the claims of the ‘321 Patent. Nor does Young need to determine this thickness. Young’s system simply identifies the line between the fat cover and the lean meat (fat/lean separation line) and uses this internal line as a reference for its cutting path. From this internal reference line, a user-defined offset value is added, allowing the user to define the amount of fat cover left behind after cutting:

The left side 121b of *knife blade 121 preferably follows line 3b, which is a fixed distance* (preferably 0.1 inch) *from fat/lean separation line 6*, and which generally follows the contour thereof. As discussed above, a 0.1 inch fat covering sufficiently keeps the loin from drying out, but doesn't make the loin look too fat. Other fat thicknesses may be desired in the alternative.

Ex. 1004, 20:60-66. Petitioner’s expert agreed that this fixed distance offset (i.e., the retained fat cover) is defined by the user:

Q. [] Let's talk about this offset. You note [] in paragraph 109 that a specific amount of fat can be retained, and you identified a 0.1 inch setting that allows .1 inches of fat to be retained beyond the fat/lean separation line. Do you see that?

A. I do.

Q. And have I described that accurately, that *that value is the amount of fat that is retained after the cut?*

A. *That's the goal, yes.*

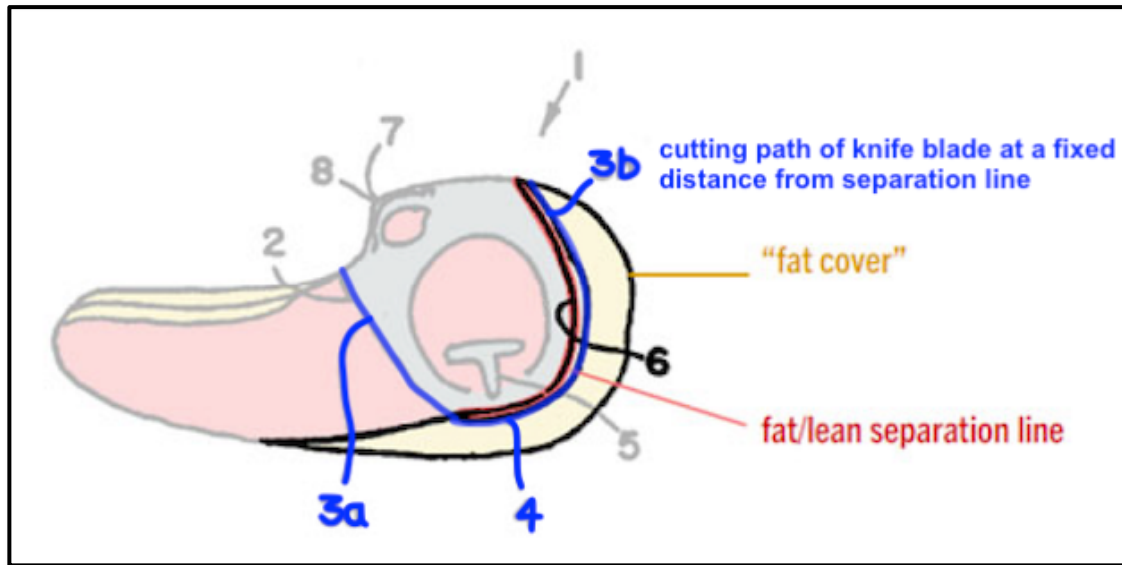
...

Q. And *that layer of fat that is retained is dictated by the value that the user inputs; correct?*

...

A. *That's my understanding.*

Ex. 2006, 33:7-34:21. Annotated Figure 10c below is exemplary of the meat product cut by *Young*, featuring the fat cover (annotated yellow), fat/lean separation line 6 (annotated red), line 3a, 4, 3b (annotated blue), showing the cutting path of *Young's* knife blade cutting (1) at a fixed distance from line 6 in 3b, (2) below bone 5 proximate the fat/lean separation area in 4, and in the same path of scribe saw cut 2:

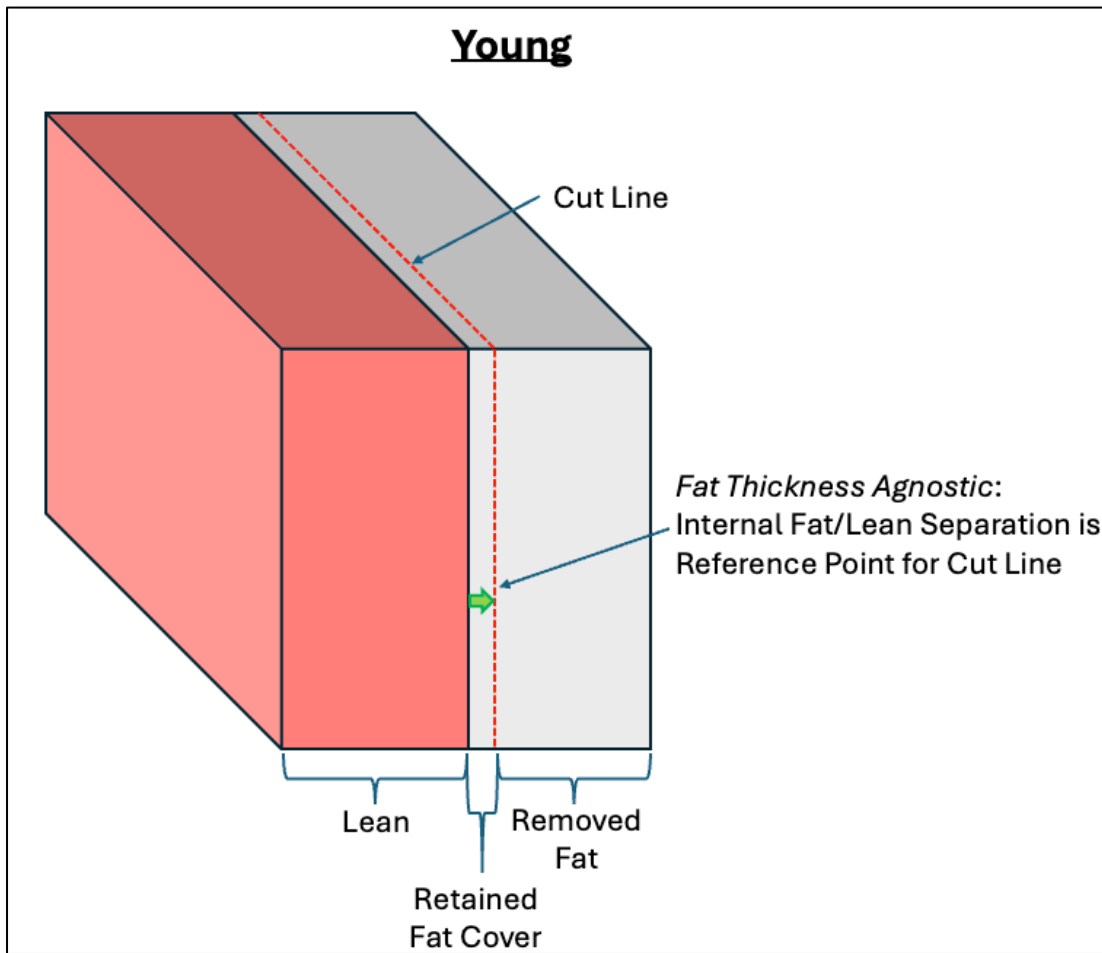


Young, Fig. 10c (annotated); *id.*, 20:55-21:2 (describing the same).

42. As shown, the cutting profile is defined by the lean/fat separation line and the user-defined preset distance from the lean/fat separation line, which defines how much fat cover remains after cutting. *Id.*, 4:5-13 (“The controller includes image processing means for determining backbone and fat/lean separation lines from the top plan image, profile calculating means for generating profiles for the vertical moving means and the first and second lateral moving means to control ... the second side of the U-shaped knife blade to follow **a preset distance from the fat/lean separation line**”); *see also id.*, 4:36-38 (follows a preset distance from the fat/lean separation line); 4:57-59 (follows a preset distance from the fat/lean separation line); 20:50-53 (knife cuts 0.1 inches from the fat/lean separation line); 25:17-24 (0.1 inches from the fat/lean separation line); 25:65-26:2 (follow fixed distances from the fat/lean separation line); 26:13-16 (knife is controlled to follow a fixed distance from

the fat/lean separation line); 26:36-40 (knife follows a fixed separation from the fat/lean separation line).

43. The following figure simplifies this cutting process described by Young:



The image above depicts the separation of a fat layer *in dependence on the fat/lean separation line* and without regard for the amount of fat removed. In other words, *Young* is agnostic as to the thickness of the fat cover and, therefore, does not determine the cut line in dependence on the fat thickness, as required by the claims

of the '321 Patent. Petitioner's expert confirmed that the cut line uses this internal line as a reference and that the cut line remains the same even if the fat thickness changes:

Q. If the meat product depicted in Figure 10c had an extra two inches of fat to the right, beyond what we're seeing here in Figure 10c, would the cut line change in Young's system?

...

A. Well, this is an illustration. There are no dimensions here.

Q. If we're just considering the dimensions that we can see in Figure 10c, would the cut line change as a result of additional fat cover thickness?

A. Well, again, this is an illustration. It's not a dimension drawing, so I don't know what the thickness is. But the whole idea here is that you want to remove the layer of fat and leave a certain amount behind. So the amount of fat will increase if the -- if the total amount of the -- *amount of fat removed is going to increase if there's more fat, but the cut line is relative to the lean piece, and that won't change.*

Ex. 2006, 35:1-20.

44. Young uses a reference curve, namely the fat/lean separation line, that is fundamentally different than the determined fat cover thickness as the basis for future cut line decisions. As Petitioner's expert admits, the cut line tracks the fat/lean separation line, and this tracking does not change with changing fat thickness. Therefore, a POSITA would understand that Young's system does not set that cut

line “in dependence on” a determined fat thickness, as claimed. I have reviewed *Young* and did not identify any teaching or suggestion in *Young* that its system ever determines how much fat is being removed, how much fat existed to begin with, or any other fat thickness-specific determination.

45. Neither Petitioner nor its expert identifies any such teaching in *Young*. Petitioner does, however, repeatedly suggest that a user can define the amount of fat cover removed by *Young's* system. This discussion confusingly conflates two distinct “fat covers.” Namely, Petitioner repeatedly quotes *Young's* teaching that a specific “fat cover” thickness is used to determine *Young's* cut line, suggesting that such a process satisfies the claimed process, which requires determining the thickness of the **removed** fat cover. For example, mapping the Claim 1 preamble, Petitioner initially acknowledges that the claimed “fat cover” is the fat removed from the meat product and then suggests that a user can choose how much “fat cover” is removed in *Young's* system:

[T]he claimed “fat cover” corresponds to Young’s “belly” layer that is removed along with fat and skin, and the claimed “flesh component of the meat product” corresponds to Young’s “loin.” (EX1003, ¶¶108-109; EX1004, Fig. 10c, 20:28-37.) As an example, Young states it can remove a fat covering layer thicker than 0.1 inch, and “[o]ther fat thicknesses may be desired in the alternative.” (EX1004, Fig. 10c, 20:28-37, 20:55-66.) A POSA would have appreciated that Young can fully remove the fat cover layer, and/or remove various thicknesses of

a fat cover layer, depending on the application and customer need.

(EX1003, ¶¶100-102, 108-113.).

Petition, 28. It takes a similar approach with claim 1[B], citing Young's discussion of a user-defined 0.1 inch "fat covering" and arguing that Young can remove specific fat thicknesses, depending on customer need:

Young states that "knife assembly 100 is used to separate the pork loin from the pork belly. . . . Through control of the knife blade along several axes, assembly 100 preferably produces an optimum separation between loin and belly, with a desired fat covering left on the loin."

(EX1004, 10:33-53.) Young states "preferably .1 inch [thick] fat covering sufficiently keeps the loin from drying out . . . Other fat thicknesses may be desired in the alternative [such as no fat covering remaining]." (EX1004, 10:33-53, 20:60-66 Figs. 1, 4, 7a-c.) As stated above, *Young can fully remove a fat cover layer of a range of thicknesses, depending on the application and customer need.*

(EX1003, ¶¶109.)

Petition, 33. In fact, *Young* says nothing about removing specific thicknesses of fat cover. Nor does *Young* suggest that the described system ever calculates how much fat is removed. *Young cannot* make any determination as to any fat thickness-specific determination because no fat thickness measurement is ever made by *Young*. Instead, as Petitioner's expert admitted on cross examination, these references in *Young* to a user-desired "fat cover" are the fat that is *retained* after cutting, rather than the fat cover removed, as required by the Challenged Claims. Ex. 2006, 38:4-

13 (conceding that “Young’s reference to ‘optimum fat cover for the loin’” is the portion of fat retained after cutting).

46. *Young* does indeed determine a specific thickness of fat to be retained on the pork loin after cutting. *See*, Petition, 33 (quoting Ex. 1004, 10:33-53) (“*Young* states that ‘knife assembly 100 is used to separate the pork loin from the pork belly. . . . Through control of the knife blade along several axes, assembly 100 preferably produces an optimum separation between loin and belly, ***with a desired fat covering left on the loin.***’”). But it does not teach or suggest ever calculating the thickness of fat cover removed from the loin, nor is the cut line made with reference to the fat cover. Accordingly, *Young* does not determine a fat cover thickness or separate fat from flesh “in dependence on” such a determination and does not anticipate the Challenged Claims.

B. Ground 2: Petitioner’s Proposed Combination of *Young* and *Norrie* Fails for Several Reasons

47. In an apparent recognition that *Young*’s system does not measure fat thickness, Petitioner’s Ground 2 briefly proposes supplementing *Young*’s system with *Norrie*’s imaging capabilities, which are allegedly used in *Norrie*’s system to measure fat thickness. Petition, 51-54. Neither Petitioner nor its expert propose any specific modifications to *Young*’s process, nor do they explain how *Young*’s fat thickness-agnostic process would make use of fat thickness information. Further, Petitioner’s expert admitted that *Norrie*’s camera provides no additional information

and that he saw no technical reason to replace *Young's* camera. Ex. 2006, 43:8-11.

Given this lack of detail, Ground 2 cannot make up for the deficiencies in Ground 1.

Further, *Norrie* and similar prior art references were disparaged by *Young* as being limited in the degree of control they provide over the loin knife and scribe saw. This weighs against the combination.

1. Petitioner Fails to Explain with Particularity the Proposed Combination, and Its Expert Admits Norrie is Redundant of Young

48. I understand that to satisfy its burden of proving obviousness, a petitioner cannot simply provide conclusory statements. Rather, the petitions must articulate specific reasoning, based on evidence of record, to support the legal conclusion of obviousness. Furthermore, focusing on purported benefits without explaining how the combination would work in the first place cannot satisfy this burden. The Petition here fails to provide the requisite specificity.

49. Petitioner dedicates fewer than three pages of analysis to Ground 2. Petitioner proposes that: (1) *Norrie* discloses “sensing the thickness of back fat” on a loin using a camera and light source 54; (2) *Young* mentions *Norrie* in its background and notes *Norrie's* advantages over old manual fat measurement systems; (3) *Young* generally describes that its design can be modified; and (4) therefore it would have been obvious “to apply the determination of thickness by the

camera and controller taught in *Norrie* in the context of *Young's* camera.” Petition, 51-54.

50. What Petitioner does not propose or discuss is how *Young* is modified by *Norrie*. I understand that the law demands specificity, which the Petitioner fails to provide. Further, what little detail the Petition did include was contradicted by Petitioner's own expert. For example, the Petition suggests that *Norrie's* camera would supplant one or more of *Young's* cameras. Petition, 53 (arguing that “[a] POSA would have been able to apply the determination of thickness by the camera and controller taught in *Norrie* in the context of *Young's* camera” and that the “combination would only require routine modifications, like changing the cameras and connecting the components”). Petitioner's expert, however, testified that *Norrie's* camera would provide no benefit to *Young*:

Q. [] Is there any technical reason to add *Norrie's* camera 54 to *Young's* system?

A. I don't see why. ***I think they could use the existing cameras of Young.***

Q. And that -- specifically, that would be *Young's* fat line camera 198 that would be used to serve the same purpose as *Norrie's* camera?

A. Yeah, I'd have to go back and check. I think -- I have to go back and check to see if *Norrie* uses the overall height of the -- of the product in the analysis. I'd have to go back and check.

Q. Okay. Can you check that? I want to just make sure I understand . . . what you[r] theory is here.

A. Yeah, my review of Norrie, *I don't believe there needs to be a different camera than the – than the Young fat line camera.*

Ex. 2006, 43:6-44:2.

51. Regarding proposed functionality that may be ported from *Norrie* to *Young*, Dr. Collins provides only a high-level description of the combination's goal:

As an example **a POSA could modify Young's controller 172's processing to determine thickness as in Norrie's computer 64.** This would be a routine software modification within the level of skill of a POSA.

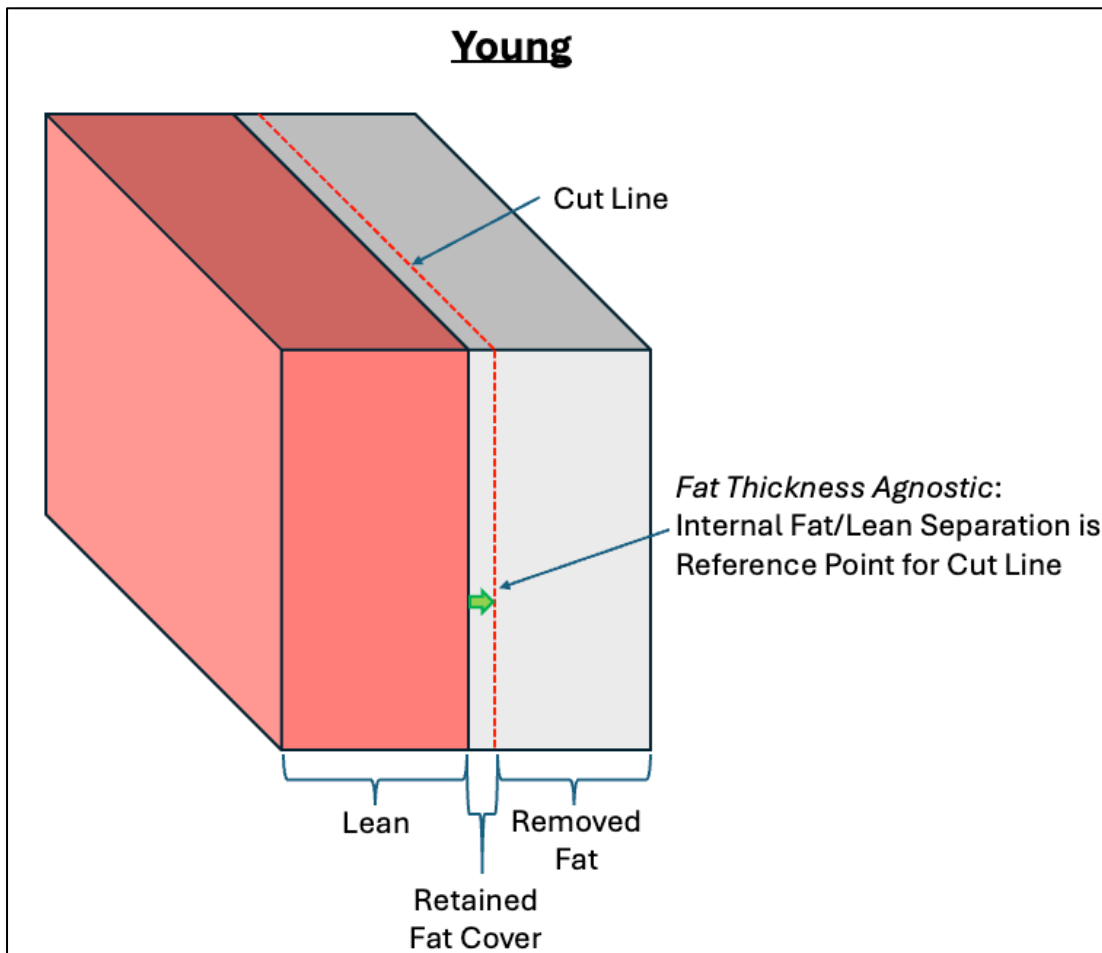
Ex. 1003, ¶177. But the same basic question remains: How is *Young's* processing being modified? There is simply no explanation by Petitioner or its expert as to how *Young's* system would be modified based on the teachings of *Norrie*. On cross examination, Dr. Collins appeared to concede that no functionality from *Norrie* would have been incorporated into *Young*, acknowledging that “*Norrie, frankly, is redundant of what's already disclosed in Young*, that everything is disclosed in *Young*.” Ex. 2006, 41:13-17.

