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A MATHEMATICAL APPROACH TO CLAIM ELEMENTS AND THE DOCTRINE OF EQUIVALENTS

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I. OVERVIEW

On May 28, 2002, the Supreme Court delivered a unanimous decision in *Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co.*[1] Justice Kennedy's opening statement of *Festo* remarked: "This case requires us to address *once again* the relation between two patent law concepts, the doctrine of equivalents and the rule of prosecution history estoppel."[2] In light of the fact that the "Court considered the same concepts"[3] in *Warner-Jenkinson Co. v. Hilton Davis Chemical Co*.[4] in 1997, why did these same concepts reoccur in *Festo*? Was it that the majority of the Federal Circuit judges who in favor of the "absolute bar" rule in the en banc *Festo* decision[5] did not understand the decision in *Warner-Jenkinson,* or was it that the judicially created doctrine of equivalents was simply "unworkable?"[6] This Article takes the position that even after *Festo,* the judicially created doctrine of equivalents is still inadequately understood and lacks a proper framework for its application. This Article, thus, first defines an element of a claim. Second, it proposes a modified tripartite test for equivalency.[7] Third, a novel approach for statistically analyzing the function and result prongs of the modified tripartite test is defined.

II. ORIGIN OF AND DECISIONS ON THE DOCTRINE OF EQUIVALENTS

The Patent Acts of 1790 and 1793 imposed no claiming requirements; the law then only demanded that inventors describe suffi-

1. Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co., 122 S. Ct. 1831, 1843 (2002).

2. *Id*. at 1835 (emphasis added).

3. *Id*. ("The Court considered the same concepts in *Warner-Jenkinson Co. v. Hilton Davis Chem. Co.*, and reaffirmed that a patent protects its holder against efforts of copyists to evade liability for infringement by making only insubstantial changes to a patented invention.") (citation omitted).

4. Warner-Jenkinson Co. v. Hilton Davis Chem. Co., 520 U.S. 17 (1997).

5. Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co., 234 F.3d 558 (Fed. Cir. 2000), *vacated by* 122 S. Ct. 1831 (2002).

6. *Festo*, 122 S. Ct. at 1840.

7. The current "tripartite test" is discussed *infra*, Section II, and the modified tripartite test is discussed *infra*, Section IV.A. These changes could be judicially implemented or adopted by legislation. *See Festo*, 122 S. Ct. at 1838 ("'Congress can legislate the doctrine of equivalents out of existence anytime it chooses.'" (quoting *Warner-Jenkinson*, 520 U.S. at 28)). While the Court does not seem particularly fond of the doctrine of equivalents, it also does not want to discard a doctrine that "remains a firmly entrenched part of the settled rights protected by the patent." *Id*.

ciently their inventions in a patent's specification to distinguish the invention from prior art and to enable one skilled in the art to practice the invention.[8] Patent claims first became a statutory requirement with the Patent Act of 1836, which required an inventor to "particularly specify and point out the part, improvement, or combination, which he *claims* as his own invention or discovery."[9] Despite this change in the law, early nineteenth-century patents typically described inventions in their specifications, with the patent claiming the invention "substantially as described herein."[10]

Almost 150 years ago, in this context in which the language of the patent claims was less significant than today, the courts first developed the doctrine of equivalents in *Winans v. Denmead*.[11] In *Winans v. Denmead*, Winans' patent described a railcar with a conical cavity for carrying coal, resulting in an even weight distribution of coal in the car and a lower center of gravity.[12] The accused railroad car had octagonal and pyramidal cavities instead, thus providing the same result as Winans' railcar without falling within the literal language of Winans' patent.[13] The trial court found no infringement, but a sharply divided Supreme Court reversed:

> The exclusive right to the thing patented is not secured, if the public are at liberty to make substantial copies of it, varying its form or proportions. And, therefore, the patentee, having described his invention, and shown its principles, and claimed it in that form which most perfectly embodies it, is, in contemplation of law, deemed to claim every form in which his invention may be copied, unless he manifests an intention to disclaim some of those forms.[14]

The majority's decision in *Winans* must be viewed from the perspective of a patent practice that did not emphasize literal claim language. Yet even at that time, the idea that a patentee could obtain legal rights against accused infringers who avoided the literal language of a patent was controversial. Writing for a four-Justice dissenting minority in *Winans*, Justice Campbell argued that the patent law requires a patentee to "particularly 'specify and point out' what he

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8. 2 DONALD S. CHISUM, CHISUM ON PATENTS § 8.02[1] (2001).

9. *Id.* at § 8.02[2] (quoting Act of July 4, 1836, ch. 357, § 6, 5 Stat. 117) (emphasis in original).

10. 5A DONALD S. CHISUM, CHISUM ON PATENTS, § 18.02[1] (2001).

11. *See* DONALD S. CHISUM ET AL., PRINCIPLES OF PATENT LAW 875 (2d ed. 2001); *see also Festo*, 122 S. Ct. at 1838 (*citing* Winans v. Denmead, 56 U.S. 330 (1853)).

12. Winans v. Denmead, 56 U.S. 330 (1853).

13. *See id*. at 340.

14. *Id*. at 343.

claims as his invention," and that "[f]ul[l]ness, clearness, exactness, preciseness, and particularity, in the description of the invention" are essential to avoid oppressive litigation.[15]

Not until 100 years after this contentious origin of the doctrine of equivalents was the major Supreme Court doctrine of equivalents decision, *Graver Tank & Manufacturing Company v. Linde Air Products Company*, written.[16] In *Graver Tank*, the patent at issue claimed a flux containing an alkaline earth metal silicate. The accused flux instead used manganese silicate, which is not an alkaline earth metal silicate. Based on evidence showing that manganese silicate and an alkaline earth metal silicate "are substantially identical in operation and in result," the Supreme Court affirmed a finding of infringement under the doctrine of equivalents.[17]

Though finding the patented and accused devices substantially identical *in operation and in result*,[18] *Graver Tank* adopted a *three part* function/way/result test for determining equivalency.[19] Subsequent decisions faithfully adopted the function/way/result test, also known as the tripartite test, as *the* test for equivalence without actually questioning the role of the "way" prong of the tripartite test.[20]

To justify the application of the doctrine of equivalents, the Court in *Graver Tank* relied on the need to protect patentees from "the unscrupulous copyist" making "unimportant and insubstantial changes and substitutions in the patent which, though adding nothing, would be enough to take the copied matter outside the claim . . . ."[21] Justice Black, in dissent, stated:

> I heartily agree with the court that "fraud" is bad, "piracy" is evil, and "stealing" is reprehensible. But in this case, where petitioners are not charged with any such malevolence, these lofty principles do not justify the Court's sterilization of Acts of Congress

15. *Id.* at 347 (Campbell, J., dissenting).

16. Graver Tank & Mfg. Co. v. Linde Air Prods. Co., 339 U.S. 605 (1950).

17. *Id.* at 611.

18. *Id.* (emphasis added).

19. *Graver Tank* does not confirm that "operation" means "function" plus "way," but it seems plausible. The Court notes: "[A] patentee may invoke this doctrine to proceed against the producer of a device 'if it performs substantially the same function in substantially the same way to obtain the same result.'" *Graver Tank*, 339 U.S. at 608 (quoting Sanitary Refrigerator Co. v. Winters, 280 U.S. 30, 42 (1929)); *see* Union Paper-Bag Mach. Co. v. Murphy, 97 U.S. 120, 125 (1877).

20. *See, e.g.,* Valmont Indus., Inc. v. Reinke Mfg. Co., 983 F.2d 1039, 1043 (Fed. Cir. 1993); International Visual Corp. v. Crown Metal Mfg. Co., 991 F.2d 768, 772 (Fed. Cir. 1993); *see also* Martin J. Adelman & Gary L. Francione, *The Doctrine of Equivalents in Patent Law: Questions That Pennwalt Did Not Answer*, 137 U. PA. L. REV. 673, 687–88 (1989) ("In most cases, the issue is invariably whether the accused device performs the overall function in substantially the same way as the claimed invention.").

21. *Graver Tank*, 339 U.S. at 607.

> and prior decisions, none of which are even mentioned in today's opinion.[22]

Justice Black further stated:

> Hereafter a manufacturer cannot rely on what the language of a patent claims. He must be able, at the peril of heavy infringement damages, to forecast how far a court relatively unversed in a particular technological field will expand the claim's language after considering the testimony of technical experts in that field.[23]

Despite the objections of Justices Black and Douglas, the doctrine of equivalents flourished after *Graver Tank*, leading to a host of significant but often diverging decisions by the Court of Appeals for the Federal Circuit.[24] On the important issue of the doctrine of equivalents, two schools of thought developed over the years at the Federal Circuit. "One school leaned toward fair protection; the other toward clear notice. Each found support in the language of the *Graver Tank* opinion."[25] Due to the divergent views of the members of the two schools, the doctrine of equivalents took "on a life of its own, unbounded by the patent claims."[26]

In this tumultuous post-*Graver Tank* environment, the key question "What is an equivalent?" was not answered with certainty.[27] "The triple identity test itself came under scrutiny. The test's abstract character diminished its value as an objective determinant of equivalency."[28] In response, the Supreme Court spoke on the issue of doctrine of equivalents in *Warner-Jenkinson* in 1997.

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22. *Id*. at 612–13 (Black, J., dissenting).

23. *Id.* at 617 (Black, J., dissenting).

24. The decisions by the Federal Circuit have great significance in patent law. While Federal Circuit decisions are subject to discretionary review by the Supreme Court, this has occurred rarely over the past 20 years, except of course twice on the issue of the doctrine of equivalents in *Warner-Jenkinson* and *Festo*.

25. Donald S. Chisum, *The Scope of Protection for Patents After the Supreme Court's Warner-Jenkinson Decision: The Fair Protection–Certainty Conundrum*, 14 SANTA CLARA COMPUTER & HIGH TECH. L.J. 1, 14 (1998) (providing a scholarly discussion of key Federal Circuit decisions on the doctrine of equivalents and on the two schools of thoughts).

26. *Warner-Jenkinson*, 520 U.S. at 28–29.

27. *See* Chisum, *supra* note 25, at 15; Adelman & Francione, *supra* note 20, at 695.