52. If Petitioner and its expert are correct that *Norrie* is functionally redundant of *Young* and adds no additional components to the combination, a POSITA would not have been motivated to combine the two references. It's a straightforward design/engineering proposition that systems aren't changed when such changes have no functional or hardware benefits. Accordingly, absent any

explanation or identification of benefits that compel modification, a POSITA would not have been motivated to modify *Young* pursuant to *Norrie*.

53. In my opinion, a POSITA would not have been motivated to combine the teachings of *Young* and *Norrie*. A POSITA would not have looked to any fat thickness determination in *Norrie* because *Young*'s process is agnostic to fat thickness. As I discuss above in detail regarding Ground 1, *Young* determines its cut line based on only the lean/fat separation line and the user-defined preset distance from the lean/fat separation line, which defines how much fat cover remains after cutting. *Id.*, 4:5-13 ("The controller includes image processing means for determining backbone and fat/lean separation lines from the top plan image, profile calculating means for generating profiles for the vertical moving means and the first and second lateral moving means to control ... the second side of the U-shaped knife blade to follow ***a preset distance from the fat/lean separation line***"); *see also id.*, 4:36-38 (follows a preset distance from the fat/lean separation line); 4:57-59 (follows a preset distance from the fat/lean separation line); 20:50-53 (knife cuts 0.1 inches from the fat/lean separation line); 25:17-24 (0.1 inches from the fat/lean separation line); 25:65-26:2 (follow fixed distances from the fat/lean separation line); 26:13-16 (knife is controlled to follow a fixed distance from the fat/lean separation line); 26:36-40 (knife follows a fixed separation from the fat/lean separation line). As I discussed above how *Young*'s fat removal process uses an

internal line, the fat/lean separation line, as a reference when determining the cut line. The cut line determination is agnostic to the fat cover thickness and the amount of fat being removed and, therefore, the cut line does not depend on measured fat thickness as required by all the claims of the '321 Patent. Instead, as illustrated below, the cut line depends on an internal fat/lean separation line and a user-defined desired amount of retained fat cover:

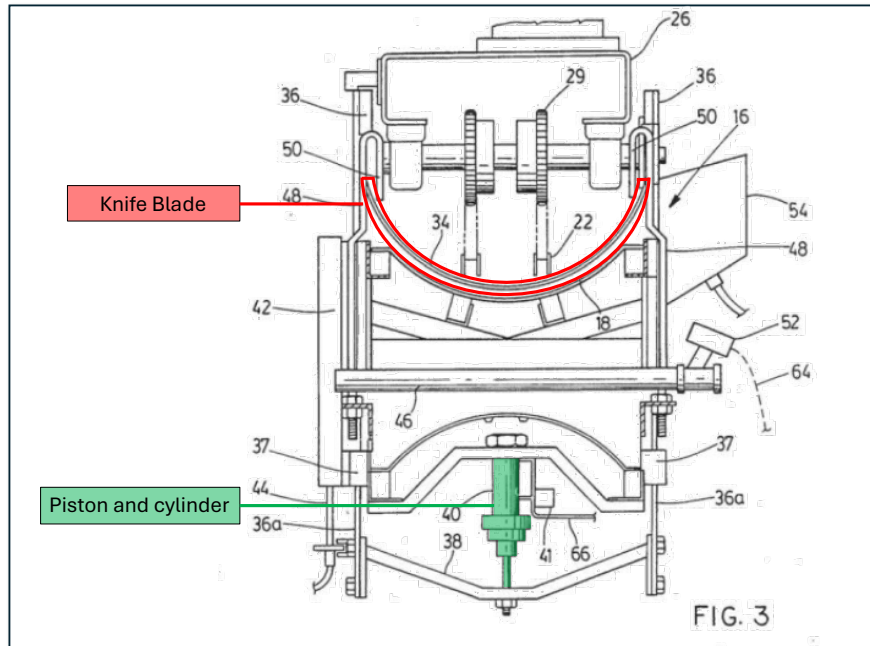


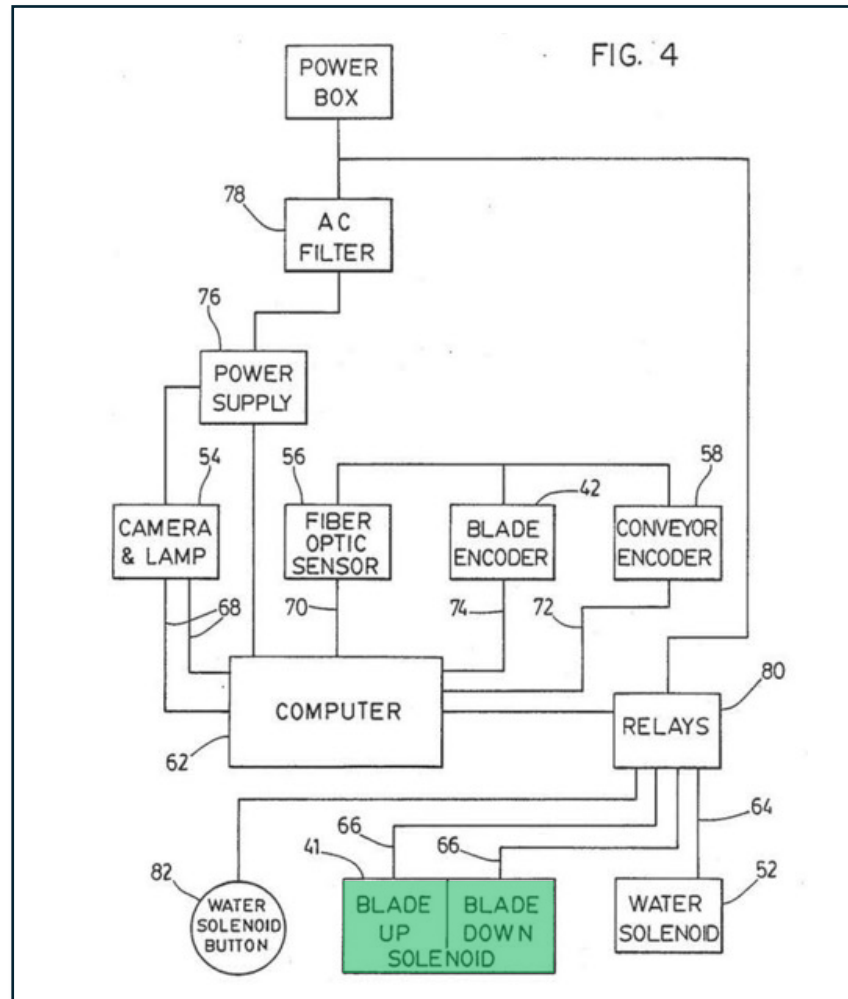
Accordingly, determining the fat thickness provides no utility to *Young's* process, and a POSITA would not have been motivated to add any such functionality from *Norrie* into *Young's* system.

2. *Young Teaches Away From Norrie*

54. Beyond the lack of detail, Ground 2 fails because *Young* teaches away from *Norrie*. Petitioner acknowledges that *Young* expressly discusses *Norrie*, but fails to address *Young's* characterization of *Norrie* as limited in the degree of control it could provide. Petition, 52-53. Namely, Petitioner states that a POSITA “would have been directed immediately to *Norrie* for increased imaging functionality.” Ex.1003, ¶176; Petition, 53. In support of this contention, Petitioner cites to *Young*, 2:18-29, which states, in part, that *Norrie* is one example of “[m]any [] systems attempt[ing] to replace human operators with automated loin knives and scribe saws, often resulting in more efficiency and more repeatable results.” Petition, 53; Ex. 1003, ¶176. But Petitioner does not mention that, immediately following this citation, *Young* disparages systems such as *Norrie*: “However, many prior automated systems are **limited in the degree of control** they provide over the loin knife and scribe saw. In particular, many systems only allow adjustment of a loin knife and/or a scribe saw in **at most one or two axes or motion.**” *Young*, 2:30-34. As discussed above, *Norrie* is indeed a system that controls its cutting blade with only one axis of motion with a single blade solenoid 41. As illustrated below, *Norrie* includes a knife

blade 34 which “may be moved upwardly and downwardly” with a “piston and cylinder 40, controlled by blade solenoid 41.” Ex. 1005, 3:27-31. *Norrie* does not describe blade movement other than teaching that the blade “can be raised and lowered.” *Id.*, 3:33.





Ex. 1005, Fig. 3 (annotated to highlight knife blade and piston/cylinder) and Fig. 4 (to highlight the “blade up” “blade down” solenoid). Accordingly, *Norrie* only discloses a single axis of blade motion.

55. Petitioner adds that *Young* would look to add additional imaging or motion functionality “to provide *more sophisticated profiles* using the preferred scribe saw and knife assemblies.” Petition, 53. However, as *Norrie*’s cutting profile is limited to a single axis of motion, a POSITA would have understood that *Norrie* did not provide a more sophisticated profile but a simpler, less sophisticated profile.

For example, *Young* discloses at least three axes of motion for each side of the U-shaped knife blade “used to control the positioning of loin knife assembly 100 about different axes.” Ex. 1004, 11:38-39. Specifically, *Young* discloses a rotational servo, a climb/dive servo, and a lateral servo. These servos enable the knife blade to rotate along the longitudinal axis of the pork side, to be raised and lowered relative to the pork side, and to be displaced laterally relative to the pork side, respectively. *See, id.*, 11:41-12:17. A POSITA would have understood that *Norrie*'s limited control directly corresponds to *Norrie*'s simplistic imaging system that only controls a single up-down blade solenoid. *See*, Ex. 1005, 3:51-59 (describing a camera observing the fat cover thickness) and 4:27-53 (describing adjusting the knife blade either up or down or no adjustment). *Young* describes “conventional automated systems” like *Norrie*, “are ***limited in the degree of control they provide*** over the loin knife and scribe saw” and “are not capable of separating [meat products] at the optimum points of separation, ***often resulting in unacceptable waste product and lower yields.***” *Id.*, 2:28-43.

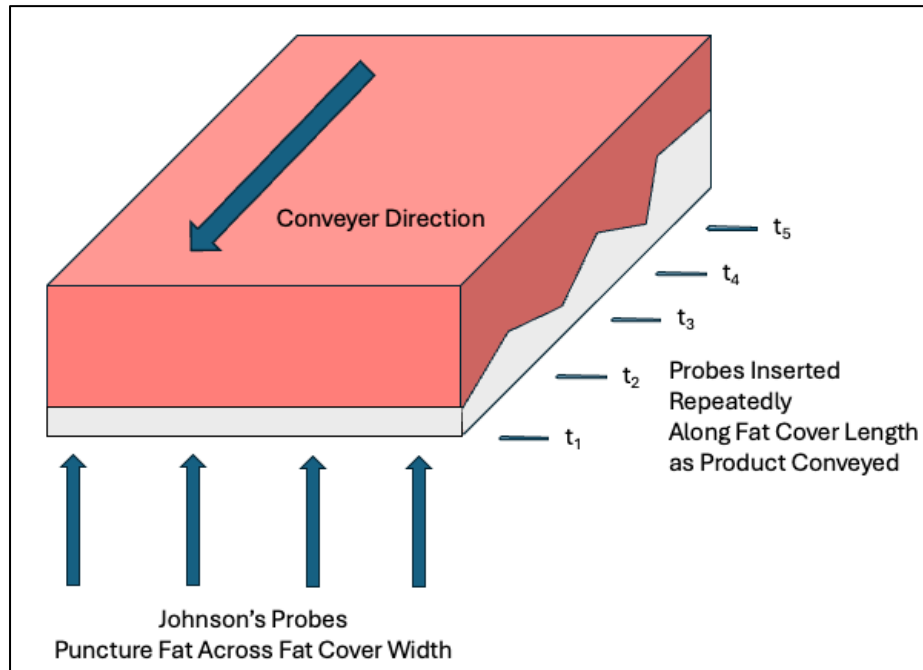
56. I understand that when a POSITA, upon reading the reference, would be discouraged from following the path set out in the reference the prior art reference is said to teach away. Here, *Young* expressly identifies *Norrie* as a known prior art system and criticizes systems like *Norrie* for their lack of control, resulting in “unacceptable waste product and lower yields.” Ex. 1004, 2:42-43 (“Thus,

conventional automated systems often are not capable of separating loins from bellies at the optimum points of separation, often resulting in unacceptable waste product and lower yields.”). A POSITA would have agreed with *Young*’s assessment of *Norrie*—*Norrie*’s single axis blade movement is a less sophisticated approach to the problem that *Young* sought to improve upon. For example, whereas *Norrie* teaches a single measurement of fat thickness based on a single camera with a subsequent single axis blade movement (Ex. 1005, 3:51-59 and 4:27-53), *Young* teaches a camera and controller to dynamically modify the cutting profile of the loin knife relative to the fat/lean separation with subsequent servo control of at least three axes of movement of the knife (Ex. 1004, 18:33-46 and 11:41-12:17). In light of *Young*’s clear disparagement of *Norrie* (and other systems like *Norrie*), a POSITA would have been discouraged from implementing *Norrie*’s simple approach in *Young*’s more sophisticated system.

C. Ground 3: Johnson and Belk are Technically Incompatible

57. Petitioner’s Ground 3 proposes replacing *Johnson*’s probe-based fat thickness measurement with *Belk*’s camera system. Petition, 54-55 (proposing that “Johnson’s loin separator . . . is improved with Belk’s imaging capabilities”). In support, Petitioner takes the position that a POSITA would “expect success in modifying Johnson via removing its probe assembly, and installing a different sensor system, such as Belk’s imaging system, with a clear view to capture image data of a

meat product as it is conveyed through Johnson's apparatus." Petition, 65. But neither Petitioner nor its expert acknowledge a fundamental incompatibility between *Johnson's* probe assembly and *Belk's* imaging system. *Johnson's* assembly detects fat thickness by physically inserting probes into the skin and through the fat until a fat/lean line is detected. As depicted below, it does this both across the width of the meat product, using an array of probes, and along the length of the meat product, repeatedly probing the fat cover over time (e.g., t_1 - t_5) as the meat product is conveyed. The below graphic illustration of *Johnson's* probe assembly shows probes aligned laterally across the width of the meat product. As the meat product is conveyed, the probes are inserted repeatedly into the meat product. This repeated insertion, measurement, re-insertion and re-measurement of the probes occurs along the entire length of the meat product over time, as indicated by t_1 - t_5 probe insertion points/times:



From these probe-based measurements, *Johnson* creates a three-dimensional map of the fat cover, capturing fat thickness across the full fat cover of the loin, including fat thickness in the center of the loin. This three-dimensional map is used to control an array of cutting blades, allowing high precision fat trimming that accommodates fat thickness changes across the width and length of the fat cover. In contrast, *Belk's* camera system merely detects the color differences between fat and lean by imaging a ***cross section*** of the meat product at a single face of the meat product. It cannot ascertain fat thickness below the surface (i.e., the interior) of the meat product, meaning it cannot collect any fat thickness data between the edges of the meat product—front-to-back or side-to-side. Accordingly, *Belk's* camera system cannot provide the same information as *Johnson's* probes—in particular, *Belk's* camera system images only the outermost face while *Johnson's* probes measure the interior

of the meat product —and would make it impossible to produce *Johnson's* three-dimensional map. Giving up the three-dimensional map feature in *Johnson's* system by limiting fat thickness information to the surface of the meat product forfeits a significant express advantage of the *Johnson* system. I do not believe a POSITA would accept such a reduction in capability.

1. Johnson is Designed to Probe Beef Strip Loins Across Their Width and Length to Detect and React to Changes in Fat Thickness

58. As an initial matter, the purpose and operation of *Johnson* is critical to understand why Ground 3 fails. *Johnson* begins by noting that the contours of fat/lean on a beef strip loin are unpredictable, requiring difficult manual removal in the prior art:

The contour of the fat/lean on a beef strip as well as on other meat cuts *is erratic* and testing has shown no correlation. Therefore humans need to physically remove the thick fat cover from the beef strip and similar cut of meat.

Ex. 1006, 1:18-21. To account for this fat/lean variability, *Johnson* proposes repeatedly detecting the fat depth as the product travels down the conveyor:

The present invention is a meat cut classification and fat trimming method and apparatus for *sensing or classifying the thickness of a layer of fat* of a cut of meat *and the various contours thereof as it travels along a conveyance path* and providing the fat thickness or

classification information to a downstream system for performing a fat trimming operation.

Id., 1:50-55. To obtain this continuous information across the products complete fat cover, *Johnson* uses a series of probes that repeatedly puncture the fat side of the strip during conveyance—both across the width via multiple probes and along the length via multiple punctures over time as the meat is conveyed:

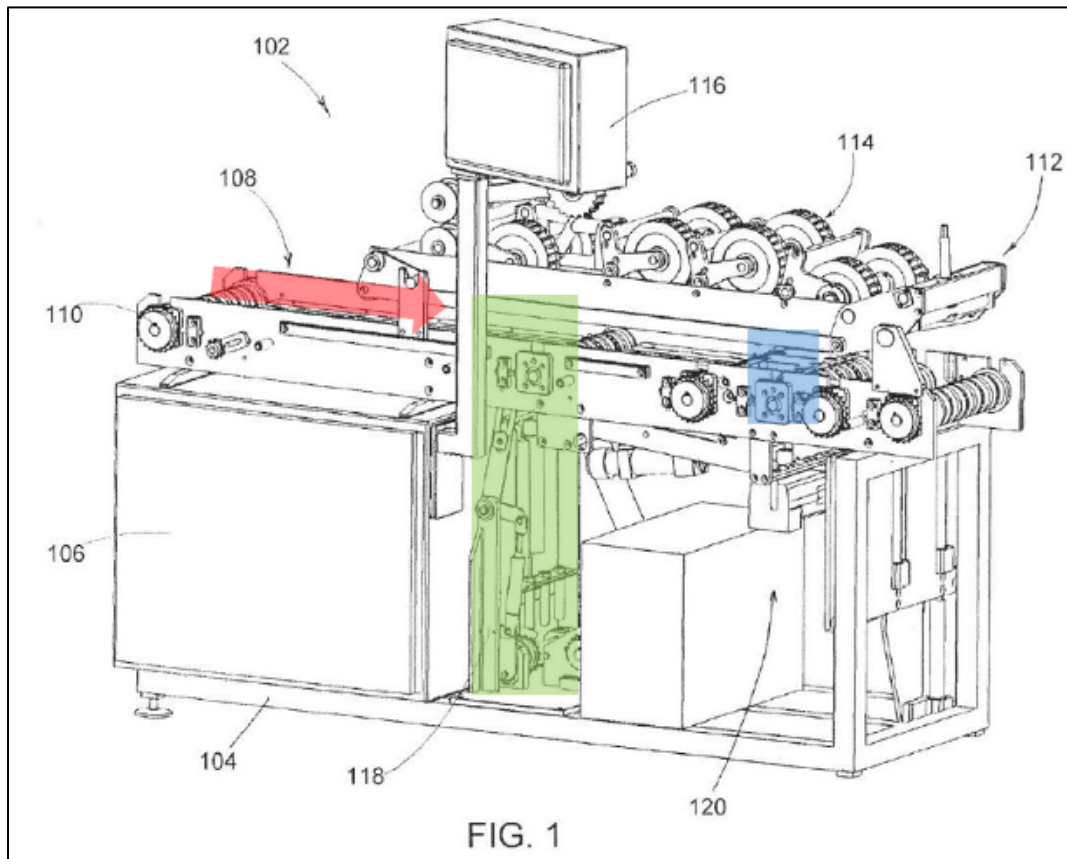
The probe can be an elongated instrument having a somewhat pointed end portion such that when it ***is pressed*** against the meat cut penetration occurs ***into the fat layer and extends through the fat to lean transition.***

The probe can be instrumented with a sensor that can determine when the probe extends through the fat to lean interface as well as instrumented with a linear encoder for sensing the amount of extension of the probe or the fat layer depth. The probe is further operable to send a signal representative of the fat thickness or the location of the fat to lean interface. ***Multiple probe insertions into the meat cut are utilized to gather multiple data points for creation of a continuous function three dimensional (3D) map.***

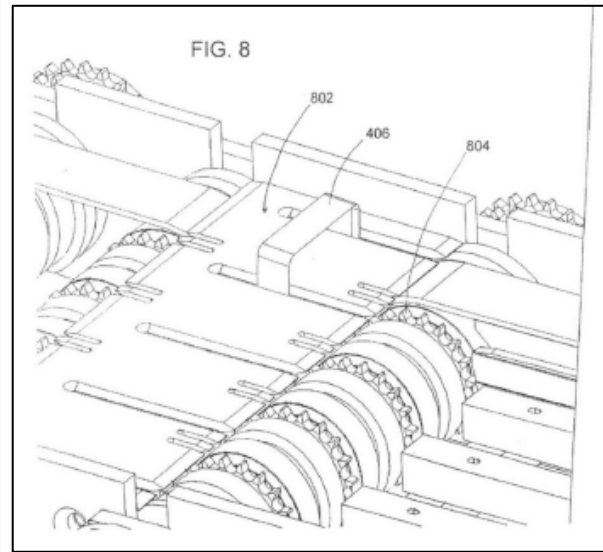
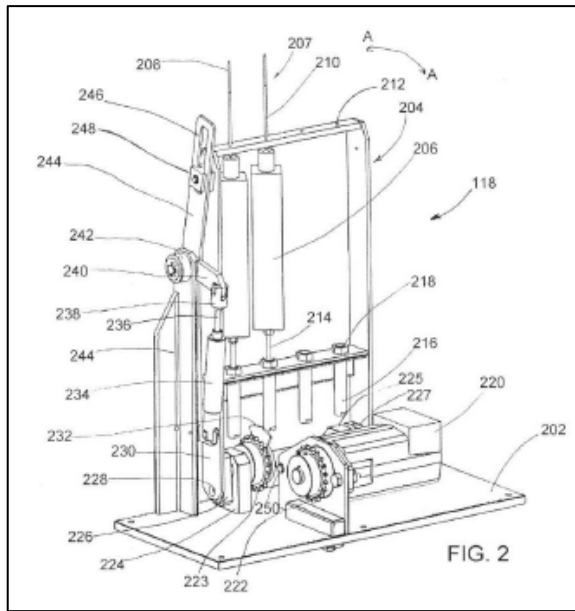
This device can utilize optical probing or other probing technology to determine the fat/lean interface on a meat cut such as a beef strip loin.

Multiple laterally aligned probes can be utilized to repetitively penetrate the meat cut. The output signal can be processed by a controller to form a map of the fat to lean interface contour. ***The controller then articulates the cutting blades to follow the fat/lean interface map.***

Id., 2:15-35. Below I have prepared an annotated version of Fig. 1 that illustrates (1) the **direction of meat conveyance** (red), (2) the **probe assembly** (green), mounted under the meat conveyor for puncturing the fat layer with probes as the meat passes by, and (3) the multi-blade **cutting mechanism** (blue) that responds to probe-based fat depth measurements to accurately remove the fat layer:



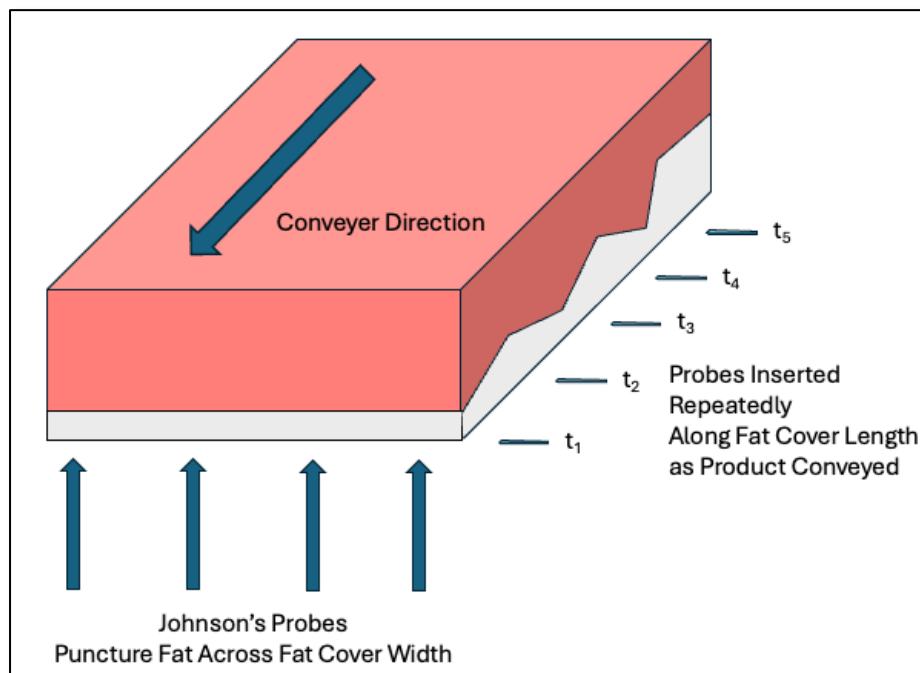
Ex. 1006, Fig. 1 (annotated). In general, the **conveyor assembly 108** includes multiple endless conveyor belts to convey meat products through the **probe assembly 118** and to the **blade assembly**. Figs. 2 and 8 below provide more detailed views of the **probe assembly** and one **cutting blade 407**:



Ex. 1006, Figs. 2, 8. As shown in Fig. 2, *Johnson* depicts two full probes and mounting locations for two additional probes (e.g., four total probes). The probe assembly “is designed such that the probes are inserted and retracted as a unit.” Ex. 1006, 7:20-21. Specifically, the “probe bank travels in a circular motion[.]” *Id.*, 7:21-22. The circular motion moves the probes in an upward motion to insert the probes, then allows the probes to translate horizontally with the meat product as it travels down the conveyor while simultaneously retracting the probes from the meat product. *Id.*, 4:27-35 (describing the circular motion of the probe assembly). As the probe assembly completes multiple cycles of probing and retracting along the length of the meat product, data from the probes is communicated to a controller that, responsive to the data, will “vary the attack angle or angle of approach of the cutting blade to follow the contour of the lean to fat interface.” *Id.*, 4:57-59. Figure 8 depicts

a single cutting blade 406 with additional slots to accommodate four total cutting blades. *See, id.*, 8:51-53 (“[o]ne cutting blade 406 is shown installed[,] there are positions for three other blades”). A chain pulls the meat product through the blade assembly.

59. Focusing on the meat product conveyed through Johnson's system, the following illustration shows how Johnson's probes puncture the fat layer to detect changes in fat thickness as the meat is conveyed toward the cutting blade:



As I explained above, *Johnson* teaches that the variability in fat thickness is detected and accounted for in a cutting map by repeatedly puncturing the fat cover as the beef strip is conveyed. A POSITA would recognize that the probes provide important *internal* information about the fat cover that is otherwise unavailable by imaging the surface of the meat product. For example, *Johnson's* probes take “measurements for

the fat to lean *interface*[,]" an inherently internal measurement detected by "multiple probe *penetrations into* the meat cut[.]". *Id.*, 4:50-53. This comprehensive data across the width of the beef strip allows *Johnson's* system to utilize multiple, independently controlled blades that track variations in fat thickness across the beef strip width. Specifically, *Johnson* expressly teaches that using multiple probes advantageously permit "controlled blades that are capable of following a three-dimensional fat/lean interface map." *Id.*, 2:37-49. *Johnson* further teaches that, responsive to the three-dimensional map of the fat to lean interface contour, "[p]referably, . . . multiple blades are utilized to allow a more accurate cut dictated by the fat/lean interface map"). *Id.*, 9:25-27. While *Johnson's* Fig. 2 depicts four probes and *Johnson's* Fig. 8 depicts positions for up to four cutting blades, each blade is independently controlled based on the three-dimensional data from the probes used to generate a fat to lean interface contour map. *See, id.*, 5:20-48 ("As indicated above, multiple blades can be utilized in order to conform more closely to the three-dimensional path or contour described by the fat/lean interface map. The blades do not necessarily correspond to a given probe, but is preferably designed to be controlled independent of a given probe to follow the contour of the map.")

2. *Ground 3 Proposes Supplanting Johnson's Probe Assembly with Belk's Color Camera*

60. As I discussed above, *Belk* teaches that its imaging device is "preferably a color video IA system." *Id.*, 3:54-61. This color image data is used by *Belk's*

system to characterize and distinguish between lean and fat. *Id.*, 9:2-6 (noting that certain color parameters “L*, a*, and b* scores [are] suggestive of . . . fat” and can be ignored when attempting to classify lean meat). In addition to the color image information for classifying tissue types, *Belk* teaches that density information can be ascertained using a “sound wave imager, tomographic imager, magnetic resonance imager, radio wave imager, microwave imager, or particle beam imager[.]” *Id.*, 9:53-58; *see also id.*, 5:24-27 (listing exemplary density-determining embodiments, including “x-ray tomography, and particle beam tomography, such as computer axial tomography (CAT) or positron emission tomography (PET)”).

61. Neither Petitioner nor its expert discusses these alternative technologies with respect to any claim limitation, focusing their mapping exclusively on the camera-based embodiment. The only specific imaging embodiment identified by Petitioner with reference to the measurement device claimed in limitation 1[A] of the ‘321 patent is *Belk*’s “video camera” embodiment. Petition, 56. The Petition cites to ¶¶ 185-189 of Dr. Collins’ Declaration in support of limitation 1[A]. Petition, 56, 57. These paragraphs of Collins’ Declaration never provide any analysis of, nor any citation to, *Belk*’s alternative technologies. Consistent with the Petition, ¶ 186 of Dr. Collins’ Declaration states, “Imaging device 12 is preferably a color camera...It is preferable for the imaging device 12 to be a color video camera.” Ex. 1003, ¶ 186. Dr. Collins then briefly discusses *Belk*’s data processing unit 16, citing to *Belk* at

7:19-21 and 8:25-49. Ex. 1003, ¶ 187. Neither of these portions of *Belk* discusses the alternative imaging technologies of *Belk*. Finally, Dr. Collins's Declaration at ¶ 188 is limited to the data processing unit, not the imaging device. Ex. 1003, ¶ 188. Indeed, Dr. Collins never provides any analysis regarding *Belk*'s alternative imaging technologies; he only provides opinions and analysis regarding *Belk*'s camera embodiment. This focus on *Belk*'s camera embodiment is consistent through Ground 3 and is required by certain challenged dependent claims. For example, Dependent claims 2 and 3 require the fat thickness determination "takes place optically" and uses a "light detector," respectively. In its mapping, Petitioner discusses only *Belk*'s camera embodiment, noting it "measures the meat product visually, i.e., optically." Petition, 66-67. Dependent claim 4 requires a "camera." The Petition discusses only *Belk*'s "camcorder or video camera" in its mapping of this claim. *Id.*, 67. Dependent claim 6 requires a light source in the form of an LED. The Petition argues that it would have been obvious at the time of the '321 Patent to use "light emitting diodes" with *Belk*'s camera. Notably, *Belk*'s density-focused imaging embodiments (e.g., PET scans, CAT scans, X-rays, sound waves, etc.) are not technologies that operate in the same spectrum as LEDs, and therefore do nothing to inform the Board as to an analysis including *Belk*'s alternative imaging technologies. Indeed, as of October 24, 2007 (the priority date of the '321 Patent), light emitting diodes were known to emit light in a limited band of the electromagnetic spectrum that does not coincide

with these alternative *Belk* embodiments. For example, commercially available LEDs typically emit light between 275 to 950 nm. Ex. 2008, 1. While some research around the priority date of the '321 indicates emission down to 210 nm (Ex. 2010), this is still far outside of the spectrum of the alternative, density-focused imaging embodiments contemplated by *Belk*. For example, *Belk's* alternative imaging embodiments, including PET, CAT, X-ray, and soundwaves, either do not rely on the emission of electromagnetic radiation at all (e.g., sound waves are not EM radiation) or rely on X-ray radiation (e.g., CAT/CT scan and x-ray both use X-ray radiation) or gamma ray radiation (e.g., PET scans) which both have wavelengths orders of magnitude shorter than electromagnetic radiation in the visible spectrum or in the spectrum emitted by LEDs. Ex. 2009, 823-824. In other words, neither X-ray nor gamma-ray emission has been demonstrated by LEDs. Ex. 2008. Neither Petitioner nor its expert provided any analysis as to why the camera-based optical imaging embodiment of *Belk* would include *Belk's* alternative imaging technologies. Therefore, to the extent Petitioner is somehow arguing that *Belk's* optical camera embodiment extends to the alternative imaging embodiments disclosed by *Belk*, I disagree. *Belk's* alternative imaging embodiments fall far outside of the *optical* camera embodiment discussed in the Petition for the reasons I discussed immediately above. Furthermore, neither Petitioner nor its expert has offered any

opinions or analysis as to how the optical camera embodiment of *Belk* would be further modified with the alternative imaging technologies embodiments of *Belk*.

62. Because Petitioner focused exclusively on *Belk*'s camera-based embodiments, as required by challenged dependent claims discussed above, Ground 3 must be limited to these camera-based embodiments.

3. Belk's Camera Cannot Provide the Necessary Data to Support Johnson's Process

63. Petitioner argues that a POSITA would "expect success in modifying Johnson via removing its probe assembly, and installing a different sensor system, such as Belk's imaging system, with a clear view to capture image data of a meat product as it is conveyed through Johnson's apparatus." Petition, 65. Neither Petitioner nor its expert attempt to explain where *Belk*'s camera would be placed within *Johnson*'s system. At best, this vague passage suggests that *Belk*'s camera would simply be installed in the same location as *Johnson*'s probes. If they were so installed, a POSITA would understand *Belk*'s cameras would be facing the fat side of the beef strip as it is conveyed through *Johnson*'s system. For example, *Johnson*'s probes are located on the bottom side of the meat product, with the meat product placed on the conveyor fat-side facing downward. Ex. 1006, 3:50-55 (describing probes extending upward to penetrate the meat cut for measuring the fat thickness). By placing *Belk*'s single camera in this position immediately below the meat product, the single-camera would only obtain an image of the single face of the meat

product exposed to the camera—the bottom, fat-cover side of the meat product—as it is conveyed.

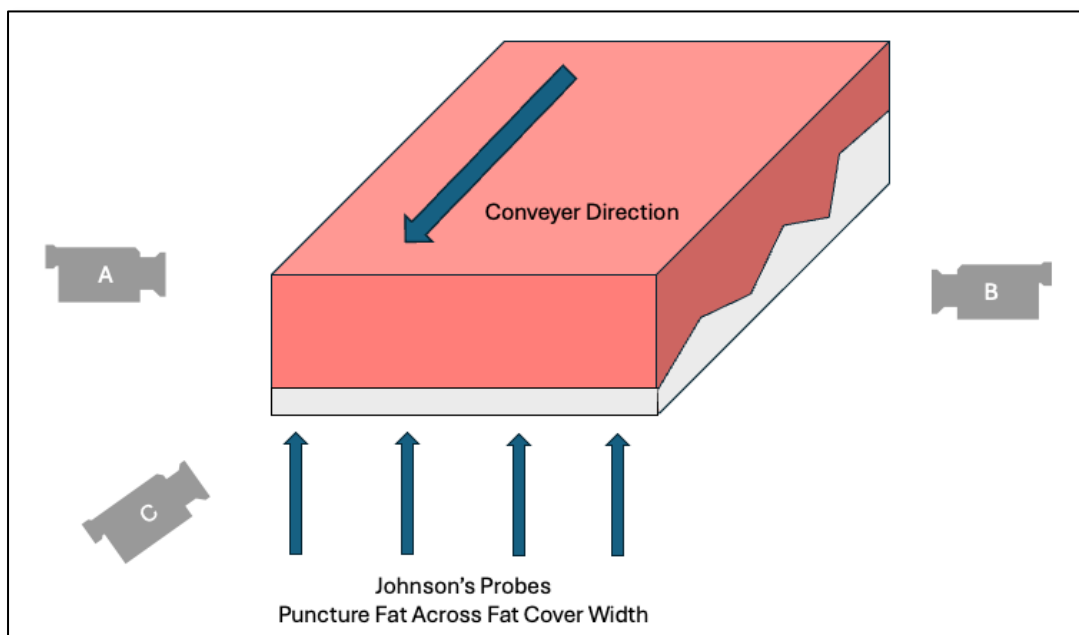
64. Critically, as *Belk* explains and Petitioner's expert admits, *Belk*'s cameras cannot ascertain fat thickness from the angle of *Johnson*'s probes. Dr. Collins's declaration explains that "subcutaneous fat depth [i.e., fat depth below the skin] ***cannot be determined by analyzing surface images alone.***" Ex. 1003, ¶86. *Belk* confirms this, teaching that subcutaneous fat depth (i.e., fat depth below the skin's surface) cannot be determined analyzing images alone:

Further, ***other parameters not determinable by means of analyzing the image data*** may be used to augment the characteristics determined from the image data, ***including***, but not limited to, ***subcutaneous fat depth.*** These additional characteristics of the meat may be used singly or in combination to improve the accuracy of prediction of Yield Grades over that obtained solely using characteristics measured from the image data.

Ex. 1007, 10:57-64. A POSITA would have understood that, consistent with *Belk*'s and Dr. Collins's explanations, *Belk*'s camera embodiments capture only surface information of the meat product and cannot be used to determine fat depth below the surface. For example, *Belk*'s optical camera embodiments are directed to analyzing color scale parameters of reflected light. Ex. 1007, Fig. 1 (noting "reflected light") and 8:25-49 (describing analyzing image data for the color scale parameters L*, a*, and b* as defined by the Commission Internationale d'Eclairage (CIE)). Color scale

information of reflected light is a surface measurement and cannot be used to determine subcutaneous fat depth. *Id.*, Fig. 1 and 10:57-64. Accordingly, were *Belk's* camera placed in the same location as *Johnson's* probes, no information regarding fat depth could be obtained.

65. Although Petitioner does not propose any other location for *Belk's* camera within *Johnson's* system, a POSITA would have understood that there is no location at which *Belk's* cameras could provide the same information as *Johnson's* probes. For example, the following illustrates (1) the location of *Johnson's* probes, which are located at the bottom, fat-cover side of the meat product, and (2) various hypothetical locations for *Belk's* camera to view the meat product. Locations A and B capture side views of the beef loin and location C captures the front of the beef loin as it is conveyed.