28. Chisum, *supra* note 25, at 15; *see also* Hilton Davis Chem. Co. v. Warner-Jenkinson Co., 62 F.3d 1512 (Fed. Cir. 1995), *rev'd*, 520 U.S. 17 (1997), in which the Federal Circuit moved away from the function/way/result formulation of the doctrine. Instead, the court explained that "the application of the doctrine of equivalents rests on the substantiality of the differences between the claimed and accused products or processes, assessed according to an objective standard." *Id.* at 1518.

Writing for a unanimous Supreme Court, Justice Thomas set out to "clarify the proper scope of the doctrine [of equivalents]."[29] After rejecting arguments that the doctrine should be abolished altogether, the Court observed that unbridled application of the doctrine conflicts with the "definitional and public-notice functions of the statutory claiming requirement[s]."[30] The Court squarely adopted the point of view of the Federal Circuit in *Pennwalt*[31] that the doctrine should be applied on an element-by-element basis: "Each element contained in a patent claim is deemed material to defining the scope of the patented invention, and thus the doctrine of equivalents must be applied to individual elements of the claim, not to the invention as a whole."[32] Furthermore, the Court emphasized that "[i]t is important to ensure that the application of the doctrine, even as to an individual element, is not allowed such broad play as to effectively eliminate that element in its entirety."[33]

Noting that the *Graver Tank* function/way/result formulation of the doctrine of equivalents is difficult to apply in certain circumstances, the Court accepted the Federal Circuit decision that function/way/result is not *the* test of infringement.[34] Nevertheless, the Court refused to offer its own formulation for the test of infringement under the doctrine of equivalents: "In our view, the particular linguistic framework used is less important than whether the test is probative of the essential inquiry: Does the accused product or process contain elements identical or equivalent to each claimed element of the patented invention?"[35]

The Supreme Court thus delegated to the Federal Circuit the task of developing formulations of the doctrine applicable to different types of patent claims, which arguably the Federal Circuit has failed to undertake in a meaningful manner up to this writing. It is not so surprising that the Federal Circuit has not acted given the rather amorphous guidance provided by the Supreme Court on what constitutes equivalency: "[E]quivalency must be determined against the context of the patent, the prior art, and the particular circumstances of the case. Equivalence, in the patent law, is not a prisoner of a formula and is not an absolute to be considered in a vacuum."[36]

The Court in *Warner-Jenkinson*, noting that prosecution history estoppel most frequently arises when the applicant narrows a claim to

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29. *Warner-Jenkinson*, 520 U.S. at 21. Justice Ginsburg, joined by Justice Kennedy, filed a concurring opinion.

30. *Id.* at 29.

31. *See* Pennwalt Corp. v. Durand-Wayland, Inc., 833 F.2d 931, 935 (Fed. Cir. 1987) (en banc).

32. *Warner-Jenkinson*, 520 U.S. at 29.

33. *Id.*

34. *See id.* at 39–40.

35. *Id.* at 40.

36. *Id.* at 24–25 (quoting *Graver Tank*, 339 U.S. at 609).

overcome a rejection based on the prior art, held: "Prosecution history estoppel continues to be available as a defense to infringement, but if the patent-holder demonstrates that an amendment required during prosecution had a purpose unrelated to patentability, a court must consider that purpose in order to decide whether an estoppel is precluded."[37] The Court however emphasized that not all claim amendments create an estoppel, stating: "[W]e see no substantial cause for requiring a more rigid rule invoking an estoppel regardless of the reasons for a change."[38] Rather, estoppel will be found only where an amendment was required "for a limited set of reasons,"[39] such as "to avoid the prior art, or otherwise to address a specific concern — such as obviousness — that arguably would have rendered the claimed subject matter unpatentable."[40]

To apply this rule, the Court created a rebuttable presumption that amending claims during patent prosecution creates an estoppel with "the burden on the patent holder to establish the reason for an amendment required during patent prosecution. The court then would determine whether that reason is sufficient to overcome prosecution history estoppel as a bar to application of the doctrine of equivalents to the element added by that amendment."[41] A sufficient reason would be one that "gives proper deference to the role of the claims in defining an invention and providing public notice, and to the primacy of the PTO in ensuring that the claims allowed cover only subject matter that is properly patentable . . . ."[42] Where no adequate reason could be established, prosecution history estoppel would act as a bar to the application of the doctrine of equivalents. In her concurrence, Justice Ginsburg cautioned against applying this presumption "woodenly" to prevent injustice to patentees who did not explain the reasons for amendments in a patent's file history.[43]

Five years after *Warner-Jenkinson*, the Supreme Court in *Festo* addressed the relationship between the doctrine of equivalents and prosecution history estoppel. In an unanimous opinion by Justice Kennedy, the Court attempted to maintain a "delicate balance . . . between inventors, who rely on the promise of the law to bring the invention forth, and the public, which should be encouraged to pursue innovations, creations, and new ideas beyond the inventor's

37. *Id.* at 40–41.

38. *Id*. at 32.

39. *Id*.

40. *Id*. at 30–31. This statement caused much confusion as to when prosecution history estoppel should apply. For example, should prosecution history estoppel apply only when an amendment was made to avoid the prior art or also when an amendment was made for other reasons such as to overcome rejections under 35 U.S.C. § 112, first and second paragraphs?

41. *Id.* at 33.

42. *Id*. at 33–34. The term "PTO" refers to the United States Patent and Trademark Office.

43. *Id.* at 41 (Ginsburg, J., concurring).

exclusive rights."[44] The Court acknowledged that a patent is "a temporary monopoly. The monopoly is a property right; and like any property right, its boundaries should be clear."[45]

Thus *Festo* reaffirmed the doctrine of equivalents as necessary to protect patent holders "against efforts of copyists to evade liability for infringement by making only insubstantial changes to a patented invention."[46] But it also recognized that "the doctrine of equivalents can create substantial *uncertainty* about where the patent monopoly ends,"[47] and thus, affirmed prosecution history estoppel as a tool for reducing the degree of uncertainty created by the doctrine of equivalents. "When the patentee responds to [a] rejection [by the PTO] by narrowing his claims, this prosecution history estops him from later arguing that the subject matter covered by the original, broader claim was nothing more than an equivalent."[48] Additionally, the Court affirmed the Federal Circuit's holding[49] that estoppel arises whenever an amendment narrows a claim for any reason relating to a statutory requirement for obtaining a valid patent.[50] Specifically, the Court stated that estoppel could arise both from amendments made to distinguish the prior art[51] and amendments made to meet the disclosure and clarity requirements of 35 U.S.C. § 112.[52]

More importantly, the Supreme Court replaced the Federal Circuit's "complete bar" rule with a rebuttable presumption against securing equivalents. The complete bar rule dictated that narrowing a claim element during patent prosecution is an absolute bar to every equivalent of the amended claim limitation, unless the prosecution history clearly shows otherwise. According to the Supreme Court:

> The Court of Appeals ignored the guidance of *Warner-Jenkinson*, which instructed that courts must be cautious before adopting changes that disrupt the settled expectations of the inventing community. In that case we made it clear that the doctrine of equivalents and the rule of prosecution history estoppel are settled law. The responsibility for changing them rests with Congress.[53]

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44. *Festo*, 122 S. Ct. at 1837.
45. *Id*. (internal citation omitted).
46. *Id*. at 1835.
47. *Id*. (citing *Warner-Jenkinson*, 520 U.S. at 29) (emphasis added).
48. *Id*. at 1835.
49. *See Festo*, 234 F.3d at 566.
50. *See Festo*, 122 S. Ct. at 1839.
51. *See id*. (citing *Warner-Jenkinson*, 520 U.S. at 30).
52. *See id*. at 1840 ("If a § 112 amendment was truly cosmetic, then it would not narrow the patent's scope or raise an estoppel.").
53. *Id*. at 41. (internal citation omitted).

The Supreme Court recognized that usually a "patentee's decision to narrow his claims through amendment should be presumed to be a general disclaimer of the territory between the original claim and the amended claim."[54] However, even if a patentee narrows a claim, he may rebut the presumption by showing that "at the time of the amendment one skilled in the art could not reasonably be expected to have drafted a claim that would have literally encompassed the alleged equivalent."[55] Specifically, the Court states that the patentee can rebut the presumption that prosecution history estoppel bars a finding of equivalence if:

> The equivalent may have been unforeseeable at the time of the application; the rationale underlying the amendment may bear no more than a tangential relation to the equivalent in question; or there may be some other reason suggesting that the patentee could not reasonably be expected to have described the insubstantial substitute in question.[56]

Besides *Festo*, 2002 produced another landmark decision on the doctrine of equivalents. The Federal Circuit in *Johnson & Johnston Associates Inc. v. R.E. Service Co*. adopted a per se rule that patent owners cannot use the doctrine of equivalents to protect disclosed but unclaimed subject matter.[57] When a patent discloses subject matter but does not claim it, the subject matter is dedicated to the public; this subject matter cannot be later be considered an equivalent to the patent's literal claim. The Federal Circuit held that Johnson & Johnston Associates could not rely on the doctrine of equivalents to establish that accused devices using steel sheets to make circuit boards infringed its patent when the patent disclosed both aluminum and steel sheets but only claimed aluminum sheets.[58]

The court in *Johnson & Johnston* stressed that it is the claims that define the scope of patent protection. A patent applicant "cannot narrowly claim an invention to avoid prosecution scrutiny by the PTO" and then use the doctrine of equivalents because the specification discloses equivalents.[59] The court noted that a patent applicant has the options of filing a reissue application within two years after issuance

54. *Id*. at 1842.
55. *Id*.
56. *Id*.
57. Johnson & Johnston Assocs. Inc. v. R.E. Serv. Co., 285 F.3d 1046, 1055 (Fed. Cir. 2002) (en banc).
58. *Id*.
59. *Id*. at 1054.

or of filing continuation applications that cover the equivalents disclosed but not originally claimed.[60]

Arguably, *Johnson & Johnston* extends the concept of prosecution history estoppel.[61] Effectively, a patent owner who discloses more than he originally claims has more to lose. He surrenders not only territory that was originally claimed but given up by amendment, but also unclaimed material in the disclosure. *Johnson & Johnston* thus requires those who draft and prosecute patent applications to exercise great care in deciding what to disclose and what to claim. Claiming too narrowly can result in a dedication to the public; in contrast, claiming too broadly can lead to rejection, amendment, and estoppel.