A POSITA would have understood that there is no angle that can generate fat thickness data that can replace the three-dimensional data internal to the product obtained by *Johnson's* probes. Even assuming for the sake of argument that *Johnson's* system accommodates meat products with side cross sections that visually indicate fat thickness (a fact not of record), locations A and B could at best, obtain fat thickness information isolated to the sides of the meat product. *Johnson's* cutting blade assembly comprises blade elements that are laterally aligned transverse to the direction of conveyance. *See*, Ex. 1006, 4:63-66, Fig. 5, Fig. 8. Because these cameras obtain only surface data, they cannot be used to determine, as *Johnson's* probes can, fat thickness in the center of the meat product. Therefore, merely imaging the sides of the meat product would not provide the same three-dimensional fat/lean interface contour information used by *Johnson* to inform and adjust the positions of its transverse and laterally aligned cutting blades. Similarly, mounting Belk's camera in location C, observing the front edge of the meat product cannot obtain any information regarding fat thickness as it changes along the length of the beef loin. For example, mounting *Belk's* camera in location C in the image above would preclude a continuous measurement of the fat cover thickness throughout the length of the meat product as is accomplished with *Johnson's* probe assembly repeatedly penetrating and measuring fat thickness along the entire length of the meat product. There are simply no possible mounting locations for *Belk's* camera

that can provide fat thickness information beyond the edges of the meat product. Furthermore, *Belk* does not provide any teaching as to using more than one camera, further precluding any three-dimensional measurement of the meat product. Because *Johnson's* probe assembly can obtain this three-dimensional information and touts this as a benefit, allowing multiple blades to be independently controlled to track a three-dimensional fat thickness map, a POSITA would understand that replacing *Johnson's* probes with *Belk's* camera would forfeit this important feature in *Johnson's* native system. A POSITA would have recognized that this three-dimensional accuracy across the whole fat cover is one of the primary improvements *Johnson's* system contributes to the art. For example, *Johnson* discusses at length the benefits of knowing the three-dimensional structure of the entire meat product. Specifically, *Johnson* touts "several advantages to the present invention[.]" including "[m]ultiple probes [to] ensure a better mapping of the profile since there is little consistency or correlation for the fat/lean contour from one beef strip to another beef strip." Ex. 1006, 2:38-43 (internal quotations removed); *see also id.*, 1:18-20 (noting the fat/lean interface can be erratic), 1:36-37 (variations in the fat thickness and contour from one meat cut to another) and 1:42-44 (the greatest disadvantage of other machines is the variable profile of the fat/lean interface). Accordingly, a POSITA would not have been motivated to make the combination set forth in Ground 3.

4. *Petitioner Misconstrues Johnson's Sensor Teachings, Incorrectly Arguing That Johnson Expressly Motivates the Combination*

66. Separate from the technical incompatibility of the proposed Ground 3 combination, Petitioner advances a motivation to combine argument that fundamentally mischaracterizes *Johnson's* teachings. Namely, Petitioner claims that "Johnson foresaw the potential to replace its probe assembly with alternate sensor devices with superior sensing or functionality, and expressly indicates its apparatus may function with 'any other appropriate sensor technology.'" Petition, 65 (further arguing that *Belk's* imaging sensors are a natural fit as an alternative sensor device that *Johnson* expressly contemplates). The sensor discussion in *Johnson* is not referring to sensors as an alternative to its probes but is instead contemplating sensors *inside Johnson's* probes.

67. *Johnson* is focused on a method of using physically penetrative probes to collect data on the meat product, and uses sensors to detect when the probe reaches the fat/lean interface:

The probe can be an elongated instrument having a somewhat pointed end portion such that when it *is pressed* against the meat cut penetration occurs *into the fat layer and extends through the fat to lean transition*. *The probe can be instrumented with a sensor that can determine when the probe extends through the fat to lean interface* as well as instrumented with a linear encoder for sensing the amount of extension of the probe or the fat layer depth.

Ex. 1006, 2:15-22. Consistent with this basic framework, the portion cited by Petitioner explains that a variety of sensors *within the probes* may be used:

The probe includes an elongated member or probe lead 207 having a substantially pointed end for penetrating the meat cut. *The probe also has a sensor assembly 252 for emitting and receiving sensor signals. The sensor assembly emits a signal through a window of the pointed end of the probe* and receives a reflected signal from the meat cut for sensing the fat to lien interface. *Optical Technology or infrared sensor technology can be utilized or any other appropriate sensor technology.*

Id., 7:59-67.

68. In other words, *Johnson* expressly states that the *probe itself* can be outfitted with a different “sensor technology” *inside of the probe*. Specifically, *Johnson*’s probe has a sensor assembly that “emits a signal *through a window* of the [] probe.” *Id.*, 7:59-64. In other words, the “other appropriate sensor technology[,]” including “Optical Technology or infrared sensor technology” espoused by Petitioner is merely different technologies *inside* of the probe. *Id.*, 7:59-67. Therefore, a POSITA would have understood that *Johnson*’s sensor discussion is limited to sensors *mounted within its probes*. There is simply no teaching or suggestion in *Johnson* that the reference contemplated a non-probe system. *See generally id.*, 1:50-2:55 (discussing the advantages of *probe* technology). Indeed, all sensor discussions expressly reference the probe assembly and are described within

the context of the probe-based system. I have reviewed *Johnson* and cannot find a single instance of *Johnson* discussing a non-probe-based system and the citations provided by Petitioner are only in the context of a probe-based system, as I discussed above. Accordingly, a POSITA would not have interpreted *Johnson* to motivate a wholesale replacement of its probes with separate sensors, as Petitioner contends.

VIII. CONCLUSION

69. I hereby declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct, and that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true. I understand that willful false statements are punishable by fine or imprisonment or both. *See* 18 U.S.C. § 1001. If called to testify as to the truth of the matters stated herein, I could and would testify competently.

Date: 22 August 2024

Respectfully submitted:



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Charles F. Reinholtz

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Education

Doctor of Philosophy, University of Florida, Mechanical Engineering, 1983
Master of Engineering, University of Florida, 1980
Bachelor of Science, University of Florida, 1976

Full-time Industrial Experience

1978, Burroughs Corporation, Orlando, Florida, Design Engineer, Non-impact Printing Group
1989-1996 Milliken and Company, Spartanburg, South Carolina, summer employment and consulting involving textile equipment design

Academic Employment Experience

Virginia Polytechnic Institute and State University, Blacksburg, Virginia
Assistant Professor, September 1983 to August 1988, Tenure Granted
Associate Professor, August 1988 to August 1993
Professor, August 1993 to 2007
W. S. White Chair for Innovation in Engineering Education, Aug. 1996 to Aug. 1999
Assistant Department Head and ABET Review Chair, 1996-2002
Alumni Distinguished Professor, 2002-2007
Embry-Riddle Aeronautical University, Daytona Beach, Florida
Professor and Chair, Department of Mechanical Engineering, 2007-2017
Professor, Department of Mechanical Engineering, 2017-2022
Emeritus Professor and Chair, 2022-

Membership in Professional Organizations and Honor Societies

<u>Society</u>	<u>Membership Grade</u>
ASME	Fellow
SAE	Member
American Nuclear Society	Member 1995-1997
Tau Beta Pi	Member
Pi Tau Sigma	Member
Sigma Xi	Member
Epsilon Lambda Chi	Member
ASEE	Member, 1984-1987, 1998-99
AUVSI	Member

Professional Honors and Awards

Benton Engineering Council Service Key, University of Florida, 1976-1977.
Procter and Gamble Best Paper Award, 9th Applied Mechanisms Conference, October 1985.
Presidential Young Investigator Award, 1987-1992, National Science Foundation
Certificate of Teaching Excellence, Virginia Polytechnic Institute and State University, 1987-88, 1997-98 and 2001-02.

ASME Outstanding Faculty Advisor Award, 1989-1990 and 1991-92
 Procter and Gamble Best Paper Award of Merit, 2nd National Applied Mechanisms and Robotics Conference, November 1991.
 George Wood Best Applied Mechanism Design Paper Award, 2nd National Applied Mechanisms and Robotics Conference, November 1991.
 Wine Award for Excellence in Teaching, Virginia Polytechnic Institute and State University, 1992.
 Virginia Tech Academy of Teaching Excellence, Inducted 1992
 Procter and Gamble Best Paper Award of Merit, 22nd ASME Mechanisms Conference, Scottsdale, Arizona, September 1992
 ASME National Faculty Advisor Award, 1995.
 Applied Mechanism Conference "Beyond the Call of Duty" Award for prodigious contributions to mechanism science, 1995.
 W. S. White Chair for Innovation in Engineering Education, Aug. 1996 to Aug. 1998
 Dean's Award for Excellence in Teaching, Virginia Tech College of Engineering, 1998
 South-Pointing Chariot Award, 1999 Applied Mechanisms and Robotics Conference, for lifetime contributions to the mechanism's community
 Ingersoll-Rand Faculty Award for Outstanding Contributions to the Mechanical Engineering Department, 2000
 National Instruments Award for Best Application of Measurement and Automation for the Development of a Tele-Operated CASE CX-160 Excavator Using FieldPoint, National Instruments Week 2002, Austin Texas, Aug 12-15, 2002.
 Virginia Tech Alumni Distinguished Professor, 2002-
 Outstanding Faculty Member Award selected and awarded by the students in Mechanical Engineering, April 2003.
 Fellow, American Society of Mechanical Engineers, 2003
 Alumni Teaching Award, Virginia Polytechnic Institute and State University, 2004
 National Instruments Virtual Instrumentation Applications Best Control Paper Award, Developing a Fully Autonomous Vehicle for Virginia Tech's Entry in the DARPA Grand Challenge," National Instruments NI Week 2006, Austin Texas.
 ASME Distinguished Service Award, 2005
 College of Engineering Certificate of Teaching Excellence, 2006-2007
 Volusia Manufacture's Association "Friend of Industry" Award, 2013
 Emeritus Professor and Emeritus Chair, Embry Riddle Aeronautical University, 2022

Funded Research

1. "Design Optimization of Spatial Mechanisms Subject to Real-World Constraints," National Science Foundation Grant MEA-8404313, June 15, 1984 through November 30, 1986, \$47,979, 100% Responsibility.
2. "Presidential Young Investigator Award: Interactive Spatial Mechanism Synthesis," National Science Foundation, Grant No. DMC 8657828, June 15, 1987 through January 31, 1993, \$312,000, 100% Responsibility.
3. "High-Speed Bearing Research," supported by the Industrial Drives Division of Inland Motor Corporation, Jan. 1, 1987 through Dec. 31, 1987, \$15,000, 100% Responsibility.
4. "Analysis of Warhead Structures," Department of the Navy, July 24, 1987 to November 15, 1987, \$99,348, Project Director with J. B. Kosmatka, R. H. Fries, A. L. Wicks, and L. D. Mitchell, Responsible for \$19,535.
5. "Analysis of Warhead Structures, Year 2," Department of the Navy, October 30, 1987 to March 31, 1988, \$174,000, Project Director with J. B. Kosmatka, R. H. Fries, A. L. Wicks, and L. D. Mitchell, Responsible for \$12,908.

6. "Hull Joint Model Test," Georgia Institute of Technology, May 16, 1988 to Aug. 16, 1988, \$10,141, Principal Investigator with R. H. Fries, Responsible for \$5,071.
7. "Design of Variable-Geometry Truss Manipulators," Virginia Center for Innovative Technology (CIT), 10/1/88 to 9/31/89, \$30,000, 100% Responsibility.
8. "Active Structures for Space Applications," 1/1/89 to 12/31/90, \$200,000, Principal Investigator with H. H. Robertshaw, Responsible for \$80,000.
9. "Computer-Aided Design of Fully-Wiped, Co-rotating Extruder Screws," Windward International and CIT, January 1, 1989 through December 31, 1989, \$44,029, Principal Investigator with Sanjay Dhande, Responsible for \$22,015.
10. "Construction of a NASP Mock-up," NASA Langley Research Center, February 1, 1989 to July 15, 1989, \$51,692, Principal Investigator with W. F. O'Brien, A. L. Wicks, and J. Marchman.
11. "Design of Advanced Manipulators for Steam Generator Maintenance," Babcock & Wilcox Co., November 1, 1989 to August 15, 1990, \$20,000, Principal Investigator with Sanjay Dhande, Responsible for \$15,000.
12. "Calibration, Control and Menu Design for an Advanced Steam-Generator Maintenance Manipulator," Babcock and Wilcox Co., February 1, 1991 through January 31, 1992, \$41,408, Principal Investigator with Sanjay Dhande, Responsible for \$31,056.
13. "Calibration, Control and Menu Design for an Advanced Steam-Generator Maintenance Manipulator," Virginia Center for Innovative Technology, February 1, 1991 through January 31, 1992, \$29,663, Principal Investigator with Sanjay Dhande, Responsible for \$22,247.
14. "Computer-Aided Design and Manufacture of Extruder Screw Elements," Windward International and CIT, July 1, 1990 through June 30, 1991, \$30,984, Principal Investigator with Sanjay Dhande, Responsible for \$15,492.
15. "Design of a Cellulose Acetate Preconditioning Heat Exchanger," Tennessee Eastman Co., October 1990 through July 1991, \$25,560, Principal Investigator with D. J. Nelson, Responsible for \$9,876.
16. "Continued Steam Generator Manipulator Support Based on Kinematic Control and Investigation of Vision Based Approach," Babcock and Wilcox Co., October 1, 1991 through September 31, 1992, \$40,000, Principal Investigator with A. L. Abbott, Responsible for \$32,000.
17. "Cellulose Acetate Packaging Study," Tennessee Eastman Co., October 1991 through July 1992, \$51,120, Principal Investigator with D. J. Nelson, Responsible for \$19,752.
18. "Continued Steam Generator Manipulator Support Based on Kinematic Control and Investigation of Vision Based Approach," Virginia CIT, January 1, 1992 through December 31, 1992, \$35,570, Principal Investigator with A. L. Abbott, Responsible for \$28,456.
19. "Preliminary Design of a Medical Waste Processing Machine," Virginia Center for Innovative Technology, June 1, 1992 through August 31, 1992, \$14,386, 100% Responsibility.
20. "Preliminary Design of a Medical Waste Processing Machine," Bioconversions Technologies, May 1, 1992 through January 31, 1993, \$16,377, 100% Responsibility.
21. "Conceptual Design of an Advanced Reactor Vessel Inspection Manipulator," B&W Nuclear Services Company, March 1, 1992 through February 28, 1993, \$30,000, 100% Responsibility.
22. "Engineering Development of a Medical Waste Processing Machine," Bioconversions Technologies, Aug. 15, 1992 to May 15, 1994, Principal Investigator with A. A. Kornhauser, \$93,088, responsible for \$46,544.
23. "Engineering Development of a Medical Waste Processing Machine," CIT, Aug. 15, 1992 to Aug. 14, 1993, Principal Investigator with A. A. Kornhauser, \$90,988, responsible for \$45,494.

24. "Enhancing the Capability and Performance of Nuclear Service Robots with Kinematic Analysis and Computer Vision," B&W Nuclear Services Co., Dec.1, 1992 to Nov. 30, 1993, with A. L. Abbott, \$50,000, responsible for \$40,000.
25. "Design of a Reactor Vessel Inspection Manipulator," B&W Nuclear Services, June 16, 1992 through June 15, 1993, \$100,146, 100% responsibility.
26. "Design of an Automated Needle/Armature Tray Loader," Siemens Automotive, Sept. 1, 1993 to Aug. 31, 1994, \$24,925, 100% Responsibility.
27. "Enhancing the Design and Performance of Nuclear Service Robots with Flexure Analysis, Computer Vision, and Optimization Techniques," B&W Nuclear Technologies, Dec.1, 1993 to Nov. 30, 1994, with A. L. Abbott, \$40,000, responsible for \$30,000.
28. "Enhancing the Design and Performance of Nuclear Service Robots with Flexure Analysis, Computer Vision, and Optimization Techniques," Center for Innovative Technology, Feb. 1, 1994 to Jan. 31, 1995, with A. L. Abbott, \$47,023, responsible for \$35,000.
29. "Design Studies for Nautilus," Nautilus, Inc, Jan.1, 1994 to Oct. 15, 1994, \$7,723, 100% responsibility.
30. "Design Studies for Nautilus," Center for Innovative Technology, Jan.1, 1994 to Dec. 31, 1994, \$13,795, 100% Responsibility.
31. "Rod Formation Dynamics," R. J. Reynolds Co., Jan. 1, 1994 to Dec. 31, 1994, with D. J. Nelson, 116,557, 50% Responsibility.
32. "A Short-term Proposal to Develop Cam-Design Software for Cadkey, Inc.," June 16, 1994 to Sept 15, 1994, \$9,981, 100% Responsibility.
33. "Design of an Automated Injector Body Tray Loader," Siemens Automotive, Sept. 1, 1994 to Aug. 31, 1995, \$20,744, 100% Responsibility.
34. "Design Studies for Nautilus," Nautilus, Inc, Dec 1, 1994 to Nov. 30, 1995, \$23,731, 100% Responsibility.
35. "Design Studies for Nautilus," Center for Innovative Technology, Dec.1, 1994 to Dec. 31, 1995, \$25,924, 100% Responsibility.
36. "Preliminary design and Equipment Selection for a Mulch-Making Machine," Fred Whitaker Co., June 1, 1995 to Dec. 31, 1995, \$10,920, %100 Responsibility.
37. "Improving the Kinematic Control of Robots with Computer Vision," NSF, July 15, 1995 to June 30, 1996, \$22,026, %100 Responsibility.
38. "Proposal to Increase Funding in Siemens Valve-Body Loader Project," Siemens Automotive, \$7,018, 100% Responsibility.
39. "Preliminary Design and Equipment Selection for a Mulch-Making Machine," CIT, June 1, 1995 to August 31, 1995, \$8,185, %100 Responsibility.
40. "Design of a Personal Smith Machine," Nautilus, Inc, July 1, 1995 to Oct. 31, 1995, \$12,273, 100% Responsibility.
41. "Development of Advanced Control Strategies for Variable Geometry Truss Manipulators," Batelle -Pacific Northwest Laboratory, Jan. 1, 1995 to June 31, 1995, \$10,000, with R. J. Salerno, 10% Responsibility.
42. "Curriculum Renewal in Mechanical Engineering at Virginia Tech," NSF SUCCEED, Sept. 15, 1995 to Dec. 15, 1995, with Paul Tidwell, \$4,500 (NSF), \$4,677 (Cost Sharing), 50% Responsibility.
43. "Development of a Parallel Architecture Robotic Wrist," Triad Investors, Jan. 1, 1996 to May 31, 1997, \$51,707, 100% Responsibility.

44. "Development of Advanced Control Algorithms for Variable Geometry Truss Manipulators," Batelle-Pacific Northwest Laboratory, Jan. 1, 1996 to June 31, 1996, \$10,000, 100% Responsibility.
45. "Curriculum Renewal in Mechanical Engineering at Virginia Tech – Year 5," NSF SUCCEED, June 16, 1996 to June 15, 1997, \$10,000 (NSF), \$10,000 (Cost Sharing), 100% Responsibility.
46. "Technology Assessment for a Robotic Vacuum Cleaner," Servus Robots Incorporated, Sept. 1, 1998 to Feb. 28, 1999 with John Bay, Bob Sturges, and Mike Deisenroth, \$8,333, 25% Responsibility.
47. "Technology Assessment for a Robotic Vacuum Cleaner," Virginia CIT, Oct. 1, 1998 to March 31, 1999 with John Bay, Bob Sturges, and Mike Deisenroth, \$25,000, 25% Responsibility.
48. "MBC Guidance Project," Long-Airdox Company, August 1998 to July 1999, P.I.: R.H. Sturges, Co-P.I.'s: M. P. Deisenroth, C.F. Reinholtz. \$100,000.
49. "MBC Guidance Project," Virginia Center for Innovative Technology (matching), August 1998 to July 1999, P.I.: R.H. Sturges, Co-P.I.'s: M. P. Deisenroth, C.F. Reinholtz. \$100,000.
50. "Vertical Integration of Mechatronics at Virginia Tech," NSF SUCCEED, Aug 1999 to July 2002, P.I.: W. R. Saunders, Co-P.I.'s: J. S. Bay, D. J. Leo, C.F. Reinholtz, \$18,000/year for three years.
51. Development of a Remote-Controlled CASE CX-160 Excavator, Naval Surface Warfare Center, Dahlgren G-64 Division, February 2003 to September 2003, Co-PI with A. L. Wicks, \$17,000
52. Investigation of Adaptive Structures for Morphing Aircraft, NASA Langley Research Center, \$65,078, July 1, 2002 to June 30, 2003, 25% (with H. Robertshaw and D. Inman).
53. Increased Scope for Delivery Orders 0019, Remote Control Excavator, Naval Surface Warfare Center, with Al Wicks, PI, \$21,223.
54. Develop the Joint Unmanned Systems Experimentation and Research (JOUSTER) Site, U.S Army RDECOM STTC, Orlando, FL, June 10, 2004 to June 9, 2007, \$12,200,000, C. Reinholtz, PI (55% Responsibility), A. Wicks, Co-PI (43% Responsibility), Carstensen Co-PI (2% Responsibility).
55. Virginia First Lego League 2004 Pilot High School Robotics Program, NASA Langley Research Center, Education Grant NNL04AA65G, \$20,000, July 9, 2004 to July 8, 2005, 100% Responsibility
56. Virginia First Lego League NIA Outreach Program, National Institute of Aerospace, Grant No. VT-03-1, \$8,000, February 1, 2005 to August 31, 2005, 100% Responsibility.
57. Heterogeneous Teams Of Autonomous Vehicles: Advanced Sensing And Control, Office of Naval Research, Dennis W. Hong, Naira V. Hovakimyan, Marty E. Johnson, Charles F. Reinholtz, Daniel J. Stilwell, A. L. Wicks, Craig A. Woolsey, Christopher L. Wyatt, 07/01/05 – 6/30/06, Total Funding: \$1,050,000, C. F. Reinholtz share: \$52,752.
58. Coordinated Sensing and Control for Surveillance and Tracking by Heterogeneous Autonomous Vehicle Teams, Daniel J. Stilwell, Christopher L. Wyatt, Craig A. Woolsey, Naira V. Hovakimyan, A. L. Wicks, Andy Kurdila, Charles Reinholtz and Michael Roan, Office of Naval Research 5/15/06 – 9/14/07, \$1,417,500, Reinholtz share: \$184,275.
59. Development Of An Autonomous Vehicle For The DARPA Urban Challenge, with Al Wicks and Dennis Hong, the Defense Advanced Research Projects Agency, 10/1/06 to 12/31/07, \$999,274.
60. Development of a Drive-by-Wire Commercial Vehicle, General Dynamics Robotics Systems (GDRS), \$54,256, 1-11-07 to 6-30-07.

61. Navigation And Autonomous Control For Nemesis, Applied Research Associates, Inc. (ARA), \$61,513, 7-1-06 to 6-30-07
62. Dynamic Model of CAT 777-797 Haul Trucks for Autonomous Operation, Caterpillar, \$74,303, 7-1-06 to 6-30-07
63. Boeing Digitally Manufactured UAV Project, \$22,740, The Boeing Company, 10-15-2010 to 12-31-2010.
64. Reconnaissance and Autonomy for Small Robots – Canine (RASR-K9), Robotic Research, \$17,951.50, 1-1-2011 to 4-30-2012
65. Proposal to Develop an Autonomous Maritime System to Compete in the International Maritime Robotics Competition, AUVSI and the Office of Naval Research, \$30,000, 10-1-13 to 12-31-14.
66. Robotic Tool Kit (RTK) Logistics Automation, (OTA) #W15QKN-14-9-1002, U.S. Army TARDEC via Great Lakes Systems & Technology LLC, \$75,000, August 2018 through September 2019, with Patrick Currier and Eric Coyle.
67. Continued Development of Robotic Tool Kit (RTK) Logistics Automation and RTK Training, (OTA) #W15QKN-14-9-1002, U.S. Army GVSC via Great Lakes Systems & Technology LLC, \$100,000, November 2019 through November 2020, with Patrick Currier and Eric Coyle.

Refereed Papers in Major Technical Journals

1. Snorri Gudmundsson, Vladimir Golubev, Sergey Drakunov and Charles Reinholtz, “Bio-Inspired Methodologies for Energy Conservation and Harvesting Flight-Path Modeling for Unmanned Aerial System,” *AIAA Journal of Aerospace Information Systems*, Volume 16, Number 7, July 2019, <https://doi.org/10.2514/1.1010597>.
2. Christine M. Dailey, Charles Reinholtz, Thais Russomano, Michael Schuette, Rafael Baptista, Rodrigo Cambraia, “Resistance Exercise Machine within Lower Body Negative Pressure for Counteracting Effects of Microgravity”, *Gravitational and Space Research*, Vol 2, No. 1 ISSN: 0898-4697, 2014.
3. Hockley, C. J., Zuercher, T.A., Patel, H.V., Gamble, G.A., Kennedy, C.L. Coyle E.J., P.N. Currier, and C.F. Reinholtz, The Development of the ERAU Maritime RobotX Challenge Autonomous System, AUVSI North America, May 2014.
4. Jesse Hurdus, Andrew Bacha, Cheryl Bauman, Stephen Cacciola, Ruel Faruque, Peter King, Chris Terwelp, Patrick Currier, Dennis Hong, and Alfred Wicks and Charles Reinholtz, “VictorTango Architecture for Autonomous Navigation in the DARPA Urban Challenge,” *AIAA Journal of Aerospace Computing, Information, and Communication*, Vol. 5, December 2008, DOI: 10.2514/1.40547.
5. Charles Reinholtz, Dennis Hong, Al Wicks, Andrew Bacha, Cheryl Bauman, Ruel Faruque, Michael Fleming, Chris Terwelp, Thomas Alberi, David Anderson, Stephen Cacciola, Patrick Currier, Aaron Dalton, Jesse Farmer, Jesse Hurdus, Shawn Kimmel, Peter King, Andrew Taylor, David Van Covern, Mike Webster, “Odin: Team VictorTango's entry in the DARPA Urban Challenge,” *Springer Tracts in Advanced Robotics* 56, ISBN 978-3-642-03990-4, Edited by Martin Buehler, Karl Iagnemma, Sanjiv Singh, 2009.
6. Andrew Bacha, Cheryl Bauman, Ruel Faruque, Michael Fleming, Chris Terwelp, Charles Reinholtz, Dennis Hong, Al Wicks, Thomas Alberi, David Anderson, Stephen Cacciola, Patrick Currier, Aaron Dalton, Jesse Farmer, Jesse Hurdus, Shawn Kimmel, Peter King, Andrew Taylor, David Van Covern, Mike Webster, “Odin: Team VictorTango's entry in the DARPA Urban Challenge,” *Journal of Field Robotics*, Vol. 25, No. 8, pg 467-492, 2008

7. David G. Schmale III, Benjamin R. Dingus, Charles Reinholtz, "Development and Application of an Autonomous Unmanned Aerial Vehicle for Precise Aerobiological Sampling Above Agricultural Fields," *Journal of Field Robotics*, Vol. 25. No. 3, pg 133-147, 2008, Copyright 2008 Wiley Periodicals, Inc.
8. Michael J. Furey, Charles F. Reinholtz, and Brian Vick, "Metal Transfer, Film Formation and Surface Temperatures on a Cam in an Automotive Engine," *Tribologia*, ISSN 0208-7774, June 2007.
9. Leedy, B., Putney, J., Bauman, C., Cacciola, S., Webster, J. M., Reinholtz, C. F., "Virginia Tech's Twin Contenders: A Comparative Study of Reactive and Deliberative Navigation," *Journal of Field Robotics*, 23(9), 709-727, September 2006.
10. Gombar, B., Terwelp, C., Fleming, M., Wicks, A. L. and Reinholtz, C.F., "JOUSTER: Joint Unmanned Systems Test, Experimentation and Research Facility," *International Test and Evaluation (ITEA) Journal*, December 2004/January 2005, pp. 9-13.
11. Stephen L. Canfield, R. Randall Soper, Charles F. Reinholtz, "Creating Highly Dexterous Manipulators Using Nonlinear Input Transmission," *ASME Journal of Mechanical Design*, Vol. 120, 1999.
12. Canfield, S. L., Soper, R. R., and Reinholtz, C. F., "Velocity Analysis of Parallel Manipulators by Truss Transformations," *Mechanism and Machine Theory*, No. 34, 1999, pp. 345 – 357.
13. Roman, Chris and Reinholtz, C. F., "Robust Course-Boundary Extraction Algorithms for Autonomous Vehicles", *IEEE Intelligent Systems*, Nov./Dec. 1998, pp.32-39.
14. Lee, H. Y., and C. F. Reinholtz, "Inverse Kinematics of Serial-Chain Manipulators," *ASME Journal of Mechanical Design*, Vol. 118, No. 3, September 1996, pp. 396 - 404.
15. Lee, H. Y., Fallon, J. B., Cordle, W. H., and Reinholtz, C. F., "Inverse Kinematic Analysis of a Mobile Underwater Inspection Robot," *Journal of Applied Mechanisms and Robotics*, Vol. 2, No. 3, July 1995.
16. Canfield, S. L. and Reinholtz, C. F., "Development of an All-Revolute-Jointed Constant-Velocity Coupling," *Journal of Applied Mechanisms and Robotics*, Vol. 2, No. 3, July 1995, pp.13-19.
17. Shooter, S. B., West, R. L. and Reinholtz, C. F., A Unified Approach to Teaching Analytical Cam Design Using Conjugate Geometry, *The International Journal of Mechanical Engineering Education*, Vol. 23, No. 2, April 1995, pp 145-156.
18. Tidwell, P. H., Bandukwala, N., Dhande, S. G., Reinholtz, C. F. and Webb, G, "Synthesis of Wrapping Cams," *Journal of Mechanical Design*, Transactions of the ASME, Vol.116, No. 2, June 1994 (revised version of 1992 ASME conference publication.)
19. Voruganti, R. S., Dhande, S. G., and Reinholtz, C. F., "Symbolic and Computational Method for Design and Flat-Pattern Development of Bifurcation, Trifurcation- Type Transition Surfaces," *Transactions of the North American Manufacturing Research Institution of SME*, Volume XXII, pp 225-232, 1994.
20. Tidwell, P. H., Glass, S. W., Hildebrand, J. J., Reinholtz, C. F., and Shooter, S. B., "COBRA - Design and Development of a Manipulator for Nuclear Steam Generator Maintenance," *Journal of Applied Mechanisms and Robotics*, Vol. 2, No. 2, April 1994.
21. Padmanabhan, B., V. Arun, and C. F. Reinholtz, "Closed-Form Inverse Kinematic Analysis of Variable Geometry Truss Manipulators," *Journal of Mechanical Design*, ASME Transactions, Vol. 114, No. 3, September 1992, pp. 438-443.

22. Arun, V., C. F. Reinholtz, and L. T. Watson, "Application of New Homotopy Techniques to Variable Geometry Trusses," *Journal of Mechanical Design*, ASME Transactions, Vol. 114, No. 3, September 1992, pp. 422-427.
23. Voruganti, R. S., Dhande, S. G., and Reinholtz, C. F., "Symbolic and Computational Conjugate Geometry for the Manufacture of Helically Swept Surfaces," *Transactions of the North American Manufacturing Research Institution of SME*, Volume XX, pp 277-282, 1992.
24. Salerno, R. J., Reinholtz, C. F., and Dhande, S. G., "Kinematics of Long-Chain Variable Geometry Truss Manipulators," *Advances in Robot Kinematics*, pp. 179-187, Edited by S. Stifter and J. Lenarcic, Springer-Verlag Wien, New York, 1991.
25. Kosmatka, J. B., R. F. Fries, and C. F. Reinholtz, "Tension and Bending Stress Concentration Factors in U, V, and Opposed U-V Notches," *The Journal of Strain Analysis for Engineering Design*, Vol. 25, No. 4, 1990, 233-240.
26. Rogers, C. A., H. H. Mabie, and C. F. Reinholtz, "Design of Spur Gears Generated with Pinion Cutters," *Mechanism and Machine Theory*, Vol. 25, No. 6, 1990, pp. 623-634.
27. Mabie, H. H., C. A. Rogers, and C. F. Reinholtz, "Design of Spur Gears Cut by a Hob," *Mechanism and Machine Theory*, Vol. 25, No. 6, 1990, pp. 635-644.
28. Williams, II, R. L., and C. F. Reinholtz, "Proof of Grashof's Law Using Polynomial Discriminants," *Journal of Mechanisms, Transmissions and Automation in Design*, ASME Transactions, Vol. 109, No. 2, June 1987, pp. 178-182.
29. Reinholtz, C. F., G. N. Sandor, and J. Duffy, "Branching Analysis of Spherical RRRR and Spatial RCCC Mechanisms," *Journal of Mechanisms, Transmissions and Automation in Design*, ASME Transactions, Vol. 108, No. 4, Dec. 1986, pp. 481-486.
30. Williams, II, R. L., and C. F. Reinholtz, "Mechanism Link Rotatability and Limit Position Analysis Using Polynomial Discriminants," *Journal of Mechanisms, Transmissions and Automation in Design*, ASME Transactions, Vol. 108, No. 4, Dec. 1986, pp. 562-564.
31. Myklebust, A., M. J. Keil and C. F. Reinholtz, "MECSYN-IMP-ANIMEC: Foundation for a New Computer-Aided Spatial Mechanism Design System," *Mechanism and Machine Theory*, Vol. 20, No. 4, 1985, pp. 257-269.
32. Reinholtz, C. F., S. G. Dhande, and G. N. Sandor, "Kinematic Analysis of Planar Higher-Pair Mechanisms," *Mechanism and Machine Theory*, Vol. 13, No. 6, 1978, pp. 619-629.

Notes, Review Articles, and Shorter Communications in Major Technical Journals

1. Fallon, J. B., and C. F. Reinholtz, "Simple Machine," short article published in the 1993 Edition of Academic American Encyclopedia, Deluxe Library Edition, Grolier, Inc., Vol. S, p. 316. Also published in the 1994 New Grolier Multimedia Encyclopedia, CD ROM Edition.
2. Fallon, J. B., and C. F. Reinholtz, "Machine," article published in the 1993 Edition of Academic American Encyclopedia, Deluxe Library Edition, Grolier, Inc., Vol. M, pp. 19-21. Also published in the 1994 New Grolier Multimedia Encyclopedia, CD ROM Edition.
3. Sandor, G. N., S. G. Dhande, and C. F. Reinholtz, discussion of "Reduction of Noise and Vibration in Roller Chain Drives," by S. W. Nicol and J. N. Fawcett, *Proceedings of the Institution of Mechanical Engineers*, Vol. 191 39/77, 1978.
4. Sandor, G. N., S. G. Dhande, and C. F. Reinholtz, discussion of "The Influence of Lubrication on Tooth-Roller Impacts in Chain Drives," by J. N. Fawcett and S. W. Nicol, *Proceedings of the Institution of Mechanical Engineers*, Vol. 191 21/77, 1978.

5. Reinholtz, C. F., review of the book *Mechanics and Design of Cam Mechanisms*, Pergamon Press, authored by F. Y. Chen, review published simultaneously in *Mechanism and Machine Theory*, Vol. 24, No. 4, 1985, and in *Shock and Vibration Digest*, Vol. 17, No. 12, 1985.

Books and Book Chapters

Mabie, H. H., and C. F. Reinholtz, *Mechanisms and Dynamics of Machinery*, 4th edition, with Solutions Manual, John Wiley and Sons, New York, 1987.

Teaching Excellence at a Research-Centered University, Edited by E. Scott Geller and Phil Lehman, Pearson Custom Publishing, Chapter 30: BRINGING THE BEST OUT OF STUDENTS: Teaching beyond the Classroom, 2006

Proceedings and Textbooks Edited

1. "Robotics, Spatial Mechanisms, and Mechanical Systems," Proceedings of the 22nd ASME Mechanisms Conference, DE-Vol. 45, September 1992, 644 Pages, Edited by G. Kinzel, C. Reinholtz, H. Lipkin, L. W. Tsai, G. R. Pennock and R. J. Cipra.
2. "Mechanism Design and Synthesis," Proceedings of the 22nd ASME Mechanisms Conference, DE-Vol. 46, September 1992, 672 Pages, Edited by G. Kinzel, C. Reinholtz, G. R. Pennock, G. J. Wiens, R. J. Cipra, B. B. Thompson and T. R. Chase.
3. "Flexible Mechanisms, Dynamics, and Analysis," Proceedings of the 22nd ASME Mechanisms Conference, DE-Vol. 47, September 1992, 662 Pages, Edited by G. Kinzel, C. Reinholtz, H. Lipkin, L. W. Tsai, G. R. Pennock, R. J. Cipra and B. B. Thompson.
4. Sandor, G. N., C. F. Reinholtz, and K. Soldner, errata to the book, *Mechanics and Design of Cam Mechanisms*, authored by F. Y. Chen, Pergamon Press, Inc., Elmsford, N.Y., 1982, 10 pages.