III. LINGERING PROBLEMS FROM *FESTO* AND *JOHNSON & JOHNSTON*

One could argue that the *Festo* and *Johnson & Johnston* decisions will have divergent effects on drafting and prosecution of patent claims: *Festo* will encourage narrow original claims (that will possibly be allowed without amendment), while *Johnson & Johnston* will encourage broad claiming of all disclosed subject matter. However, the combined effect of the *Festo* and *Johnson & Johnston* decisions may encourage a patent applicant to write narrower claims and to disclose only those embodiments claimed. Applicants will also tend to omit even identifying equivalents known to them, but possibly unknown to the public at the time of filing the patent application. This behavior would inhibit disclosure and therefore not "promote the Progress of . . . useful Arts," for which patent law have been created under the Constitution.[62]

A. Effects of Festo and Johnson & Johnston on the Patent System

The patent system under the U.S. Constitution rests on the policy that progress in science and technology is promoted by the free dissemination of knowledge and information in return for a temporary monopoly granted by the patent law. The person who is most likely to first recognize the foreseeable equivalents of a new invention is the inventor himself. Though the invention could be the result of the inventor's having developed a few examples with a select number of

60. *Id*. at 1055.

61. *See* Donald S. Chisum, The Supreme Court's *Festo* Decision: Implications for Patent Claim Scope and Other Issues 25, (July 8, 2002) (unpublished manuscript, on file with the author); *see generally*, *Johnson & Johnston*, 285 F.3d at 1046.

62. U.S. CONST. art. I, § 8, cl. 8.

species, the inventor might recognize that other species would likely work in the invention.

After the *Festo* and *Johnson & Johnston* decisions, the inventor will have to make one of the following four choices in drafting the application. The first choice is to recite broad original claims and disclose embodiments and equivalents, beyond the scope of the claim. This choice could be fatal to the applicant in providing protection beyond the literal terms if the claims are subsequently narrowed, due to prosecution history estoppel and because equivalents that are disclosed but unclaimed will be precluded.

The second choice is to recite broad original claims, but only narrowly disclose the embodiments. Thus, the applicant omits identifying any equivalents. This choice still fails to provide protection beyond literal terms if the claims are subsequently narrowed due to prosecution history estoppel.

The third choice is to recite narrow original claims and disclose many embodiments and equivalents. Even assuming that the narrow original claims would be allowed without further narrowing, this strategy still precludes equivalents that are disclosed but unclaimed.[63]

The fourth and final choice is to recite narrow original claims and disclose only the embodiments claimed, omitting identification of any equivalents. Assuming that the narrow original claims are allowed without further narrowing, this strategy should not preclude any equivalents that could have been foreseeable by the inventor, but were not disclosed in the specification. Therefore, patent drafters will tend to employ this fourth choice by drafting multiple narrow claims and disclosing only the subject matter claimed, rather than risk inadvertent disclosure of unclaimed equivalents. If the applicant discloses equivalents in the application and narrows the claim by an amendment, then "[t]he patentee . . . [would never be able to] show that at the time of the amendment one skilled in the art could not reasonably be expected to have drafted a claim that would have literally encompassed the alleged equivalent."[64] Even if the applicant does not narrow a claim, but discloses unclaimed equivalents, *Johnson & Johnston* precludes equivalents that are disclosed but unclaimed.[65]

Does the fourth choice "promote the Progress of . . . useful Arts?"[66] The answer is "no" for several reasons. First, the progress of technology is cumulative. Most inventions are built on previous inventions, particularly as a result of some "leads," or insights, provided by the disclosures of other inventors. *Festo* and *Johnson & Johnston* would inhibit public disclosure of such leads. Second, narrowly claim-

63. *See, e.g., Johnson & Johnston*, 285 F.3d at 1055.
64. *Festo*, 122 S. Ct. at 1842.
65. 285 F.3d at 1055.
66. U.S. CONST. art. I, § 8, cl. 8.

ing an invention will lead to smaller rewards, at least in terms of the literal scope of the claim.[67] The smaller rewards, in turn, would make inventors question whether they should "bring the invention forth"[68] to the public or simply keep it a secret. Third, with the prime objective of preventing narrowing of a claim by amendment, applicants will get narrow original claims allowed and then rely on the doctrine of equivalents to allege infringement. The Supreme Court in *Festo* recognizes that reliance on the doctrine of equivalents to extend a patent owner's scope of protection beyond the literal of a patent's claims "may lead to wasteful litigation between competitors."[69] *Festo*, in combination with *Johnson & Johnston*, nevertheless promotes narrow claims and minimal disclosure.

B. Inequitable Outcomes and Unfairness to Patent Owners

Prosecution history estoppel arises under *Festo* "when an amendment is made to secure the patent[,] . . . the amendment *narrows* the patent's scope."[70] Though the Supreme Court in *Festo* addressed the issue of prosecution history estoppel, it failed to address the fundamental issue: "What constitutes 'equivalency?'"[71].

The critical issue in the doctrine of equivalents is defining equivalency.[72] Only then can prosecution history, and estoppel arising from it, be further addressed with greater determinacy that will allow clear application of these doctrines.

Defining equivalency requires analysis of the scope of a patent claim in light of the specification, prior art, and prosecution history under the current patent law. "Imagine two United States patents, both with the same inventor, the same drawings, the same written description, the same claims, the same filing date, and the same issuance date. Is there any difference between these two imaginary patents?"[73] The answer is:

> [A]s every law student knows . . . "it depends." It depends on what the patent attorney responsible for each of these patents represented to the Patent Office during the application process. *Unless the two patent*

67. *See Festo*, 122 S. Ct. at 1837.

68. *Id*.

69. *Id*.

70. *Id*. at 1840 (emphasis added).

71. "What constitutes equivalency must be determined against the context of the patent, the prior art, and the particular circumstances of the case." *Graver Tank*, 339 U.S. at 609.

72. *See* Adelman & Francione, supra note 20, at 695. ("Whether the doctrine of equivalents is applied on an element-by-element basis or an entirety basis does not answer the key question: What is 'equivalent'?").

73. T. Whitley Chandler, *Prosecution History Estoppel, the Doctrine of Equivalents, and the Scope of Patents*, 13 HARV. J. L. & TECH. 465, 466 (2000).

> *attorneys made the exact same statements in response to the exact same questions by the Patent Office, then under current law the two patents very likely differ in the protection they afford their respective inventors.* In other words, an inventor's right to his discoveries depends not only upon the final patent issued by the Patent Office, but also upon the additions, deletions, amendments, arguments, clarifications, statements, scribbles, scratches, yawns, and sideway glances made by his attorney.[74]

Should the answer be "it depends?" Arguably, yes. However, the factors on which it should depend should be limited to *explicit, recorded representations* made by the patentee upon which the public has a right to rely. "If competitors cannot be certain about a patent's extent, they may be deterred from engaging in legitimate manufactures outside its limits, or they may invest by mistake in competing products that the patent secures."[75]

Assume that there are three patent attorneys handling hypothetical Cases 1, 2, and 3 of the same subject matter of the same inventor with the same drawings, the same written description (except Case 3, which discloses additional embodiments), the same filing date, but different original claims, with each case having only one claim. Assume that in Case 1, the examiner did not reject any claims over the prior art but simply objected to the specification, for example, for a drawing correction. Subsequently, the three patent attorneys made no statements but amended the claims to the same claims in the three cases, which subsequently issued on the same day.[76] For the patents issued from Cases 1–3, under the current patent law, the extent (meaning the right to exclude) of the scope of the claims for each patent could end up totally different even though the issued claims in the three cases are the *same*. To investigate this outcome, Cases 1–3 are schematically represented in Figures 1–3. In these figures, the space within the envelope formed by the continuous black line 1 represents the boundary between the prior art and unclaimed territory.[77] The boundary of the prior art can be objectively determined in the context of the invention because it already exists at the time of filing the pat-

74. *Id*. (emphasis added).

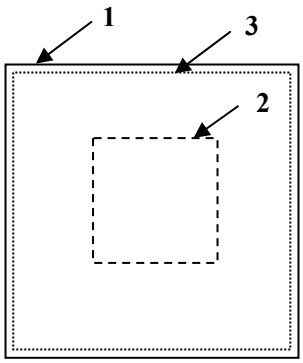
75. *Festo*, 122 S. Ct. at 1837.

76. Arguably, another hypothetical situation could be the following. In the first action in the three cases, the examiner did not reject any claims over the prior art but simply rejected some of the claims as indefinite under 35 U.S.C. § 112. Subsequently, the three patent attorneys made no statements but amended the claims to the same claims in the three cases, which subsequently issued on the same day. The attorneys could have successfully argued that the claims were not indefinite but chose not to do so.

77. For purposes of illustration, the unclaimed territory is arbitrarily shown as a square, but it could be of any shape depending on the prior art.

ent application.[78] The space within the envelope formed by dashed line 2 represents the literal scope of an allowed claim. The space within the envelope formed by dotted line 3 represents the maximum allowable scope of a patent claim limited by the prior art.[79]

Figure 1: Graphical Representation of Case 1

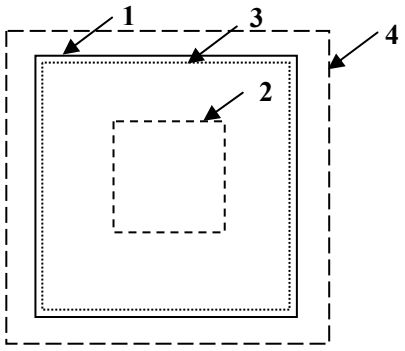


Case 1 — *Narrow Original Claim*: Figure 1 shows the relationship between the prior art (the space outside the square formed by continuous black line 1), the claimed invention (the space within the square formed by line 2), and the maximum permissible claim (the space inside the square formed by line 3). For case 1, the original claim is the same as the allowed claim (line 2) and is contained within the limit of the prior art (line 1). The allowed claim also encompasses all embodiments and equivalents disclosed in the specification.

Figure 2: Graphical Representation of Case 2

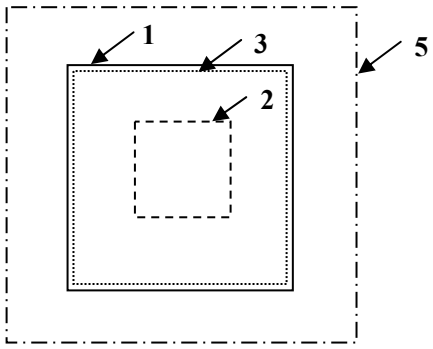
78. Though the patent attorneys or particular examiners might not know the prior art boundary at the time of filing, it can still be determined later.

79. What is the extent of "the maximum allowable scope of a patent claim" or "maximum permissible claim"? The maximum allowable scope of a patent claim is limited by the prior art, accounting for novelty and obviousness over the prior art, and in the limit, it would approach the boundary of the prior art, though not touching the boundary. The space between lines 1 and 3 is the subject matter that is not anticipated by prior art, but is still obvious. It is the same as the mathematical concept of limit, which is based on the notion that the value **f(x)** of a function **f** approaches **L** as the value of **x** approaches **c**. In the context of a patent claim and prior art, **x** represents an element of the claim, **f(x)** represents the invention as a whole, **c** represents the value of the element in the prior art at the boundary, and **L** represents the invention as a whole of a hypothetical claim that just reaches the prior art at the boundary.



Case 2 — Broad Original Claim: The space within the envelope formed by dotted line 4 represents the literal scope of the original claim that overlaps the prior art (line 1). This original claim exceeds the maximum permissible claim (space enclosed by line 4 exceeds space enclosed by line 3). However, the ultimately allowed claim is the same as that in Case 1 (square enclosed by line 2).

Figure 3. Graphical Representation of Case 3



Case 3 — *Narrow Original Claim with Broad Disclosure*: In this case, the allowed claim is the same as that of Case 1 (the space within the square formed by line 2). However, the extent of the disclosure of the specification (space within the square formed by line 5), based on the applicant's knowledge of the invention at the time of filing, discloses embodiments beyond those actually claimed (line 5 encloses all of the area included within line 2).[80] Thus, Case 3 is the same as Case 1, except that the allowed claim encompasses some, but not all embodiments or equivalents disclosed in the specification.

80. The space within the envelope formed by dotted line 5 also represents the extent of the disclosure that could have been included in the specifications in Cases 1 and 2 if the applicant wanted to do so.

In all three cases, the area between the envelopes formed by dotted lines 2 and 3 represents an "equity" envelope wherein an accused product could be "equivalent" to what is literally claimed (the envelope formed by dotted line 2). It is important to recognize that the scope of the claims defined by dotted line 2 is not "'expanded' or 'broadened' under the doctrine of equivalents."[81] Judge Rich explained this in *Wilson Sporting Goods*:

> To say that the doctrine of equivalents extends or enlarges *the claims* is a contradiction in terms. The claims — i.e., the scope of patent protection *as defined by* the claims — remain the same and application of the doctrine *expands the right to exclude* to "equivalents" of what is claimed.
>
> The doctrine of equivalents, by definition, involves going beyond any permissible interpretation of the claim language; i.e., it involves determining whether the accused product is "equivalent" to what is described by the claim language.[82]

In Cases 1–3, the allowed claim and the prior art, or the boundary up to which one could furthest extend the right to exclude equivalents, remains the same. Arguably, the scope of protection available to a patent owner should be the same in Cases 1 and 2, in which both the allowed claim and specification are identical. Also, the scope of protection available to a patent owner should be the same in Cases 1 and 3 because the allowed claim and prior art in both cases are the same. Yet, under *Festo* and *Johnson & Johnston*, the scope of protection available to a patent owner may be totally different in Cases 1–3.

In Case 1, the doctrine of equivalents expands the patent owner's right to exclude an equivalent of what is claimed if the equivalent falls within the "equity" envelope and was not disclosed in the specification.[83] This outcome arises in Case 1 because the applicant did not narrow the original claim and did not disclose "foreseeable equivalents" that were known to him, but not known to the public at the time of filing his application. There is no legal requirement that an applicant disclose equivalents and substitutes known to the applicant; nevertheless, this is a bad bargain in which the public is "shortchanged"

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81. Wilson Sporting Goods Co. v. David Geoffrey & Assocs., 904 F.2d 677, 684 (Fed. Cir. 1990), *cert. denied*, 498 U.S. 992 (1990).

82. *Id*. (emphasis in original).

83. *See Johnson & Johnston*, 285 F.3d at 1055. (The Federal Circuit decided that patent owners cannot use the doctrine of equivalents to protect disclosed but unclaimed subject matter.).

of information known to the patentee at the time of the submission of the patent. [84]

In Case 2, the scope of the original claim extends up to dotted line 4. Because the original claim is considered to be part of the original specification, the original disclosure in Case 2 (and also in Case 1 which has the same written description) extends up to or beyond dotted line 4. As a result of an amendment, the allowed claim in Case 2 is narrowed to be the same as that in Case 1, extending up to dotted line 2. However, under *Festo*, the patent owner in Case 2 has no right to exclude equivalents that fall within the equity envelope, except for equivalents resulting from after-arising technology, which by definition are not reasonably foreseeable.[85] This situation arises in Case 2 because the patentee narrowed his claim during prosecution. Therefore the patentee in Case 1 obtained more patent protection for ultimately the same claim as in Case 2.

In Case 3, the allowed claim is the same as the original claim (the envelope enclosed by dotted line 2). However, the applicant was generous in educating the public of possible equivalents and substitutes, as the disclosure in the specification extends through the equity envelope beyond the boundary of the prior art. In this situation, there is no narrowing of the original claim. Nevertheless, the patent owner's right to exclude an equivalent is the same as in Case 2 under *Johnson & Johnston*, [86] except that the patent owner still has the right to exclude undisclosed "equivalents."

In Cases 1 and 2, what was already in the public domain remains the same, and the allowed claims and specifications are the same. Yet, the patentee's rights to exclude "equivalents" of what is claimed drastically differ. This outcome does not seem fair when the reason for reaffirming the doctrine of equivalents in *Festo* was to provide justice by:

> [P]rotect[ing the] inventor not only from those who produce devices falling within the literal claims of the patent but also from copyists who "make unimportant and insubstantial changes and substitutions in

84. Lawrence B. Ebert, *Supreme Court Festo: Equivalents Still Limited*, 9 INTELL. PROP. TODAY No. 7, at 10, 12 (July 2002). Ebert explains that another problem with the unforeseeable equivalents standard is that it "offer[s] perverse incentives to a competitor seeking to design around a patented invention . . . [to] safely adopt a foreseeable (and trivial) variation of an amended claim element and thereby avoid infringement." *Id*. Furthermore, a competitor has a disincentive to invent "an innovative variation . . . [because] he runs the risk of adopting an unforeseeable embodiment, for which equivalent protection does exist. Thus, unforeseeable equivalents encourage trivial changes by competitors rather than step-out changes." *Id*.

85. *See* Chiuminatta Concrete Concepts, Inc. v. Cardinal Indus., Inc., 145 F.3d 1303, 1310 (Fed. Cir. 1998).

86. *See Johnson & Johnston*, 285 F.3d at 1055.

> the patent which, though adding nothing, would be enough to take the copied matter outside the claim, and hence outside the reach of law."[87]

The Court in *Graver Tank* said that "[a]n important factor [for determining equivalency] is whether persons reasonably skilled in the art would have known of the interchangeability of an ingredient not contained in the patent with one that was."[88] The rule of *Graver Tank* provides protection to a patent owner to exclude equivalents that were objectively understood by persons skilled in the art to be counterparts of a claim element at the time of filing, but which are not within the literal meaning of the claim. *Festo* has modified *Graver Tank*'s reliance on "known . . . interchangeability"[89] as an important factor for determining equivalency by foreclosing foreseeable equivalents if a patentee *narrows* his claims.[90] The unforeseeable equivalents rule of *Festo* provides protection to a patent owner to exclude equivalents that were not foreseeable to one skilled in the art at the time of amendment. The rules of *Graver Tank* and *Festo* do not contradict, however, because *Festo* applies only when a claim is narrowed.

The Court in *Festo* states that "courts must be cautious before adopting changes that disrupt the settled expectations of the inventing community."[91] However, in creating the "unforeseeable"[92] equivalents rule, *Festo* may disrupt settled expectations of the inventing community as to what is equivalent.[93] Arguably, the "unforeseeable" equivalents rule is not a new rule, but is supported by *Chiuminatta*[94] and Judge Rader's concurrence in *Johnson & Johnston*.[95] In contrast, the Federal Circuit's decision in *Johnson & Johnston* does disrupt the

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87. *Festo*, 122 S. Ct. at 1838 (quoting *Graver Tank*, 339 U.S. at 607); *see* Hilton Davis Chem. Co. v. Warner-Jenkinson, 62 F.3d 1512, 1521 (Fed. Cir. 1995), *rev'd*, 520 U.S. 17 (1997), which states:

> In several recent opinions, this court has referred to the doctrine of equivalents as "equitable." The term "equitable" can have many meanings. The Supreme Court explained in *Graver Tank* that the doctrine prevents the unfairness of depriving the patent owner of effective protection of its invention, 339 U.S. at 607, 70 S. Ct. at 855–56, thereby achieving a fair or "equitable" result. Thus, in doctrine of equivalents cases, this court's allusions of equity invoke equity in its broadest sense — equity as general fairness.

88. *Graver Tank*, 339 U.S. at 609.

89. *Id*.

90. *Festo*, 122 S. Ct. at 1837.

91. *Id*. at 1841.

92. *Id*. at 1842.

93. This Article argues that the "unforeseeable" equivalents rule is a good rule to accommodate after-arising technology. See *infra*, Section IV.A.3.

94. *See Chiuminatta*, 145 F.3d at 1310.