Conference Publications

1. Casey Troxler, Patrick Currier, Charles Reinholtz, "Impact of Automated Lane Change Assist on Energy Consumption," SAE Technical Paper 2020/4/14.
2. Gudmundsson, Snorri, Vladimir Golubev, Sergey Drakunov, Charles Reinholtz, "Bio-Inspired Opportunistic Approaches in Energy-Conserving/Harnessing Flight-Path Modeling for UAS," AIAA Modeling and Simulation Technologies Conference, AIAA Aviation and Aeronautics Forum and Exposition 2016.
3. Christopher Hockley, Timothy Zuercher, Christopher Kennedy, Gene Gamble, Hitesh Patel, Patrick Currier, Eric Coyle, Charles Reinholtz, "System Architecture, Development and Results of the Embry-Riddle Aeronautical University Maritime RobotX Platform," Control ID#: 2028351, Session: UMS-02, Unmanned Systems: Technologies and Applications, AIAA Science and Technology Forum 2015.
4. Jesse Farmer and Charles Reinholtz, "Kinematic Analysis and Design of a Two-Body Articulated Robotic Vehicle," Proceedings of ASME 2009 International Mechanical Engineering Congress & Exposition, November 13-19, 2009, Lake Buena Vista, Florida, USA
5. Gerald R. Lane, Charles Reinholtz, Mohan Krishnan, Mark J. Paulik, Nassif Rayess, "Articulated Unmanned Ground Vehicles (UGVs) Controlled with Complimentary Semi- & Autonomous Mobility Behaviors," NATO symposium on "Platform Innovations and System Integration for Unmanned Air, Land and Sea Vehicles", Florence, Italy, May 14-18, 2007.
6. Brett M. Leedy and Charles Reinholtz, "Developing a Fully Autonomous Vehicle for

- Virginia Tech's Entry in the DARPA Grand Challenge,” National Instruments NI Week 2006, Austin Texas, (winner, Virtual Instrumentation Applications Paper Contest Best Control Paper Award).
7. Sean Baity, Charles F. Reinholtz and Alfred L. Wicks, “Kinematic Design of a Novel All-wheel Drive Multi-Body Articulated Unmanned Ground Vehicle,” AUVSI Unmanned Systems North America 2006.
 8. Grant Gothing, Jesse Hurdus, Al Wicks and Charles Reinholtz, “Implementation of JAUS on a 2004 Cadillac SRX Using a Potential Fields Architecture”, AUVSI Unmanned Systems North America 2006.
 9. Benjamin Dingus, Elizabeth Hoppe, Jansen Lee, Nicholas Misyak, David Pape, Justin Ryan, Matthew Schivikas, Steven Ross Shake, Christopher Veraa, Rachael Ramirez, Charles Reinholtz, “Development of a Fixed-Wing Autonomous Aerial Vehicle at Virginia Tech,” AUVSI UAV Competition Journal Paper, <http://www.bowheadsupport.com/paxweb/seafarers/default.htm>, June, 2006.
 10. Ruél Faruque, Andrew Bacha, Charles Reinholtz, “Implementing a JAUS Design Process on Two Autonomous Robots for the Intelligent Ground Vehicle Competition,” 6th Annual Intelligent Vehicle Systems Symposium, Grand Traverse Resort & Spa-Traverse City, MI, June 2006.
 11. Sean Baity, Jonathan Frentzel, Brett Gombar, Michael Fleming, Chris Terwelp, Al Wicks, Charles Reinholtz and Andrew Bacha, “Portable Wireless Site Instrumentation for Unmanned System Experimentation” AUVSI Unmanned Systems North America 2005, June 28-30, 2005, Baltimore, MD
 12. Shane Barnett, Sean Baity, Ben Hastings, Chris Terwelp, Charles Reinholtz, Bill McBride, Andrew Moore, Development of a Tow Capacity Test Device for Small Unmanned Vehicles, AUVSI Unmanned Systems North America 2005, June 28-30, 2005, Baltimore, MD
 13. Gregg Vonder Reith, Ken Meidenbauer, Imraan Faruque, Chris Sharkey, Jared Cooper, Shane Barnett, Charles Reinholtz, “Development of an Autonomous Aerial Reconnaissance Platform at Virginia Tech,” AUVSI UAV Competition Journal Paper, <http://www.bowheadsupport.com/paxweb/seafarers/default.htm>, June 14-18, 2005.
 14. Andrew Bacha, Michael Fleming, Chris Terwelp, Charles Reinholtz and Al Wicks, “A Behavior Based Approach to Autonomous Lane Following,” 5th Annual Intelligent Vehicle Systems Symposium, Grand Traverse Resort & Spa-Traverse City, MI, June 13-16, 2005
 15. Sean Baity, Brett Gombar, Michael Fleming, Charles Reinholtz, “Design for the Intelligent Ground Vehicle Competition,” 5th Annual Intelligent Vehicle Systems Symposium, Grand Traverse Resort & Spa-Traverse City, MI, June 13-16, 2005
 16. Whittier, W. B., Reinholtz C. F., and Stubbs, M. D., “Single Degree-of-Freedom Morphing Wing: Design and Synthesis,” Proceedings of the ASME Design Engineering Technical Conference and Computers and Information in Engineering Conference, September 28-October 2, 2004, Salt Lake City, Utah, DETC2004-57019
 17. L. D. Wiggins, Stubbs, M. D., Johnston, C. O., Robertshaw, H. H., Reinholtz, C. F., and Inman, D. J., “Design and Analysis of a Morphing Hyper-Elliptic Cambered Span (HECS) Wing,” American Institute of Aeronautics and Astronautics Structural Dynamics & Materials Conference, Palm Springs, California, 19-22 April, 2004
 18. Wicks, A. L., Fleming, M., Terwelp C. and Reinholtz, C. F., “Development of a Remote-Controlled CASE CX-160 Excavator Using FieldPoint,” National Instruments NI Week 2002, Austin Texas, Aug 12-15, 2002. (winner of the Best Application of Measurement and Automation Award)
 19. Kedrowski, P. R., Conner, D. C., Reinholtz, C. F., Global Map Building and Look-Ahead

- Implementation on an Outdoor Autonomous Vehicle, Proceedings of the SPIE Photonics Conference, Symposium on Intelligent Systems for Advanced Manufacturing, Vol. 4573, number 16, 29-30 October 2001, Boston, MA
20. Kedrowski, P. R., Conner, D. C., Reinholtz, C. F., Optimized Parametric Calibration of Autonomous Vehicles, Proceedings of the SPIE Photonics Conference, Symposium on Intelligent Systems for Advanced Manufacturing, Vol. 4573, number 18, 29-30 October 2001, Boston, MA
 21. Kedrowski, P. R., Reinholtz, C. F., Abbott, M. S., Conner, D. C., Biplanar bicycle as a base vehicle for Autonomous applications. SPIE Mobile Robots XV, 2000, Boston, MA.
 22. Conner, D. C., Kedrowski, P. R., Reinholtz, C. F., Bay, J.S., Improved dead reckoning using caster wheel sensing on a differentially steered 3-wheeled autonomous vehicle. SPIE Mobile Robots XV, 2000, Boston, MA.
 23. Conner, D. C., Kedrowski, P. R., Reinholtz, C. F., Multiple camera, laser rangefinder, and encoder data fusion for navigation of a differentially steered 3-wheeled autonomous vehicle. SPIE Mobile Robots XV, 2000, Boston, MA.
 24. Soper, R. R., Anderson, J. M., Jacobs, D. C., James, M. M., Reinholtz, C. F., "Analytical Synthesis of Cams Conjugate to Elliptical Followers," *Proceedings of the 6th National Applied Mechanisms and Robotics Conference*, Cincinnati, OH, December 13-15, 1999.
 25. Abbott, M. S., Carr, A., Soper, R. R., Reinholtz, C. F., "Hamiltonian Dynamics and Numerical Optimization of the Trebuchet," *Proceedings of the 6th National Applied Mechanisms and Robotics Conference*, Cincinnati, OH, December 13-15, 1999.
 26. Soper, R. R., Abbott, M. S., Reinholtz, C. F., "Coupled Camera Stabilization and Propulsion Mechanism and Control Law Development for an Autonomous Biplanar Bicycle," *Proceedings of the 6th National Applied Mechanisms and Robotics Conference*, Cincinnati, OH, December 13-15, 1999.
 27. Coleman, P. K., Mayhew, D. M., Bay, J. S., Reinholtz, C. F., "Enhancing Engineering Education using an Interdisciplinary Team-Oriented Approach to Autonomous Robot Design," ASEE Annual Conference and Exposition, Charlotte NC, June 20-23, 1999.
 28. Reinholtz, C. F., Bay, J., Soper, R. R., Abbott, M., and Grove, D., 1999, "The Biplanar Bicycle," Proceedings of the 1999 ASME International Mechanical Engineering Congress and Exposition, Nashville, TN, Nov. 14-19, *Innovations in Vehicle Design and Development*, DE-Vol.101, pp.157-160.
 29. Abbott, M. S., Soper, R. R., Grove, D. E., and Reinholtz, C. F., 1999, "Planar Dynamics and Control of a Two-Wheeled Single-Axle Vehicle," Proceedings of the 1999 ASME International Mechanical Engineering Congress and Exposition, Nashville, TN, Nov. 14-19, *Innovations in Vehicle Design and Development*, DE-Vol.101, pp.161-169.
 30. Grove, D. E., Soper, R. R., Abbott, M. S., and Reinholtz, C. F., 1999, "Orientation-Regulated Platforms for Use on Biplanar Bicycles," Proceedings of the 1999 ASME International Mechanical Engineering Congress and Exposition, Nashville, TN, Nov. 14-19, *Innovations in Vehicle Design and Development*, DE-Vol.101, pp.171-177.
 31. Soper, R. R., Reinholtz, C. F., Canfield, S. L., and Williams, R. L. III, 1999, "Contention-Free Control of Over-Constrained Variable Geometry Trusses," Proceedings of the 1999 ASME Design Engineering Technical Conferences, 25th Design Automation Conference, Las Vegas, NV, Sept. 12-15, ASME Paper No. DETC99/DAC-8668.
 32. Bay, J., Saunders, W., Reinholtz, C. F., Pickett, P., Johnston, L., "Mechatronics Education at Virginia Tech," *SPIE International Symposium on Intelligent Systems and Advanced Manufacturing*, Nov. 1998.

33. R. Randall Soper, Charles F. Reinholtz, Stephen L. Canfield, "Synthesis of Multi-Degree-of-Freedom Force Generating Linkages," *Proceedings of the ASME Design Engineering Technical Conferences*, Atlanta, Georgia, September 1998, CD ROM Proceedings, paper DETC98/MECH-5975
34. Stephen L. Canfield, R. Randall Soper, Charles F. Reinholtz, "Creating Highly Dexterous Manipulators Using Nonlinear Input Transmission," *Proceedings of the ASME Design Engineering Technical Conferences*, Atlanta, Georgia, September 1998, CD ROM Proceedings, paper DETC98/MECH-59756
35. Burgiss, M. J., Reinholtz, C.F, and Bay, J., "Education and Research Experience of the Autonomous Vehicle Team at Virginia Tech," *SPIE Conference on Intelligent Systems and Automated Manufacturing*, Pittsburgh, PA, Oct. 1997, pp. 295-305.
36. Soper, R. R., Reinholtz, C. F., Gao, D., Canfield, S. L., "The Mathematics of Manipulator Statics: Minimum Principles, Duality, and Underlying Linear Symmetry," *Proceedings of the 5th National Applied Mechanisms and Robotics Conference*, Cincinnati, OH, October 12-15, 1997
37. Soper, R. R., Reinholtz, C. F., and Scardina, M. T., "Synthesis of Linkage-Based Selectorized Weight Machines," *Proceedings of the 5th National Applied Mechanisms and Robotics Conference*, Cincinnati, OH, October 12-15, 1997
38. Soper, R. R., Reinholtz, C. F., and Canfield, "Maximum Number of Precision Positions in Nonclassical Linkage Synthesis," *Proceedings of the 5th National Applied Mechanisms and Robotics Conference*, Cincinnati, OH, October 12-15, 1997.
39. Coombs, D. J., Canfield, S. L., Soper, R. R., and Reinholtz, C. F., "Design of User-Weight-Based Exercise Machines," *Proceedings of the 5th National Applied Mechanisms and Robotics Conference*, Cincinnati, OH, October 12-15, 1997
40. Canfield, S. L., Soper, R. R., and Reinholtz, C. F., 1997, "Dynamic Force Analysis of the Carpal Wrist," *Proceedings of the 1997 ASME Design Engineering Technical Conferences* (CD-ROM), Design Automation Conference, Sacramento, CA, September 15-20, 97-DETC/DAC-3970, 1997.
41. Canfield, S. L., Soper, R. R., and Reinholtz, C. F., "Uniformity as the Guide to Evaluation of Dexterous Manipulator Workspaces," *Proceedings of the 1997 ASME Design Engineering Technical Conferences* (CD-ROM), Design Automation Conference, Sacramento, CA, September 15-20, 97-DETC/DAC-3969, 1997
42. Shooter, S.B. and C.F. Reinholtz, "AutoCam - A Modular Decision Support System for the Design of Cam Mechanisms", *Proceedings of the 1997 ASME Design Automation Conference*, Sacramento California, September 1997. September 15-20, 97-DETC/DAC.
43. Soper, R. R., Canfield, S. L., Reinholtz, C. F., and Mook, D. T., "New Matrix-Theory-Based Definitions for Manipulator Dexterity," *Proceedings of the 1997 ASME Design Engineering Technical Conferences* (CD-ROM), Design Automation Conference, Sacramento, CA, September 15-20, 97-DETC/DAC-4410, 1997.
44. Soper, R. R., Mook, D. T., and Reinholtz, C. F., "Vibration of Nearly-Perfect Spring Equilibrators," *Proceedings of the 1997 ASME Design Engineering Technical Conferences* (CD-ROM), Design Automation Conference, Sacramento, CA, September 15-20, 97-DETC/DAC-3768, 1997.
45. Canfield, S. L., Reinholtz, C. F., "Development of the Carpal Robotic Wrist" *Proceedings of the ISER97*, June 15-18, 1997
46. Tidwell, P. H., Soper, R. R., and Reinholtz, C. F., "Synthesis of Force-Generating Mechanisms," *Proceedings of the 24th Biennial Mechanisms Conference*, Irvine, California, August 18-22, 1996, paper 96-DETC/MECH-1211.
47. Canfield, S. L., Soper, R. R., Hendricks, S. L., and Reinholtz, C. F., "Velocity Analysis of Truss-

- Type Manipulators," *24th Biennial Mechanisms Conference*, Irvine, California, August 18-21, 1996, paper DETC/MECH-1158.
48. Canfield, S. L., Ganino, A. J., Salerno, R. J., and Reinholtz, C. F., 1996, "Singularity and Dexterity Analysis of the Carpal Wrist," *24th Biennial Mechanisms Conference*, Irvine, California, August 18-21, 1996, paper DETC/MECH-1156.
 49. Glass, S. W., Ranson, C. C., Reinholtz, C. F. and Calkins, J. M., "Modular Robotics Applications in Nuclear Power Plant Maintenance," *Proceedings of the 58th American Power Conference*, April 9-11, 1996.
 50. Calkins, J. M., Canfield, S. L., Salerno, R. J. and Reinholtz, C. F., "An Optimization-Based, Matrix Operator Approach to Real-Time Compensation of Static Deflections in Robotic Manipulators," *Proceedings of the 4th National Applied Mechanisms and Robotics Conference*, December 10-14, 1995, Cincinnati, Ohio, Paper AMR 95-019.
 51. Canfield, S. L., Voruganti, R.S. and Reinholtz, C. F., "Minimizing Pose Errors in Robotic Systems Through Calibration," *Proceedings of the 4th National Applied Mechanisms and Robotics Conference*, December 10-14, 1995, Cincinnati, Ohio, Paper AMR 95-017.
 52. Scardina, M.T., Soper, R. R., Calkins, J. M. and Reinholtz, C. F., "Optimal Synthesis of Force-Generating Planar Four-Link Mechanisms," *Proceedings of the 4th National Applied Mechanisms and Robotics Conference*, December 10-14, 1995, Cincinnati, Ohio, Paper AMR 95-003.
 53. Canfield, S. L., Salerno, R. J. and Reinholtz, C. F., "Design of an All-Revolute, Constant-Velocity Coupling," *SAE International Off-Highway & Powerplant Congress & Exposition*, September 11-13, 1995, Milwaukee, Wisconsin, ISSN 0148-7191, Paper no. 952133.
 54. Soper, R. R., Scardina, M., Tidwell, P., Reinholtz, C. F. and Lo Presti M. A., "Closed-Form Synthesis of Force-Generating Planar Four-Bar Linkages," *DE-Vol. 82, Advances in Design Automation*, *Proceedings of the 1995 ASME Design Technical Conferences*, Boston, MA, September 17-21, 1995, pp. 845-851.
 55. Salerno, R. J., Canfield, S. L., Ganino, A. J. and Reinholtz, C. F., "A Parallel, Four-Degree-of-Freedom Robotic Wrist," *DE-Vol. 82, Advances in Design Automation*, *Proceedings of the 1995 ASME Design Technical Conferences*, Boston, MA, September 17-21, 1995, pp. 765-771.
 56. Glass, S. W., Fallon, J. B., Reinholtz, C. F., Abbott, A. L. "Machine Vision Calibration for a Nuclear Steam Generator Robot," *Proceedings of the 1994 ANS Winter Annual Meeting*, Washington D.C., November 1994.
 57. Fallon, J. B., Shooter, S. B., Reinholtz, C. F. and Glass, S. W., "URSULA: Design of an Underwater Robot for Nuclear Reactor Vessel Inspection," *Proceedings of the ASCE Specialty Conference*, Albuquerque, NM, Feb. 26 to March 3, 1994, pp. 311-319.
 58. Canfield, S. L., Salerno, R. J., and Reinholtz, C. F., "Kinematic Design of a Large-Angular-Motion Constant-Velocity Coupling," *DE-Vol.70, Mechanism Synthesis and Analysis*, *Proceedings of the 1994 ASME Design Technical Conferences*, Minneapolis, MN, Sept. 11-14, 1994, pp. 167-174.
 59. Shooter, S. B., Tidwell, P. H. and Reinholtz, C. F., "Analytical Approach to Cam-Modulated Linkage Synthesis Using Conjugate Geometry," *Mechanism Synthesis and Analysis*, *Proceedings of the 1994 ASME Design Technical Conferences*, Minneapolis, MN, Sept. 11-14, 1994, pp. 167-174.
 60. Salerno, R. J. and Reinholtz, C. F., "A Modular, Long-Reach Truss-Type Manipulator for Waste Storage Tank Remediation," *DE-Vol.70, Mechanism Synthesis and Analysis*, *Proceedings of the 1994 ASME Design Technical Conferences*, Minneapolis, MN, Sept. 11-14, 1994, pp. 167-174.

61. Fallon, J. B., Reinholtz, C. F., Vallance, R. R., and Voruganti, R. S., "Improving Robot System Performance Using Computer Vision," Mechanism Synthesis and Analysis, Proceedings of the 1994 ASME Design Technical Conferences, Minneapolis, MN, Sept. 11-14, 1994, pp. 167-174.
62. Garg, A. K., Reinholtz, C. F., Kornhauser, A. A., Voruganti, R. S., Douglass, C. H. and Walker, T. E., "Design and Development of a Bioremediation-Based System for Treating Medical Waste," Proceedings of the 26th Mid-Atlantic Industrial Waste Conference, Aug, 7-10, 1994, pp.53-60.
63. Glass, S. W, Fallon, J. B., Reinholtz, C. F., Abbott, A. L. and Asher, J. D. "Machine Vision Independent Position Verification for a Nuclear Steam Generator Robot," Proceedings of the 1994 EPRI Conference, Washington D.C, November 1994.
64. Canfield, S. L. and Reinholtz, C. F., "Development of and All-Revolute-Jointed Constant-Velocity Coupling, Proceedings of the 3rd National Applied Mechanisms and Robotics Conference, November 7-10, 1993, Cincinnati, Ohio, Paper AMR 93-081.
65. Tidwell, P. H., Hendricks, M. W., Fallon, J. B., Stulce, J. R., Beisgen, L. C. V., Reinholtz, C. F., and Maples, A. B., "Acoustic Pose Determination Applied to an Underwater Mobile Robot," Proceedings of the 3rd National Applied Mechanisms and Robotics Conference, November 7-10, 1993, Cincinnati, Ohio, Paper AMR 93-084.
66. Lee, H. Y., Fallon, J. B., Cordle, W. H., and Reinholtz, C. F., "Inverse Kinematic Analysis of a Mobile Underwater Inspection Robot," Proceedings of the 3rd National Applied Mechanisms and Robotics Conference, November 7-10, 1993, Cincinnati, Ohio, Paper AMR 93-085.
67. Shooter, S. B. and Reinholtz, C. F., "Extrinsic Calibration of Portable Manipulators," Proceedings of the 22nd ASME Mechanisms Conference, DE-VOL 45, September 1992, pp. 501-506.
68. Shooter, S. B., Reinholtz, C. F. and Dhande, S. G., "On the Kinematic Design of Manipulators for Limited Access Workspaces (LAWS)," Proceedings of the 22nd ASME Mechanisms Conference, DE-VOL 45, September 1992, pp. 485-491.
69. Tidwell, P. H., Bandukwala, N., Dhande, S. G., Reinholtz, C. F. and Webb, G, "Synthesis of Wrapping Cams," Proceedings of the 22nd ASME Mechanisms Conference, DE-VOL 46, September 1992, pp. 337-343. (Procter and Gamble Best Paper Award of Merit, 22nd ASME Mechanisms Conference, Scottsdale, Arizona, September 1992)
70. Padmanabhan, B., Tidwell, Salerno, R. J. and Reinholtz, C. F., "VGT-Based Gimbals: Practical Construction and General Theory," Proceedings of the 22nd ASME Mechanisms Conference, DE-VOL 47, September 1992, pp. 437-443.
71. Arun, V., Padmanabhan, B., Kolady, K., and Reinholtz, C. F., "Determination of the workspace of the 3-DOF Double-Octahedral Variable-Geometry Truss Manipulator," Proceedings of the 22nd ASME Mechanisms Conference, DE-VOL 45, September 1992, pp. 493-500.
72. Tidwell, P. H., Glass, S. W., Hildebrand, J. J., Reinholtz, C. F., and Shooter, S. B., "COBRA - Design and Development of a Manipulator for Nuclear Steam Generator Maintenance," Proceedings of the 2nd National Applied Mechanisms and Robotics Conference, November 3-6, 1991, Cincinnati, Ohio, (Winner of Procter and Gamble Best Paper Award and Winner of The George Wood Best Applied Paper Award).
73. Stulce, J. R., and Reinholtz, C. F., "Observations on Caterpillar Locomotion and Their Application to a Crawling Robot," Proceedings of the 2nd National Applied Mechanisms and Robotics Conference, November 3-6, 1991, Cincinnati, Ohio.
74. Stulce, J. R., W. D. Burgos, S. G. Dhande, and C. F. Reinholtz, "Conceptual Design of a Multibody Passive-Legged Crawling Vehicle," Proceedings of the 1990 ASME Mechanisms Conference, DE-Vol. 26, Cams, Gears Robot and Mechanism Design, Sept. 16-19, 1990, pp. 199-205.

75. Arun, V., and C. F. Reinholtz, L. T. Watson, "Enumeration and Analysis of Variable Geometry Truss Manipulators," Proceedings of the 1990 ASME Mechanisms Conference, DE-Vol. 26, Cams, Gears Robot and Mechanism Design, Chicago, IL, Sept. 16-19, 1990, pp. 93-98.
76. Dhande, S. G., B. Padmanabhan, C. F. Reinholtz, and R. S. Voruganti, "Computer-Aided Design and Manufacture of Approximate Ruled Surfaces," Proceedings of the Second International Conference on Computer Integrated Manufacturing, IEEE Computer Society Press, Troy, NY, May 21-23, 1990, pp. 137-142.
77. Tidwell, P. H., C. F. Reinholtz, H. H. Robertshaw, C. G. Horner, "Kinematic Analysis of Generalized Adaptive Trusses," First Joint US/Japan Conference on Adaptive Structures, Maui, Hawaii, November 13-15, 1990.
78. Padmanabhan, B., and C. F. Reinholtz, "Design of Robotic Manipulators Using Variable-Geometry Trusses as Joints," paper 89 AMR-8C-7, Proceedings of the First National Applied Mechanisms and Robotics Conference, Vol. II, 1989.
79. Thompson, J. M., C. F. Reinholtz, and A. Myklebust, "Exact Analysis and Synthesis of the RSCR Spatial Mechanism," ASME paper No. 88131, Trends and Developments in Mechanisms, Machines and Robotics--1988 Proceedings of the 20th Mechanisms Conference, Orlando, FL, Sept. 25-28, 1988.
80. Williams, R. L., II, C. F. Reinholtz, "Forward Dynamic Analysis and Power Requirement Comparison of Parallel Robotic Mechanisms," ASME paper No. 88078, Trends and Developments in Mechanisms, Machines and Robotics--1988 Proceedings of the 20th Mechanisms Conference, Orlando, FL, Sept. 25-28, 1988. (Also accepted for publication in the ASME Journal of Mechanisms, Transmissions and Automation in Design, 1989.)
81. Williams, R. L., II, C. F. Reinholtz, "Closed-Form Workspace Determination and Optimization for Parallel Robotic Mechanisms," ASME paper No. 88079, Trends and Developments in Mechanisms, Machines and Robotics--1988 Proceedings of the 20th Mechanisms Conference, Orlando, FL, Sept. 25-28, 1988.
82. Robertshaw, H. H., and C. F. Reinholtz, "Variable Geometry Trusses," Proceedings of the US Army Research Office Workshop on Smart Materials, Structures and Mathematical Issues, Sept. 15-16, 1988.
83. Salerno, R. J., C. F. Reinholtz, and H. H. Robertshaw, "Shape Control of High Degree of Freedom Variable Geometry Trusses," presented at the NASA Workshop on Controls/Structures Integration, Williamsburg, VA, July 11-13, 1988.
84. Williams, R. L., II, C. F. Reinholtz, "Closed-Loop Planar Manipulators: Part I - Forward and Inverse Kinematics; Part 2 - Workspace Optimization," Proceedings of the 10th Applied Mechanisms Conference, Dec. 6-9, 1987, New Orleans, Louisiana.
85. Rogers, C. A., H. H. Mabie, and C. F. Reinholtz, "Numerical Determination of Accuracy Points Using Chebyshev Polynomials for Displacement and Velocity Synthesis," Proceedings of the 10th Applied Mechanisms Conference, Dec. 6-9, 1987, New Orleans, Louisiana.
86. Mabie, H. H., C. F. Reinholtz, and C. A. Rogers, "Determination of Hob Offsets to Maximize the Ratio of Recess to Approach Action and Balance Tooth Strengths for Nonstandard Spur Gears by Limit Analysis," Proceedings of the 10th Applied Mechanisms Conference, Dec. 6-9, 1987, New Orleans, Louisiana.
87. Mabie, H. H., C. F. Reinholtz, and C. A. Rogers, "Determination of Pinion Cutter Offsets to Maximize Recess to Approach Action or to Equalize Tooth Strengths of Nonstandard Spur Gears with Backlash," Proceedings of the 10th Applied Mechanisms Conference, Dec. 6-9, 1987, New Orleans, Louisiana.

88. Reinholtz, C. F., and D. Gokhale, "Design and Analysis of Variable Geometry Truss Robots," Proceedings of the 10th Applied Mechanisms Conference, Dec. 6-9, 1987, New Orleans, Louisiana.
89. Reinholtz, C. F., V. Arun, and R. L. Williams, "A Reassessment of the Tasks of Kinematic Synthesis," Proceedings of the 10th Applied Mechanisms Conference, Dec. 6-9, 1987, New Orleans, Louisiana.
90. Arun, V., and C. F. Reinholtz, "Design of the RCCC Spatial Mechanism," Proceedings of the 10th Applied Mechanisms Conference, Dec. 6-9, 1987, New Orleans, Louisiana.
91. Klatt, M. A., and C. F. Reinholtz, "Mechanism Optimization Using Zero-Order Methods and Penalty Functions: A Comparison of Incremented Versus Nonincremented Penalty Parameter," DE-VOL. 10-1, Advances in Design Automation, Vol. 1, Proceedings of the 1987 Design Automation Conference, Boston, MA, Sept. 27-30, 1987, pp. 205-213.
92. Rogers, C. A., R. E. Cobb, and C. F. Reinholtz, "Incorporating Computer Programming Projects Into the Mechanical Engineering Curriculum," Proceedings of the Fifth National Conference on University Programs in Computer-Aided Engineering, Design, and Manufacturing (UPCAEDM '87), pp. 176-180.
93. Williams, R. L., C. F. Reinholtz, and A. Myklebust, "Complete Function-Generation Synthesis and Design of RSSR Spatial Mechanisms," ASME Paper 86-DET-151, presented at the 19th ASME Mechanisms Conference, Columbus, Ohio, October 1986.
94. Reinholtz, C. F., "Integrating Computers into Kinematics Courses at VPI&SU," Proceedings of the Fourth National Conference on University Programs in Computer-Aided Engineering, Design and Manufacture, August 1986, pp. 127-130.
95. Mabie, H. H., C. F. Reinholtz, D. Puzio, and G. M. Irwin, "Optimum Design of Spur Gear Teeth Cut with a Hob," Proceedings of the Ninth Applied Mechanisms Conference, Kansas City, MO, 1985, Vol. 2, Session VIII.B, Paper VI.
96. Keil, M. J., A. Myklebust, and C. F. Reinholtz, "Prediction of Link Interference in Planar Mechanisms," Proceedings of the Ninth Applied Mechanisms Conference, Kansas City, MO, 1985, Vol. 1, Session III.B, Paper V, (Winner of Proctor and Gamble Best Paper Award).
97. Myklebust, A., C. F. Reinholtz, W. H. Francis, and M. J. Keil, "Design of a Radar Guidance Mechanism Using MECSYN-ANIMEC," ASME Paper 84-DET-139, presented at the 18th ASME Mechanisms Conference, Cambridge, Massachusetts, October 10, 1984.
98. Sandor, G. N., A. G. Erdman, E. Raghavacharyulu, and C. F. Reinholtz, "On the Equivalence of Higher and Lower Pair Planar Mechanisms," Proceedings of the Sixth World Congress of the International Federation for the Theory of Machines and Mechanisms, New Delhi, India, 1983.
99. Sandor, G. N., D. Kohli, X. Zhuang, and C. F. Reinholtz, "Synthesis of a Five-Link Spatial Motion Generator," ASME paper 82-DET-130, 1982.
100. Sandor, G. N., D. Kohli, A. Ghosal, and C. F. Reinholtz, "Closed-Form Analytic Synthesis of a Five-Link Spatial Motion Generator," Proceedings of the Seventh Applied Mechanisms Conference, Kansas City, MO, 1981, pp. XXVI-1 to XXVI-7

Patents

1. "Spatial, Parallel-Architecture, Robotic Carpal Wrist," U. S. Patent 5,699,695, Inventors: Canfield, S. L., Reinholtz, C. F., Salerno, R. J., and Ganino, Anthony J., Assignee: Virginia Tech Intellectual Properties, Inc., Awarded December 23, 1997.
2. "Snubber Profile," U. S. Patent 4,998,942, Inventor: Reinholtz, Charles F. Assignee: Milliken Research Corporation, Spartanburg, S.C., Awarded March 12, 1991.

Invited Presentations at National Meetings

1. "Test Drive an Autonomous Vehicle: Experiences from the 2007 DARPA Urban Challenge," Presentation to USAA, 19 January 2009, San Antonio, TX
2. "Challenges and Opportunities Offered by the DARPA Grand Challenge," Invited Presentation and Panel Discussion at the 2004 AIAA Unmanned Aerial Vehicle Conference, Chicago, IL, September 2004.
3. "Product Safety and Product Liability," Invited Lecture at the 2001 ASME World Congress, New York, NY, Nov.13, 2001
4. "Life after Tenure" Invited Speaker and Panelist at the ASEE Annual Conference and Exposition, Charlotte NC, June 20-23, 1999.
5. "Reduced Complexity Robotics," Invited presentation at the 1998 ASME Design Technical Conferences, 25th Biennial Mechanisms Conference, Atlanta, GA, September 1998.
6. "Trends and Opportunities in Mechanisms Research," Plenary Panel Session Speaker at the 4th National Applied Mechanisms and Robotics Conference, Cincinnati, Ohio, December 10-14, 1995.
7. "Trends and Opportunities in Robotics," Opening Plenary Session Lecture at the 10th Applied Mechanisms Conference, Dec. 6-9, 1987, New Orleans, Louisiana.
8. "Observations on Robotics and Mechanisms Research," Opening Plenary Panel Session Speaker at the 2nd National Applied Mechanisms and Robotics Conference, November 3-6, 1991, Cincinnati, Ohio, November 3-6, 1991.

University Service

Invited Speaker at the following University Events and Alumni Association Chapter Meetings:

June 23, 2005, Research Triangle Park Alumni Chapter, Raleigh, NC

March 18, 2004, Greensboro, NC Triad Alumni Chapter

March 31, 2004, Atlanta Alumni Chapter

November 1, 2004, Committee of 100 - Hotel Roanoke

November 21, 2004, Class of 1968, Donaldson Brown

Advisor to the following Embry Riddle Autonomous Vehicle Teams:

Unmanned Aerial Systems Competition, 2007-Present

International Aerial Robotics Competition, 2007-Present

Intelligent Ground Vehicle Competition, 2007-Present

RoboBoat, 2007-Present

RoboSub, 2007-Present

Maritime RobotX Competition, 2013-Present

EcoCAR (CAVs Advisor), 2016-Present

Member, College Promotion and Tenure Committee 2018-21

Fulbright Scholarship Advisory Committee 2005

Advisor to the Virginia Tech Autonomous Aerial Vehicle Competition Team, 2004-

Advisor to the Virginia Tech DARPA Grand Challenge Team, 2003-

Virginia FIRST Lego League Coordinator, 2002-

Advisor to the Virginia Tech Intelligent Ground Vehicle Competition Team, 1995-

Advisor to Entering Honors Students 2003-

Horton Honors Scholarship Selection Committee 2003-

Member, University Strategic Planning Committee, 2001

Chair, Virginia Tech Academy of Teaching Excellence 2000-2001

Vice Chair, Virginia Tech Academy of Teaching Excellence 1999-2000

Member, University Promotion and Tenure Committee 2000-2001
 Member, College Promotion and Tenure Committee 2000-2001
 Chair, Mechanical Engineering Curriculum Committee 1997-2002
 Chair, Mechanical Engineering ABET Review, 1998-2002
 Member, College of Engineering Curriculum Committee 1997-2002
 Member, 1st Year Special Curriculum Review Committee 1997
 Member, Engineering Dean Search Committee, 1993-4
 Chairman, Mechanical Engineering Honors and Awards and Publicity Committee, 1993-99
 Member, Mechanical Engineering Honors and Awards and Publicity Committee, 1993-99
 Chairman, College Wine Teaching Award Committee, 1992-95
 Chairman, University Wine Teaching Award Committee, 1995-96
 Member, Mechanical Engineering Department Head Search Committee, 1992-93
 Member, Mechanical Engineering Curriculum Committee, 1984-87, 1992-2004
 Member, Mechanical Engineering Tenure and Promotion Committee, 1989-2004
 Member, Mechanical Engineering Graduate Committee, 1987-89
 Member, Mechanical Engineering Recruiting Committee, 1992-93
 Member, Sigma Xi High School Teaching Award Committee 1987-88, Chairman 1989
 Member, College of Engineering Commencement Committee, 1988-
 Faculty Advisor to the Virginia Tech Student Section of ANS, 1993-
 Faculty Advisor to the Virginia Tech Student Section of ASME, 1988-
 Faculty Advisor to the Virginia Tech Chapter of Tau Beta Pi, 1984-88
 Host for the Virginia Tech Academic Challenge, 1991

Professional Service

<u>Society</u>	<u>Positions Held</u>
ASME	Secretary of the Virginia Section 1987-92 Chairman of the National Student Mechanism Competition 1987-88 Chairman of the Joint Regional Conference 1989 and 2000 Virginia Tech Student Section Advisor, 1988-2007 Member of the ASME Mechanisms Committee, 1990-1993 Associate Technical Editor, <i>ASME Journal of Mechanical Design</i> , 1991-93 Paper Review Chairman, 22nd ASME Mechanisms Conference, Sept. 1992 Conference Arrangements Chairman, 23rd ASME Mechanisms Conference, Sept. 1994 Member, ASME National Design Contest Committee, 1996-2002 Virginia Section Newsletter Editor, 1994-2000 Region IV Senior Representative to the National Student Sections Committee, 1995-2000
Sigma Xi	High School Teaching Award Committee, Member 1987-88, Chair 1989
ANS	Student Section Advisor, Virginia Tech, 1993-95
NAE	Invited review Board member, National Academies' National Research Council (NRC) Army Research Laboratory Technical Assessment Board (ARLTAB), May 2004

Graduate Advising

Master's Degree Students Completed				
	Degree	Name	Completion Date	Title
1	MS	Robert L Williams, II	8/85	Synthesis and Design of the RSSR Spatial Mechanism for Function Generation
2	MS	Arun Veeraraghavan	3/86	Computer Aided Design of the RCCC Spatial Mechanism
3	MS	Michael A. Klatt	10/86	Design Optimization of Planar Mechanisms
4	MS	Kevin K. Moyers	11/87	A Microcomputer-Based Data Acquisition System for Diagnostic Monitoring of High-Speed Electric Motors
5	MS	Christodoulos S. Demetriou	12/87	A PC Implemented Kinematic Synthesis System for Planar Mechanisms
6	MS	Dipen P. Gokhale	12/87	Kinematic Analysis and Animation of a Variable-Geometry Truss Robot
7	MS	William R. Seith	5/88	Design of a Flying Cutter
8	MS	George M. Clessas	5/88	Direct Calculation of Cable Tension in a Store Separation Program Which Models the Launch of an Aerial Tow Target
9	MS	Mark W. Biegler	8/88	Determination of Stress Concentration Factors Using Experimental Methods
10	MS	Nandan Joshi	2/88	Mobility Analysis of Variable-Geometry Trusses
11	MS	Vasant Marathe	12/88	Design of a Hot Melt Book Binding Machine
12	MS	Babu Padmanabhan	12/88	Design of a Robotic Manipulator Using Variable-Geometry Trusses as Joints
13	MS	Robert J. Salerno	6/89	Shape Control of High Degree-of-Freedom Variable-Geometry Truss Manipulators
14	MS	Ravinder S. Voruganti	8/90	Symbolic and Computational Conjugate Geometry for Design and Manufacturing Applications
15	MS	Steven B. Shooter	12/90	Conceptual Manipulator Design for Limited Access Workspaces
16	MS	Paul Mele	5/91	Mechanical Design of a Stewart Platform-Based Crawling Vehicle
17	M.S.	William K. Carpenter	12/92	Design of Medical Waste Treatment Systems Employing Bioremediation
18	MS	Allen Maples	5/93	Design of a Robust Acoustic Positioning System for an Underwater Nuclear Reactor Vessel Inspection Robot
19	MS	William Cordle	5/93	Numerical Inverse Kinematics for a Six Degree-of-Freedom Manipulator
20	MS	Glenn Melnyk	6/93	Mechanisms for Automated Toolhead Changing in Nuclear Steam Generator Robotics
21	MS	Steve Payne	5/94	A CAD-Interactive Software Package for the Synthesis of Planar Disk Cams
22	MS	Anil K. Garg	8/94	Design, Installation and Testing of a Bioremediation-Based System for Treating Regulated Medical Waste
23	MS	Todd Denkins	12/94	Design Methodology to reduce the Number of Actuators in Complex Mechanisms