95. *Johnson & Johnston*, 285 F.3d at 1056 ("[T]he doctrine of equivalents does not capture subject matter that the patent drafter reasonably could have foreseen during the application process and included in the claims.") (Rader, J., concurring).

settled expectations of the inventing community, which has relied on the adage that more description in a patent specification is better has generally disclosed many more embodiments than claimed.

C. Lack of an Objective Standard for Equivalency

Festo refers to equivalents and unforeseeable equivalents throughout the decision, and also recognizes that "[i]t may be difficult to determine what is, or is not, an equivalent to a particular element."[96] Surprisingly, the Court in *Festo* does nothing to address the two key questions: (1) What is an element? (2) "What is an 'equivalent'?"[97]

The Supreme Court in *Warner-Jenkinson* was previously asked to provide guidance "regarding the linguistic framework under which 'equivalence' is determined."[98] The Federal Circuit majority in *Hilton Davis* debated whether the "so called triple identity, or function-way-result" or "insubstantial differences" test was better for determining equivalency.[99] The Supreme Court granted certiorari to address the issue on appeal in *Warner-Jenkinson* and stated "the particular linguistic framework used is less important than whether the test is probative of the essential inquiry: Does the accused product or process contain elements identical or equivalent to each claimed element of the patented invention?"[100] Furthermore, *Warner-Jenkinson* suggested that the "insubstantial differences" test "offers little additional guidance" for determining equivalency, and urged the Federal Circuit to formulate "the test for equivalence in the orderly course of case-by-case determinations."[101] *Warner-Jenkinson* effectively gave free reign to the Federal Circuit with no substantive guidance on what is "equivalent," other than to say that the "insubstantial differences" test is not very helpful.[102] Maybe the Court in *Warner-Jenkinson* recognized that an acceptable, precise "linguistic framework" for determining equivalency could possibly result in inconsistent outcomes in different cases.

Shortly after *Warner-Jenkinson*, the Federal Circuit employed a function/way/result test in *Sage Products v. Devon Industries*.[103] To understand the lack of an objective standard for equivalence in the context of the function/way/result test, consider the outcome of apply-

96. *Festo*, 122 S. Ct. at 1839.
97. Adelman & Francione, *supra* note 20, at 695.
98. *Warner-Jenkinson*, 520 U.S. at 39–40.
99. *Hilton Davis*, 62 F.3d at 1517–18.
100. *Warner-Jenkinson*, 520 U.S. at 40.
101. *Id.*
102. *Id.*
103. Sage Prods. v. Devon Indus., 126 F.3d 1420 (Fed. Cir. 1997).

ing this test in *Winans*[104] and *Sage Products*. In *Winans*, the subject of dispute was whether the doctrine of equivalents applied to changes in the shape of a coal car; Denmead, the alleged infringer, constructed railroad cars that were octagonal and pyramidal in shape and achieved substantially all the advantages of Winans' patented conical car.[105] The dissenting opinion of Justice Campbell paints a clearer picture as to what was different between the patented railcar of Winans and the accused railcar:

> There was no contradiction, in the evidence given at the trial, in reference to its description, nor as to the substantial effects of its use and operation. In the size, thickness of the metal employed in its construction, weight, and substantial and profitable results, the one car does not materially vary from the other. The difference consists in the *form*, and in that, it is visible and palpable.[106]

Thus the word "form" is synonymous to "way" in the function/way/result test as applied in Federal Circuit cases such as *Sage Products*.[107] In other words, the difference between the patented railcar of Winans and the accused railcar was that the accused railcar did not perform its function in substantially the same "way" as required under the function/way/result test.

Sage Products involved a mechanical patent, U.S. Patent No. 4,779,728 (the '728 patent) owned by Sage Products, directed to a hazardous medical waste container, with a slot at its top to allow entry of waste materials into the container.[108] The container also had restrictive barriers above and below the slot to restrict access to the container interior.[109] The only independent claim in the '728 patent (with emphasis to the disputed terms) reads:

104. Winans v. Denmead, 56 U.S. 330 (1853).
105. *See Winans*, 56 U.S. at 340.
106. *Id*. at 345 (Campbell, J., dissenting) (emphasis added).
107. *Sage Prods*., 126 F.3d at 1422.
108. *Id*.
109. *Id*.

1. A disposal container comprising:
   a. a hollow upstanding container body,
   b. *an elongated slot at the top of the container body* for permitting access to the interior of the container body,
   c. barrier means disposed adjacent said slot for restricting access to the interior of said container body, at least a portion of said barrier means comprising
      i. *a first constriction extending over said slot*, and
      ii. a complementary second constriction extending beneath said slot, and
   d. a closure disposed adjacent said slot.[110]

According to *Sage Products*, in Devon's container, the "elongated slot" was within the container body, not at the top of the container body.[111] Also, Devon's container did not have a first constriction that extended *over* the slot. Instead, in Devon's container there was a first constriction and a second constriction, and the space between them was construed to be the "elongated slot."[112] Therefore, the accused device did not literally infringe claim 1.[113]

The Federal Circuit in *Sage Products* therefore had to decide whether Devon's container "that does not literally infringe a claim may nonetheless infringe under the doctrine of equivalents if every element in the claim is literally or equivalently present in the accused device."[114] Sage Products argued that an elongated slot in Devon's container that was located within the container body was an equivalent of an elongated slot located at the "top of the container."[115] In another theory of equivalence, Sage Products argued that a hinged member in Devon's container that did not substantially constrict access to a slot was an equivalent of "a first constriction extending over said slot."[116] In rejecting these equivalency theories, Judge Rader stated:

> The claim at issue defines a relatively simple structural device. A skilled patent drafter would foresee

110. *Id*. (emphasis added).
111. *Id*. at 1423.
112. *Id.*
113. *Id*. at 1422–23. The court stated:
> The district court properly interpreted "top of the container body" to mean the "highest point, level, or part of." The court also properly interpreted "extending over said slot" to require that the first constriction be "above" the elongated slot. The patentee nowhere indicated any intention to deviate from these ordinary meanings of the claim terms.
Id.
114. *Id*.
115. *Id*. at 1424.
116. *Id*.

> the limiting potential of the "over said slot" limitation. No subtlety of language or complexity of the technology, nor any subsequent change in the state of the art, such as later-developed technology, obfuscated the significance of this limitation at the time of its incorporation into the claim. If Sage desired broad patent protection for any container that performed a function similar to its claimed container, it could have sought claims with fewer structural encumbrances. Had Sage done so, then the Patent and Trademark Office (PTO) could have fulfilled its statutory role in helping to ensure that exclusive rights issue only to those who have, in fact, contributed something new, useful, and unobvious. Instead, Sage left the PTO with manifestly limited claims that it now seeks to expand through the doctrine of equivalents. However, as between the patentee who had a clear opportunity to negotiate broader claims but did not do so, and the public at large, it is the patentee who must bear the cost of its failure to seek protection for this foreseeable alteration of its claimed structure . . . .
>
> In sum, the '728 patent claims a precise arrangement of structural elements that cooperate in a particular *way* to achieve a certain *result*. Devon achieves a *similar result* — restricted entry to a medical disposal container — but it does so by a *different arrangement of elements* [i.e., a different way].[117]

Winans and *Sage Products* exhibit several similarities. First, both are directed to the determination of equivalency of an element in a mechanical patent. Second, in both cases the accused infringing device produced a similar result as that of the claimed device. Third, in both cases the accused infringing device had a different "form"[118] or "arrangement of elements"[119] than that in the claimed device. In terms of applying the function/way/result test, Judge Rader decided that Devon's container did not infringe the '728 patent claims because the way or "arrangement of elements" was different, though the result was similar.[120] The majority in *Winans* decided that the claim required only that the car "be so near to a true circle as substantially to embody

117. *Id*. at 1425 (emphasis added) (internal citation omitted).
118. *Winans*, 56 U.S. at 345.
119. *Sage Products*, 126 F.3d at 1425.
120. *Id*.

the patentee's mode of operation, and thereby attain the same kind of result as was reached by his invention."[121]

Professor Adelman believes that "the court in *Sage Products* has it right," referring to the decision's accordance with the "triple entity" test.[122] But, by the triple entity test, the decisions in *Sage Products* and *Winans* cannot be reconciled as explained above. It is arguable that there was no function/way/result test at the time of *Winans*. However, in order to properly unify the past decisions of the Supreme Court and Federal Circuit on the doctrine of equivalents (including *Winans* and *Sage Products*), an objective standard is required for the determination of equivalency under the doctrine of equivalents. The proposed modified tripartite test discussed in this Article, *infra*, Section IV.A.3, provides such a standard.

IV. A MATHEMATICAL APPROACH TO THE DOCTRINE OF EQUIVALENTS

The Supreme Court in *Graver Tank*[123] stated that "a patentee may invoke this doctrine to proceed against the producer of a device 'if *it* performs substantially the same function in substantially the same way to obtain the same result.'"[124] To further clarify that "it" means the device *as a whole*, the Court stated, "[t]he theory on which it is founded is that 'if two devices do the same work in substantially the same way, and accomplish substantially the same result, they are the same, even though they differ in name, form, or shape.'"[125]

To place some limitation on the doctrine of equivalents, the Federal Circuit in *Pennwalt*[126] and subsequently the Supreme Court in *Warner-Jenkinson*[127] adopted the so-called "All Elements Rule." The court in *Pennwalt* stated:

> Under the doctrine of equivalents, infringement may be found (but not necessarily) if an accused device performs substantially the same overall function or work, in substantially the same way, to obtain substantially the same overall result as the claimed invention. That formulation, however, does not mean

121. *Winans*, 56 U.S. at 344.

122. Martin Adelman, *Is the Use of the Doctrine of Equivalents to Fix Mistakes a Mistake?*, 27 N. KY. L. REV. 1021, 1031 (2000).

123. Graver Tank & Mfg. Co. v. Linde Air Prods. Co., 339 U.S. 605 (1950).

124. *Id.* at 608 (quoting Sanitary Refrigerator Co. v. Winters, 280 U.S. 30, 42 (1929)) (emphasis added).

125. *Id.* (quoting Union Paper-Bag Mach. Co. v. Murphy, 97 U.S. 120, 125 (1877)).