24	MS	Joseph Calkins	12/94	Real-Time Compensation of Static Deflections in Robotic Manipulators
25	MS	Randy Soper	8/95	Synthesis of Planar Four-Link Mechanisms for Force Generation
26	MS	Keith Garguilo	8/95	Design and Testing of a Nonlinear Mechanical Advantage Demonstration Mechanism
27	MS	Ganino, A. J.	5/96	Mechanical Design of the Carpal Wrist: A Parallel-Actuated, Singularity-Free Robotic Wrist
28	MS	Larkin, Susan	6/96	Wheeled Autonomous Mobile Robots for use in Harsh Environments: A Survey of Recent Publications
29	MS	Iskandar, Kurnia	6/96	Computer Assisted Synthesis of Wrapping Cam Mechanisms
30	MS	Riutort, Kevin	7/96	Applied Design and Implementation of Straight-Line Mechanisms
31	MS	Saccoccio, Greg	8/96	Error Modeling of the Carpal Wrist
32	MS	Scardina, Mike	10/96	Optimal Synthesis of Force-Generating Planar Four-Link Mechanisms
33	MS	Palmer, Matthew	12/96	Kinematics of Beam-Flexure Four-Bar Linkages with Applications in a Compound Bow
34	MS	Coombs, Dana	2/97	Design of User-Weight-Based Exercise Machines
35	MS	Doyle, Matthew	12/97	The Foundation for CADSPAM
36	MS	Hayes, Thomas J.	12/97	The Creative Entrepreneurs Organization
37	MS	Adler, Alex	5/98	Testing and Understanding Screwdriver Bit Wear
38	MS	Haynie, C. Dean	8/98	Mechanical Design and Navigation Strategies for a Zero-Turn-Radius Autonomous Vehicle
39	MS	Holland, Michael	12/98	Assembly Optimization for Double-Row Ball Bearings
40	MS	Abbott, Michael	6/00	Dynamics and Control of the Biplanar Bicycle
41	MS	Conner, David	8/00	Sensor Fusion, Navigation, and Control of Autonomous Vehicles
42	MS	Jillcha Wakjira	1/01	Design of a SMA Heat Engine
43	MS	Carr, Angela	5/01	Position Control Comparison of Equilibrated and Mass Counterweight Systems
44	MS	Kedrowski, Philip	5/01	Development and Implementation of a Self-Building Global Map for Autonomous Navigation
45	MS	Blackett, Ricardo	5/01	Optimization of Multi-Degree-of-Freedom Force Generating Mechanisms
46	MS	Matthew Thompson	7/01	Design of a Cyclic Sliding, Dynamically Loaded Wear Testing Device for the Evaluation of Total Knee Replacement Materials
47	MS	Rundgren, Brian	12/01	Design and Optimization of Force Generation Linkages to Include Dynamic Effects
48	MS	Schiller, Ean	9/02	Heat Engine Driven by Shape Memory Alloys: Prototyping and Design

49	MS	Gopinath, Sudir	12/02	Using Color and Shape Analysis for Boundary Line Extraction in Autonomous Vehicle Applications
50	MS	Whittier, Will	12/02	Kinematic Analysis of Tensegrity Structures
51	MS	Terwelp, Chris	5/03	Remote Control of Hydraulic Equipment for Unexploded Ordnance Remediation
52	MS	Henshaw, Graham	5/03	Single-Session Design: Design Methodology in Compressed Timeframes Derived from the Robot Rivals Television Series
53	MS	Corey, Chris	12/03	Epicyclic Gear Train Solution Techniques with Application to Tandem Bicycling
54	MS	Fleming, Michael	12/03	Teleoperated Control of Hydraulic Equipment for Hazardous Material Handling
55	MS	Stubbs, Matthew	12/03	Kinematic Design and Analysis of a Morphing Wing
56	MS	Bacha, Andrew	5/05	Line Detection and Lane Following for an Autonomous Robot
57	MS	Frentzel, John	5/05	A Wireless Instrumented Payload for Testing Unmanned Vehicles
58	MS	Naik, Ankur	12/05	Arc Path Collision Avoidance Algorithm for Autonomous Ground Vehicles
59	MS	Barnett, Shane	12/05	Development of a Tow Capacity Test Device for Small Unmanned Vehicles
60	MS	Cooper, Jared	12/05	Modeling of a Small-Scale Remote Controllable Helicopter for Simulation and Control Development
61	MS	Baity, Sean	5/06	Development of a Next-generation Experimental Robotic Vehicle (NERV) that Supports Intelligent and Autonomous Systems Research
62	MS	Leedy, Brett	5/06	Two Minds for One Vehicle: A Case Study in Deliberative and Reactive Navigation
63	MS	Gombar, Brett	5/06	Design and Evaluation of a Mobile Instrumentation Platform for Unmanned Vehicle Testing
64	MS	Putney, Joseph	5/06	Reactive Navigation of an Autonomous Ground Vehicle Using Dynamic Expanding Zones
65	MS	Willis, Christopher Ryan	5/06	A Kinematic Analysis and Design of a Continuously Variable Transmission
66	MS	James Hayward Bittorf	6/06	Mechanical Device to Assist the Landing of Unmanned Aerial Vehicles
67	MS	Ramirez, Rachael	8/06	Computer Vision Based Analysis of Broccoli for Application in a Selective Autonomous Harvester
68	MS	Grant Edward Gothing	7/07	Development of the “Discretized Dynamic Expanding Zones with Memory” Autonomous Mobility Algorithm for the Nemesis Tracked Vehicle Platform
69	MS	David Burns Van Covern	7/07	Collaborative Target Localization and Inspection Using a Heterogeneous Team of Autonomous Vehicles
70	MS	Thomas James Alberi	4/08	A Proposed Standardized Testing Procedure for Autonomous Ground Vehicles

71	MS	Patrick Norman Currier	4/08	Development of an Automotive Ground Vehicle Platform for Autonomous Urban Operations
72	MS	Jesse Lee Farmer	2/08	Kinematic Analysis of a Two Body Articulated Robotic Vehicle
73	MS	Chris Hockley	12/10	Development of an Autonomous Monocopter
74	MS	Katrina Corley	4/11	Supervisory Autonomous Control of Homogeneous Teams of Unmanned Ground Vehicles: Application to The Multi-Autonomous Ground-Robotic International Challenge
75	MS	Robert Andrew Lister	5/11	Classification of Marine Vessels in a Littoral Environment Using a Novel Training Database
76	MS	Kevin Rigby	8/11	Localization of Aircraft Using Wide-Baseline Stereopsis
77	MS	Lafe Zabowski	8/11	A Low Cost, Computer Vision Based, Target Tracking Hexapod
78	MS	Christine Dailey	5/12	A Novel Resistance Exercise Machine for Use in a Lower Body Negative Pressure Box to Counteract the Effects of Weightlessness

Ph.D. Students Completed				
1	PhD	Robert L. Williams II	5/88	Planar Robotic Mechanisms: Analysis and Configuration Comparison
2	PhD	Arun Veeraraghavan	9/90	The Solution of Variable-Geometry Truss Problems Using New Homotopy Continuation Methods
3	PhD	Shahriar Tavakkoli	6/91	Shape Design Using Intrinsic Geometry
4	PhD	Babu Padmanabhan	12/92	A Study of Isostatic Framework with Application to Manipulator Design
5	PhD	Robert J. Salerno	12/93	Positional Control Strategies for a Modular, Long-Reach, Truss-Type Manipulator
6	PhD	Paul Tidwell	8/95	Wrapping Cam Mechanisms
7	PhD	J. Barry Fallon	8/95	Improving the Kinematic Control of Robots by Estimating the End-Effector Pose Directly with Computer Vision
8	PhD	Steven B. Shooter	12/95	Information Modeling in Mechanical Design: With Application to Cam Mechanism Design
9	PhD	Ravi S. Voruganti	12/95	Robot System Characterization: Error Modeling, Identification, Analysis and Calibration
10	PhD	Canfield, Steve	5/98	Development of the Carpal Wrist
11	PhD	Stulce, John	1/02	Conceptual Design of a Multibody Passive-Legged Crawling Vehicle
12	PhD	Calkins, Joseph	8/02	Quantifying Coordinate Uncertainty Fields in Coupled Spatial Measurement Systems
13	PhD	Snorri Gudmundsson	12/16	A Biomimetic, Energy-Harvesting, Obstacle-Avoiding, Path-Planning Algorithm for UAVs

Charles F. Reinholtz, Ph.D.

Deposition and Court Testimony, 2019 - Present

Year	Counsel	Opposing Counsel	Case Information (Client Shown in Boldface)	Plaintiff/ Defendant	Deposition/ Court Appearance
2019	Weil, Gotshal & Manges LLP	Wilson, Sonsini, Goodrich & Rosati	Sanofi-Aventis , Plaintiffs v. Mylan GmbH, Biocon Ltd., Defendant, C.A. No. 17-cv-09105-SRC-CLW	Plaintiff	Markman Hearing Court Testimony, April 12, 2019, Newark, New Jersey
2019	Stephoe & Johnson LLP	Finneegan, Henderson, Farabow, Garrett & Dunner, LLP	Autel Robotics v SZ DJI Technology, et. al., In the Matter of Certain Unmanned Aerial Vehicles and Components Thereof, ITC Investigation No. 337-TA-1133	Complainant	Deposition, July 19 and 12, 2019, Washington, DC
2019	Weil, Gotshal & Manges LLP	Wilson, Sonsini, Goodrich & Rosati	Sanofi-Aventis , Plaintiffs v. Mylan GmbH, Biocon Ltd., Defendant, C.A. No. 17-cv-09105-SRC-CLW	Plaintiff	Deposition, October 15, 2019, Washington, DC
2019	Stephoe & Johnson LLP	Finneegan, Henderson, Farabow, Garrett & Dunner, LLP	Autel Robotics v SZ DJI Technology, et. al., In the Matter of Certain Unmanned Aerial Vehicles and Components Thereof, ITC Investigation No. 337-TA-1133	Complainant	ITC Court Testimony, Oct 21 to 23, 2019, Washington, DC ALJ: Charles Bullock
2019	Kirkland & Ellis, LLP	Gibson Dunn and Finneegan, Henderson, Farabow, Garrett & Dunner, LLP	iRobot Corp. v. SharkNinja, Civil Action No. 1:19-cv-12125	Plaintiff	Deposition, October 28, 2019, Washington, DC
2019	Stephoe & Johnson LLP	Finneegan, Henderson, Farabow, Garrett & Dunner, LLP	Autel Robotics v SZ DJI Technology, Inter Partes Review, Case IPR2019-00249 and Case IPR2019-00250, Patent 7,979,174 B2	Patent Owner	Deposition, October 31, 2019, Chicago, IL
2019	Stephoe & Johnson LLP	Finneegan, Henderson, Farabow, Garrett & Dunner, LLP	Autel Robotics v SZ DJI Technology, Inter Partes Review, Case PGR2019-00016, Patent 10,044,013B2, PGR	Patent Owner	Deposition, November 15, 2019, Orlando, FL

			2019-00014, Patent 9,979,000, Case IPR2019-00343, Patent 9,260,184 B2		
2019	Weil, Gotshal & Manges LLP	Wilson, Sonsini, Goodrich & Rosati	Sanofi-Aventis v. Mylan GmbH, Biocon Ltd., Defendant, C.A. No. 17-cv-09105-SRC-CLW	Plaintiff	Court Testimony, December 2-4, 2019, Newark, NJ
2019	Fish & Richardson P.C	Pepper Hamilton LLP	2019, Floodbreak, LLC , Plaintiff, v. Art Metal Industries, LLC, et al., Defendants, No. 3:18-cv-503, United States District Court District of Connecticut, 2019.	Plaintiff	Deposition, December 13, 2019, Bridgeport, CT
2020	Steptoe & Johnson LLP	Finnegan, Henderson, Garret & Dunner, LLP	Autel Robotics v. SZ DJI Technology , Inter Partes Review, Case IPR2019-00846, Patent 9,260,184 B2	Patent Owner	Deposition, April 3, 2020 (appearing by videoconference from New Smyrna Beach, FL)
2020	Finnegan, Henderson, Farabow, Garrett & Dunner, LLP	Sierne, Kessler, Goldstein & Fox, P.L.L.C	Caterpillar v. Wirtgen GmbH, et. al. , Modification Proceeding in the Matter of Certain Road Construction Machines and Components Thereof, ITC Investigation No. 337-TA-1088	Complainant	Deposition, May 12, 2020 (appearing by videoconference from New Smyrna Beach, FL)
2020	Steptoe & Johnson LLP	Finnegan, Henderson, Farabow, Garrett & Dunner, LLP	Autel Robotics v. SZ DJI Technology , Inter Partes Review, Case IPR2019-00846, Patent 9,260,184 B2	Patent Owner	Deposition, June 16, 2020 (appearing by videoconference from New Smyrna Beach, FL)
2020	Fish & Richardson P.C	Davis & Kuelthau, s.c.	Wash World Inc., Plaintiff, v. Belanger Inc., et al. , Defendants, Case No.: 19-Cv-1562, United States District Court Eastern District of Wisconsin	Patent Owner	Deposition, December 3, 2020, (appearing by videoconference from Eugene, OR)
2020	Fish & Richardson P.C	Troutman Pepper Hamilton Sanders LLP	Floodbreak, LLC , Plaintiff v. Art Metal Industries, LLC, et al., Defendants, No. 3:18-cv-503, United States District Court District of Connecticut.	Patent Owner	Court Testimony, December 9 & 10, Bridgeport, CT (appearing by videoconference from Florence, OR)

2020	Sterne, Kessler, Goldstein & Fox, P.L.L.C	Willkie Farr & Gallagher LLP	Civil Action No. 5:19-cv-6021	Defendant	Deposition, December 21, 2020, (appearing by videoconference from Moab, UT)
2021	Faegre Drinker Biddle & Reath LLP	RuyakCherian LLP	Team Worldwide Corporation, Plaintiff, v. Academy, Ltd. D/B/A Academy ports + Outdoors, et al. , Defendants, Lead Case No. 2:19-cv-00092-JRG-RSP	Defendant	Deposition, January 5 & 6, 2021, (appearing by videoconference from Colorado Springs, CO)
2021	Durie Tangri LLP	Kramer Levin Naftalis & Frankel LLP	Midwest Athletics and Sports Alliance, LLC v. Xerox Corporation (represented by Durie Tangri LLP) v Case No. 6:19-CV-06036-EAW-MJP.	Defendant	Deposition, September 20, 2021 (appearing by videoconference from New Smyrna Beach, FL)
2021	Kirkland & Ellis, LLP	Finnegan, Henderson, Farabow, Garrett & Dunner, LLP	iRobot Corp. v. SharkNinja, In The Matter of Certain Robotic Floor Cleaning Devices And Components Thereof, ITC Investigation No. 337-TA-1252	Complainant	Deposition, October 6, 2021 (appearing by videoconference from New Smyrna Beach, FL)
2021	Fish & Richardson P.C	Latham & Watkins LLP and Finnegan, Henderson, Farabow, Garrett & Dunner, LLP	AbbVie Inc. and AbbVie Biotechnology Ltd, Plaintiff, v Alvotech Hf. , Civil Action No. 1:21-cv-2258, United States District Court for the Northern District of Illinois Eastern Division.	Defendant	Deposition, December 6, 2021, (appearing by videoconference from Boulder, CO)
2022	Kirkland & Ellis, LLP	Finnegan, Henderson, Farabow, Garrett & Dunner, LLP	iRobot Corp. v. SharkNinja, In The Matter of Certain Robotic Floor Cleaning Devices And Components Thereof, ITC Investigation No. 337-TA-1252	Complainant	ITC Court Testimony, January 6, 7 and 12 (appearing by videoconference from the offices of Kirkland & Ellis, Washington, DC), ALJ: MaryJoan McNamara

2022	Faegre Drinker Biddle & Reath LLP	Crowell & Moring	Wonderland Nurserygoods Co., Ltd., Plaintiff, v. Baby Trend, Inc. , Denny Tsay and Betty Tsai, Defendants, Case No. 5:14-cv-01153-JWH-SPx	Defendant	Deposition, April 12, 2022, Daytona Beach, FL
2022	Sterne, Kessler, Goldstein & Fox, P.L.L.C	Willkie Farr & Gallagher LLP	Provisur Technologies, Inc., Plaintiff, v. Weber, Inc., Textor, Inc., et. al. , United States District Court, Western District of Missouri, St. Joseph Division, Case No. 5:19-CV-06021.	Defendant	Deposition, May 5, 2023, Washington, DC
2022	Fish & Richardson P.C	Davis & Kuelthau, s.c.	Wash World Inc., Plaintiff, v. Belanger Inc., et al. , Defendants, Case No.: 19- Cv-1562, United States District Court Eastern District of Wisconsin	Patent Owner and Defendant	Court Testimony, August 2 &3, United States District Court Eastern District of Wisconsin, Green Bay, WI
2022	Faegre Drinker Biddle & Reath LLP	Crowell & Moring	Graco Children's Products Inc. and Wonderland Nurserygoods Co., Ltd. v. Baby Trend, Inc. et. al. , "In the Matter of Certain Playards and Strollers," ITC Investigation No. 337-TA-1288	Defendant	Deposition, September 27-28, 2022, Indianapolis, Indiana
2022	Sterne, Kessler, Goldstein & Fox, P.L.L.C	Willkie Farr & Gallagher LLP	Provisur Technologies, Inc., Plaintiff, v. Weber, Inc., Textor, Inc., et. al. , United States District Court, Western District of Missouri, St. Joseph Division, Case No. 5:19-CV-06021.	Defendant	Court Testimony, October 25 &26, United States District Court, Western District of Missouri, Kansas City
2022	Faegre Drinker Biddle & Reath LLP	Crowell & Moring	Graco Children's Products Inc. and Wonderland Nurserygoods Co., Ltd. v. Baby Trend, Inc. et. al. , "In the Matter of Certain Playards and Strollers," ITC Investigation No. 337-TA-1288	Respondent	ITC Court Testimony, Washington, DC, December 13-15, 2022, ALJ: Bryan F. Moore
2023	Fish and Richardson	K&L Gates LLP	Kidde v. First Alert & BRK, USDC WDTX (CA No. 6:22-00566) Civil Action No. 6:22-cv-411-ADA	Plaintiff	Deposition Testimony, Atlanta, GA, January 4, 2023

2023	Fish and Richardson	Husch Blackwell LLP	MGI Digital Technology S.A v Duplo U.S.A. , Case No. 8:22-cv-00979-DOC-KES, District Court for the Central District of California	Defendant	Deposition, March 7, 2023 (appearing by videoconference from New Smyrna Beach, FL)
2023	Fish and Richardson	Morgan, Lewis & Bockius LLP	Persawvere, Inc., v. Milwaukee Electric Tool Corporation , C.A. No. 21-cv-00400-GBW	Plaintiff	Deposition Testimony, Wilmington, DE, July 11, 2023
2023	Fish and Richardson	K&L Gates LLP	Kiddle v. First Alert & BRK , USDC WDTX (CA No. 6:22-00566) Civil Action No. 6:22-cv-411-ADA	Plaintiff	Deposition Testimony, Atlanta, GA, October 28-29, 2023
2023	Fish and Richardson	Husch Blackwell LLP	MGI Digital Technology, v DUPLO U.S.A. Corp. , Case No. 8:22-CV-00979-DOC-KES	Defendant	Deposition Testimony, November 3, 2023 (appearing by videoconference from New Smyrna Beach, FL)
2023	Fish and Richardson	Morgan, Lewis & Bockius LLP	Persawvere, Inc., v. Milwaukee Electric Tool Corporation , C.A. No. 21-cv-00400-GBW	Plaintiff	Court Testimony, Wilmington, DE, December 5-8, 2023
2024	Fish and Richardson	Husch Blackwell LLP	MGI Digital Technology, v DUPLO U.S.A. Corp. , Case No. 8:22-CV-00979-DOC-KES	Defendant	Court testimony, February 6-9, 2024, US District S. District of Central California, Judge David O. Carter
2024	Knobbe, Martens, Olson & Bear, LLP and Katten Muchin Rosenman LLP	Fenwick and West, LLP	Novo Nordisk Inc. v Orbicular Pharmaceutical and Biocon , C.A. No.: 22-856 (Cfc)	Defendant	Deposition, Charlotte, North Carolina, February 27, 2024
2024	Fish and Richardson	Morgan, Lewis & Bockius LLP	Persawvere, Inc., v. Milwaukee Electric Tool Corporation , C.A. No. 21-cv-00400-GBW	Plaintiff	Court Testimony, Wilmington, DE, March 6, 2024

2024	Finneegan, Henderson, Farabow, Garrett & Dunner, LLP	Quinn, Emanuel, Urquhart & Sullivan, LLP	Boston Dynamics, Inc. v. Ghost Robotics Corporation , Case No. 1:22- cv-01483-MN (D. Del)	Defendant	Deposition, Washington, DC, July 20, 2024
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