126. Pennwalt Corp. v. Durand-Wayland, Inc., 833 F.2d 931, 935 (Fed. Cir. 1987) (en banc).

127. Warner-Jenkinson Co. v. Hilton Davis Chem. Co., 520 U.S. 17 (1997).

> one can ignore claim limitations . . . . In applying the doctrine of equivalents, each limitation must be viewed in the context of the entire claim . . . . To be a "substantial equivalent," the element substituted in the accused device for the element set forth in the claim must not be such as would substantially change the way in which the function of the claimed invention is performed . . . . It is clear from this that the district court correctly relied on an element-by-element comparison to conclude that there was no infringement under the doctrine of equivalents, because the *accused devices* did not perform substantially the same functions as the Pennwalt invention.[128]

After the *Pennwalt* decision, Adelman and Francione wrote:

> Whether the doctrine of equivalents is applied on an element-by-element basis or an entirety basis does not answer the key question: What is an "equivalent"?
>
> Language in Federal Circuit decisions suggests that the doctrine of equivalents cannot be used to encompass more than an "insubstantial change" or "minor modification"; ordinarily, however, the cases recite the standard function-way-result test, which gives no indication of what constitutes such a change. Until this question is answered, great uncertainty will surround the doctrine of equivalents, and the court's adoption of the element-by-element approach will do little to ameliorate the situation. [129]

In an attempt to prevent the doctrine of equivalents from being "applied broadly,"[130] the Supreme Court in *Warner-Jenkinson* stated:

> Each element contained in a patent claim is deemed material to defining the scope of the patented invention, and thus the doctrine of equivalents must be applied to individual elements of the claim, *not to the invention as a whole*. It is important to ensure that the application of the doctrine, even as to an individ-

128. *Pennwalt*, 833 F.2d at 934–35 (second emphasis added) (citations omitted).
129. Adelman & Francione, *supra* note 20, at 695–96 (footnotes omitted).
130. *Warner-Jenkinson*, 520 U.S. at 29.

> ual element, is not allowed such broad play as to effectively eliminate that element in its entirety.[131]

Because the Supreme Court did not explain "not to the invention as a whole," the guidance from *Warner–Jenkinson* has not clarified the application of the doctrine of equivalents. For example, Judge Plager of the Federal Circuit wrote the following:

> On the doctrinal side of indeterminacy, the most obvious and well-known example in patent law is the doctrine of equivalents. This judicially thought-up doctrine extends the reach of the patent claim beyond its literal application, to cover equivalents that are thought to be insubstantially different from the specific limitations in the claim . . . .
>
> This level of indeterminacy under the doctrine of equivalents is compounded by the rule that says a patentee cannot claim for purposes of infringement under the doctrine what was given up during prosecution of the patent before the PTO. For example, suppose the applicant's draft claim sought a range for the inventive *device* of 50 to 90 units, and the PTO examiner rejected the claim on the grounds that prior art disclosed a range of 85 and above. The applicant amends the claim to recite a range of 50 to 75, and the patent issues with the claim so reading. What did the patentee give up? Does a competitor's device that operates at 80 infringe? Clearly not literally, but under the doctrine of equivalents?
>
> One answer is, it depends; *is 80 an insubstantial difference from a range that goes to 75*?[132]

Thus it is clear that even in applying the All Elements Rule, the correct question for the determination of equivalency in Judge Plager's hypothetical should have been: "Is the accused device operating at 80 an insubstantial difference from a device operating at 75?" and not "is 80 an insubstantial difference from a range that goes to 75?" The misunderstanding of the All Elements Rule after *Warner-Jenkinson* is illustrated by the statements of Judge Plager that one

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131. *Id*. (emphasis added).

132. S. Jay Plager, *Challenges for Intellectual Property Law in the Twenty-First Century: Indeterminacy and Other Problems*, 2001 U. ILL. L. REV. 69, 72–73 (2001) (emphasis added).

must apply either the function/way/result or the insubstantial difference test to each element and check if the claimed and equivalent elements have an insubstantial difference or the claimed and equivalent elements perform substantially the same function, in substantially the same way, to produce substantially the same result. However, a careful reading of *Pennwalt* suggests that in carrying out the element-by-element analysis one instead should examine the effect on the accused product or process *as a whole* of substituting only one element with a corresponding claimed element. Besides, one should not examine the effect of substituting several elements of the accused product or process with several claimed elements. Proper application of *Pennwalt* and the function/way/result tripartite test first requires a determination of what the elements in a claimed product or process are.

A. A Modified Tripartite Test for Equivalence on an Element-by-Element Basis

1. An Element is a Variable Having a Degree of Freedom

There is no clear answer to the question: What is the difference between an element and a limitation? The Federal Circuit in *Festo* noted:

> In our prior cases, we have used both the term "element" and the term "limitation" to refer to words in a claim. It is preferable to use the term "limitation" when referring to claim language and the term "element" when referring to the accused device. However, because the en banc questions use the term "element," we use that term in this opinion.[133]

133. Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co., 234 F.3d 558, 564 n.1 (Fed. Cir. 2000), *vacated by* 122 S. Ct. 1831 (2002) (internal citations omitted). *See also*, Paul Michel, *A View From the Court of Appeals for the Federal Circuit*, *in* 3 INTERNATIONAL PERSPECTIVES ON INTELLECTUAL PROPERTY 4, 9 (Kraig M. Hill & Toshiko Takenaka eds., 1997). Judge Michel states:

> I like to call it [referring to the "all-elements rule"] the "all-limitations rule," because I don't know what an element is. And every time I've had to debate with someone, it's clear that they have a slightly different idea of what an element is than what I think it is. Once you get past atomic elements, I don't think it's a useful word.

Id. Even though Judge Michel's perspective on the meaning of the term "element" might appear to be rather cynical, his explanation provides a clear picture of the high level of confusion existing in even the mind of a Federal Circuit judge regarding the meaning of the word "element" as used in the "all-elements rule."

An additional concern is whether it is "possible to circumvent or control the all elements rule by reducing the number of elements and grouping elements together?"[134]

Despite these ambiguities, the Federal Circuit in *Festo* clarified that an estoppel against equivalents applies only against a claim element that was the subject of a narrowing amendment.[135] An amendment narrowing one element in a claim does not preclude the patent owner from asserting the doctrine of equivalents with regard to other elements in the claim. Though the definition of an element is critical to the application of the doctrine of equivalents, the Supreme Court in *Festo* does not address the issue in any way. Therefore, the lack of clarity regarding what the elements in a claim are will continue.

To provide a scientific definition of elements, it is necessary to examine the term "degrees of freedom." The degrees of freedom for a claimed product or process are *the independent variables that must be specified in order to define the claimed product or process completely*.

Consider the following hypothetical product claims:

1. A product comprising **x**, **y**, and **z**.

2. A product comprising **w** and **x**, said **w** comprising **y** and **z**.

In claim 1, one can specify arbitrarily the definitions (or values) of the three variables **x**, **y**, and **z**. The phrase "specify arbitrarily" means that **x**, for example, can be defined without incorporating the definitions of **y** or **z**. On the other hand, in claim 2, one can specify arbitrarily the definition (or values) of **x**, **y**, and **z**, but not **w**. This is because the variable **w** is defined in terms of **y** and **z**, and, therefore, cannot be arbitrarily defined without incorporating the definitions of **y** or **z**. The variables that can be arbitrarily specified are the degrees of freedom representing the elements of the claim. Thus, *an element is a variable having a degree of freedom*. Because the degrees of freedom of the independent variables must be specified in order to define the claimed product or process completely, a complete definition of the claimed product or process can be achieved when and only when all the degrees of freedom, or elements, have been specified.

Mathematically, in set theory notation, claim 1 is represented as $\mathbf{C_1 = \{x, y, z\}}$; $\mathbf{C_1}$ is a "set," which is a collection of objects called "elements" of the set, namely **x, y,** and **z**, which define claim 1. The curly brackets, i.e., { }, denote the physical beginning and end of the set defining an open-ended claim characterized by a transitional phrase such as "comprising," "containing," "including," or "character-

134. CHISUM ET AL., *supra* note 11 at 902.
135. *See Festo*, 234 F.3d at 566.

ized by."[136] If the transitional phrase in the claim is "consisting of,"[137] then one should use the square brackets, i.e., [ ], at the beginning and end of the set. If the transitional phrase in the claim is "consisting essentially of,"[138] then one should use the diamond brackets, i.e., < >, at the beginning and end of the set.

Similarly, claim 2 is represented in set theory notation as $\mathbf{C_2 = \{w, x\}}$ where $\mathbf{C_2}$ is a set containing subset **w** and element **x**.[139] Subset **w** is defined as **w = {y, z}** where **y** and **z** are the elements. Claim 2 is represented in terms of the collection of elements **x**, **y**, and **z** as $\mathbf{C_2 = \{w = \{y, z\}, x\} = \{\{y, z\}, x\}}$.

If the "order" (which is analogous to the way of the tripartite test) in which **w** and **x** are put together plays no role in defining claim 2, then **{{y, z}, x} = {x, {y, z}}**, and **w** and **x** represent an unordered pair. On the other hand, if one needs to pair **w** and **x** in a specific way (making it possible to "read off" which comes "first" and which comes "second"), then $\mathbf{\{\{y, z\}, x\} \neq \{x, \{y, z\}\}}$ if $\mathbf{w \neq x}$, and **w** and **x** represent an ordered pair.

Set notation can show the modification of claims to include additional limitations on the elements:

3. A product comprising **x**, **y**, and **z**, wherein **x** is greater than 2 and less than 40 and **x** is even.

In this case, claim 3 is represented by as $\mathbf{C_3 = \{x, y, z: 2 < x < 40}$ **and x is even}**.

Having explained the meaning of elements in product claims and how product claims could be represented by set theory, the next logical issues are defining the elements in a process claim and representing a process claim by set theory.

Consider the following hypothetical process claims:

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136. *See, e.g.*, Genentech, Inc. v. Chiron Corp., 112 F.3d 495, 501 (Fed. Cir. 1997) ("'Comprising' is a term of art used in claim language which means that the named elements are essential, but other elements may be added and still form a construct within the scope of the claim."); *Ex parte* Davis, 80 U.S.P.Q. 448, 450 (Bd. App. 1948) (noting that "comprising" leaves "the claim open for the inclusion of unspecified ingredients even in major amounts").

137. *See, e.g.*, *In re* Gray, 53 F.2d 520, 521 (C.C.P.A. 1931) (The transitional phrase "consisting of" excludes any element, step, or ingredient not specified in the claim.); *Ex parte* Davis, 80 U.S.P.Q. at 450 (defining "consisting of" as "closing the claim to the inclusion of materials other than those recited except for impurities ordinarily associated therewith").

138. *See, e.g.*, *In re* Herz, 537 F.2d 549, 551–52 (C.C.P.A. 1976) (emphasis added) (The transitional phrase "'consisting essentially of'" limits the scope of a claim to the specified" materials or steps "and those that do not *materially* affect the *basic* and *novel* characteristic(s)" of the claimed invention.); PPG Indus. v. Guardian Indus., 156 F.3d 1351, 1354 (Fed. Cir. 1998) ("A 'consisting essentially of' claim occupies a middle ground between closed claims that are written in a 'consisting of' format and fully open claims that are drafted in a 'comprising' format.").

139. Note that because **w** is a subset, it is not an element.

4. A process comprising heating **x**, cooling **y**, and evaporating **z**.

5. A process comprising heating **w** and cooling **x**, said **w** comprising **y** and **z**.

In claims 4 and 5, the elements are still **x**, **y**, and **z** as in claims 1 and 2 because one can specify arbitrarily the definitions (or values) of these three variables **x**, **y**, and **z**. In set theory notation, claim 4 is represented as $\mathbf{C_4}$ **= {x, y, z: x is heated, y is cooled, and z is evaporated}**. Similarly, claim 5 is represented as $\mathbf{C_5}$ **= {{y, z}, x: y and z are heated and x is cooled}**.

Assume that claim 5 is modified to include some additional limitations:

6. A process comprising heating **w** and cooling **x**, said **w** comprising **y** and **z**, wherein **x** is greater than 2 and less than 40 and **x** is even.

In this case, claim 6 is represented as $\mathbf{C_6}$ **= {{y, z}, x: y and z are heated, x is cooled, 2 < x < 40 and x is even}**. In summary, any product or process claim can be unambiguously represented by a set containing a collection of objects called elements of the set, wherein the elements are the independent variables that one can specify arbitrarily, i.e., the degrees of freedom in the claim.

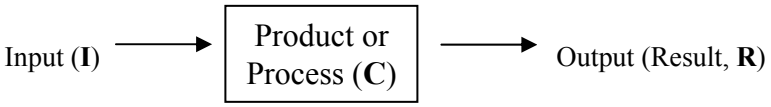
2. A Mathematical Model for the Tripartite Test

Based on the mathematical meaning of the term element in a claim, I now propose a mathematical model, called "the input-output model," that provides a mathematical explanation of the function/way/result test. This model describing directly the relationship between the input and result obtained by a product or process is an example of an input-output model.[140] It is a convenient form because it represents directly the cause-and-effect relationship in a product or process. For this reason, similar models are also appealing to process engineers and control designers for modeling a process.[141] Every product or process and its associated variables can be described pictorially as shown in Figure 4.

Figure 4: A product or process (defined by set **C**) and its associated input (**I**) and output (defined by result **R**) shown as an input-output model.

140. *See* GEORGE STEPHANOPOULOS, CHEMICAL PROCESS CONTROL: AN INTRODUCTION TO THEORY AND PRACTICE 81 (1984).

141. *See id.*



The main block represents the product or process, while the arrows indicate the inputs and outputs of the product or process. A mathematical model that is convenient and useful in explaining the function/way/result test should conform to the picture in Figure 4, i.e., given a certain input, it provides directly the output, or the result. In particular, the model has the following general form for each output (**R**) as a function of each input (**I**):

$$\mathbf{R = f(I)\ C} \qquad (1)$$

where **f** is a functionality that defines the relationship between input **I** and result **R**, and **C** is a set defining the product or process.[142] Consider that **C = {x, y, z}**, where **C** is the set defining the claim and **x**, **y**, and **z** are the elements of the set. Substituting **C** with **{x**, **y**, **z}** in Equation (1) gives:

$$\mathbf{R = f(I)\ \{x, y, z\}} \qquad (2)$$

The result (**R**) obtained by the claimed product or process is a function of three degrees of freedom, **x**, **y**, and **z**, as shown in Equation (2). This relationship as modeled in Equations (1) and (2) provides the basis for a mathematical explanation of the function/way/result test.

Assume that the degrees of freedom of the accused product or process are **x***, **y**, and **z**, instead of **x**, **y**, and **z** in the claimed product or process, the functionality is **f*** instead of **f**, and the value of the result obtained in the accused product or process is **R***, not **R**. The accused product or process does not literally infringe the claim containing **{x**, **y**, **z}** because it does not contain **x**. Does the accused product or process infringe the claim under the doctrine of equivalents? To make this determination on an element-by-element basis, one must first replace **x** in Equation (2) with **x*** and keep **y** and **z** the same as in Equation (2) to arrive at the following input-output model relationship for the accused product or process:

$$\mathbf{R^* = f^*(I)\ \{x^*, y, z\}} \qquad (3)$$

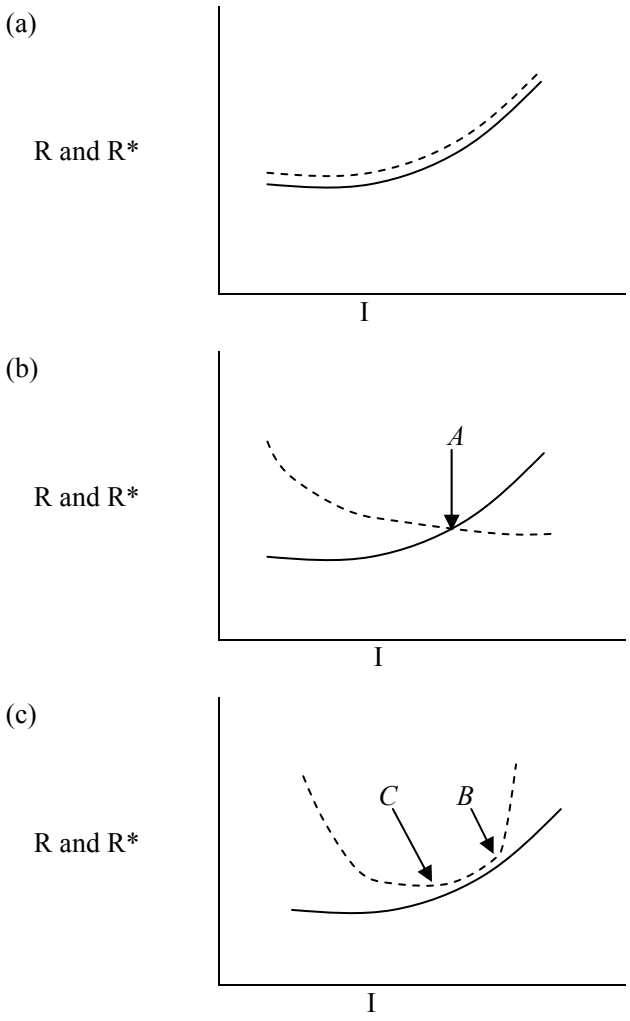
142. The functionality could be linear if **f** is a constant value such that equal increments in **I** would produce corresponding equal increments in **R** or the functionality could be non-linear such that equal increments in **I** could produce different increments in **R**.

Next one could undertake the function/way/result analysis to determine if the accused product or process performs substantially the same function in substantially the same way to obtain substantially the same result as the claimed product or process.[143] In Equations (2) and (3), the functionalities **f** and **f*** designate the functions of the claimed and accused products or processes because the functionalities provide the degree of the interaction or modification that occurs on the input by the claimed and accused products or processes. If the functionalities **f** and **f*** are substantially the same, then the accused product or process performs substantially the same function as the claimed product or process. Similarly, for a given input **I**, if the values of the results **R** and **R*** are the same or substantially the same, then the accused product or process produces substantially the same result as the claimed product or process. Finally, to determine if the accused product or process performs its function in substantially the same way as that of the claimed product or process, one looks at the "order" (i.e., the interrelationship in time, space, dimension, etc.) among the elements **x**, **y**, and **z** and the corresponding "order" among elements **x***, **y**, and **z**. If the "orders" among the elements in the accused and claimed products or processes are substantially the same, then the accused product or process performs its function in substantially the same way as that of the claimed product or process.

The relationships between the input and result obtained by the claimed and accused processes by the input-output models represented by Equations (2) and (3) are depicted graphically for different hypothetical situations in Figure 5.

143. *See Graver Tank*, 339 U.S. at 608.

Figure 5: Input-output models of the relationships between the inputs (**I**) and results (**R** and **R***, represented by solid and dashed lines respectively) for the claimed and accused processes according to Equations (2) and (3).



In Figure 5, the claimed device contains elements **x**, **y**, and **z** while the accused device contains elements **x***, **y**, and **z**. Figure 5(a) shows that the functionalities **f** and **f*** are substantially the same because the curves of **R** and **R*** of the claimed and accused processes are almost parallel. Figure 5(a) also shows that the results obtained by

the claimed and accused processes, **R** and **R***, are substantially the same because the "gap" between the curves of **R** and **R*** is substantially insignificant. If the "orders" among the elements in the accused and claimed processes are substantially the same, then the accused process infringes the claimed process under the doctrine of equivalents.

Figure 5(b) shows that the results obtained by the claimed and accused processes, **R** and **R***, are the same at point **A** where the curves of **R** and **R*** intersect and substantially the same in the vicinity of **A**. Clearly, the accused process infringes literally the claimed process at point **A**. Yet, it is evident from Figure 5(b) that the functionalities **f** and **f*** are totally different, and therefore the accused process does not perform substantially the same function as the claimed process. Thus, even if the orders among the elements in the accused and claimed processes are substantially the same and the results produced in the vicinity of **A** are substantially the same, the accused process does not infringe the claimed process under the doctrine of equivalents because the functions are different.

Figure 5(c) shows an interesting variation of Figure 5(a). Assume that the orders among the elements in the accused and claimed processes are substantially the same. Then, Figure 5(c) shows that the accused process infringes the claimed process under the doctrine of equivalents when the input is in the range of **B** to **C**. What should be the outcome if the accused product or process operates in actual operation with an input outside the range **B** to **C**? In that case, the accused process would not infringe a process claim under the doctrine of equivalents. On the other hand, an accused product would infringe a product claim if the accused product is capable of operating with an input in the range **B** to **C**, even though it does not do so in actual operation.

In light of Equations (1) to (3), it is valuable to look at the meaning of the phrase "the doctrine of equivalents must [not] be applied . . . to the invention *as a whole*."[144] Clearly from the literal reading of the above phrase one cannot apply a test for equivalency by simultaneously varying the values of several elements and looking at the result obtained thereby. This means that one cannot simultaneously vary all the degrees of freedom in a set defining a claim, for example, change **{x**, **y**, **z}** to **{x***, **y***, **z***}, and then apply the tripartite test to check if an accused product or process infringes a claimed product or process under the doctrine of equivalents.

One likewise cannot vary two degrees of freedom simultaneously for the determination of infringement under the doctrine of equiva-

144. *Warner-Jenkinson*, 520 U.S. at 29 (emphasis added).

lents, because this would violate the rule that "the doctrine of equivalents must be applied to individual elements of the claim."[145]

The established scientific method for isolating the effects produced by different variables is to vary just one independent variable and observe the result while keeping all other independent variables constant.

3. The Proposed Modified Tripartite Test

The current "function/way/result" tripartite test is a scientifically and mathematically sound test for determining equivalency for applying an element-by-element analysis. However, there are two weaknesses in its implementation.

The first weakness is that no quantitative method has been applied to determine if the accused product or process has substantially the same result and function as the claimed product or process. To address the first weakness, a quantitative method called the "'t'-test" is proposed in section IV.B.1, *infra*.

The second weakness is that the "way" prong, which represents the "order" of the elements as explained above, is in many cases the most contentious issue for the determination of infringement under the doctrine of equivalents.[146] This problem is caused by the lack of any scientific test that proves that one order of one set of elements is *substantially the same* from another order of a different set of elements. One can determine whether the order of the elements in the accused product or process is the same or different from the order of the elements in the claimed product or process. However, it is difficult, if not impossible, to prove that two orders are substantially the same when they are not the same. One way to prove that two orders are substantially the same is by showing that the results of the two orders are substantially the same. Even if the results of the two orders are similar, the determination of whether the two orders are substantially the same still remains a question of fact that would be decided by the jury.

I propose that when at least one element is the product of an after-arising technology only the "function" and "result" prongs of the tripartite test should be applied in determining equivalency under the doctrine of equivalents. Thus in order to minimize inconsistencies, the "way" prong should *not* be applied to any element of an accused product or process in which at least one element is the product of an

145. *Id.*

146. *See* Adelman & Francione, *supra* note 20, at 687–88 ("In *Pennwalt*, as in most equivalents cases, there was no dispute that the accused device performed substantially the same overall function or work and achieved substantially the same overall result. In most cases, the issue is almost invariably whether the accused device performs the overall function in substantially the same way as the claimed invention.") (citations omitted).

after-arising technology. An element that is the product of an after-arising technology and adapted for use in a product or process would likely result in a different "order," particularly spatial arrangement, among the elements of the product or process. Arguably, a potential infringer of a claimed product or process could circumvent infringement under the doctrine of equivalents by replacing an element in an accused product or process with an element that is the product of an after-arising technology.

The transition from vacuum tubes to transistors is an example of after-arising technology; the phenomenon of after-arising technologies is often cited as a primary justification of the doctrine of equivalents:

> Without a doctrine of equivalents, any claim drafted in current technological terms could be easily circumvented after the advent of an advance in technology. A claim using the terms "anode" and "cathode" from [vacuum] tube technology would lack the "collectors" and "emitters" of transistor technology that emerged in 1948. Thus, without a doctrine of equivalents, infringers in 1949 would have unfettered license to appropriate all patented technology using the out-dated terms "cathode" and "anode." Fortunately, the doctrine of equivalents accommodates that unforeseeable dilemma for claim drafters. Indeed, in *Warner-Jenkinson Co., Inc. v. Hilton Davis Chemical Co*., . . . the Supreme Court acknowledged the doctrine's role in accommodating after-arising technology.[147]

While this is a perfect example of after-arising technology that the doctrine of equivalents is supposed to accommodate, careful analysis reveals that the facts regarding vacuum tubes and transistors will indicate no equivalency when considered in the current function/way/result tripartite test. The "way" anodes and cathodes work and are spatially arranged in vacuum tubes is totally different from the "way" collectors and emitters work and are spatially arranged in transistors.[148] However, the function and the result obtained by a transistor are substantially the same as those of a vacuum tube. The proposed modified tripartite test would have however recognized the transistor as an after-arising equivalent of a vacuum tube; under the current tri-

147. *Festo*, 234 F.3d at 619 (Rader, J., concurring-in-part, dissenting-in-part) (internal citation omitted).

148. *See* 14 MCGRAW-HILL ENCYCLOPEDIA OF SCIENCE & TECHNOLOGY 38, 314 (5th ed. 1982).

partite test, it would have been difficult to establish equivalence in "way."

The less stringent modified tripartite test, examining only function and result for accused products or processes incorporating after-arising technology, is consistent with the opinion of Judge Rader in *Festo*. Rader suggested that the doctrine of equivalents should play a special role in extending a patent claim's literal scope to after-arising technology based on forseeability.[149] A patent claim draftsperson cannot reasonably be expected to have drafted a claim literally covering the unanticipated equivalent.

The proposed mathematical model of the tripartite test would also eliminate apparent inconsistencies between previous court decisions, for example *Winans* and *Sage Products*. Precisely speaking, in both cases the accused infringing device had a different form or arrangement of elements than the claimed device, but the function/way/result test suggested the accused container in *Sage Products* did not infringe the '728 patent claims, while the accused railcar in *Winans* infringed because it "attain[s] the same kind of result."[150] In *Winans*, even though the claimed and accused cars had different forms, "for practical purposes"[151] the circular and octagonal forms had substantially the same arrangement, i.e., "order," of the elements. In this case, applying the tripartite test, the accused octagonal railroad car of Denmead would infringe Winans' claimed conical railroad car under the doctrine of equivalents because the accused railroad car had substantially the same function of carrying coal and produced substantially the same results of an even weight distribution of coal in the car and a lower center of gravity.

In *Sage Products*, the claim at issue defined a relatively simple container. Claims could have been drafted by a skilled patent drafter to cover the accused container, which did not contain any elements that embodied after-arising technology. Thus, Judge Rader correctly applied the traditional tripartite test including the "way" prong and decided that the accused container "achieves a *similar result* — restricted entry to a medical disposal container — but it does so by a

149 *Festo*, 234 F.3d at 619–20 (Rader, J., concurring-in-part, dissenting-in-part).

150. *Winans*, 56 U.S. at 340.

151. "'[F]or practical purposes, one was as good as the other; that a polygon of many sides would be equivalent to a circle; that the octagon car, practically, was as good as the conical one; and that, substantially, [Denmead's own] witness saw no difference between the two.'" *Id*. at 334. A circle is a polygon of infinite sides. Mathematically, a polygon of eight or more sides approximates a circle. For example, the area of a regular octagon whose eight corners touch a circle is 90% of the area of the circle. Besides, the Court in *Winans* states that "the immediate tendency of the load of coal, when put into an octagon car, was to bulge out its size and convert it into a conical one." *Id*. at 333. In other words, the evidence demonstrated that the octagon substantially took on a shape of a circle.

different arrangement [i.e., a different way or "order"] *of elements*."[152]

I propose the modified tripartite test to account for unforeseeable equivalents: the doctrine of equivalents may be invoked against an accused product or process if it performs substantially the same function in substantially the same or in an unforeseeable way to obtain substantially the same result.[153] If the accused product or process does not encompass an element from later-developed technology, then I propose that the phrase "in substantially the same way" from *Graver Tank* be interpreted as "in the same way." This modification is justified because one can determine if the elements of two sets have the same or different "orders," but it is difficult to establish if the elements of two sets have "substantially the same orders" except in situations as that in *Winans*.

4. Clarification of the *Corning Glass* Conundrum

The decision of the Federal Circuit in *Corning Glass Works v. Sumitomo Electric USA*, *Inc*.[154] has been a difficult decision to reconcile with the All Elements Rule. The invention was directed to an optical waveguide in Corning's U.S. Patent No. 3,659,915 (the '915 patent), in which claim 1 reads:

> 1. An optical waveguide (**W**) comprising
>
> *a cladding layer* (**c_1**) formed of a material selected from the group consisting of *pure fused silica* (**s_p**) and *fused silica* (**s_1**) to which *a dopant material* (**d_1**) on at least an elemental basis has been added, and *a*

152. *Sage Products*, 126 F.3d at 1425 (emphasis added).

153. *See* Hughes Aircraft Co. v. U.S., 140 F.3d 1470, 1475 (Fed. Cir. 1998). According to the Federal Circuit in *Hughes*:

> [A]s a result of an advance in technology, . . . the synchronism in the accused device is coordinated by the computer instead of by real-time execution of the command from the ground. As recognized in *Hughes VII* [*Hughes Aircraft Co. v. U.S.*, 717 F.2d 1351 (Fed. Cir. 1983)], the difference between [the] operation[s] . . . [of the accused and claimed devices makes] no change in the function performed, or in the basic manner of operation, or in the result obtained. The court in *Hughes VII* correctly performed an analysis of the function, way, and result of the individual elements in the accused devices and concluded that these elements equivalently met the claim limitations at issue.

Id. (internal quotations and citations omitted).

It took 15 years for the Federal Circuit to confirm the decision of *Hughes VII* because of the indeterminacy in applying the "way" prong to an accused device or process incorporating after-arising technology. The proposed modified tripartite test would have allowed the court to arrive at the same outcome on equivalency without the prolonged 15 years of litigation.

154. Corning Glass Works v. Sumitomo Elec. USA, Inc., 868 F.2d 1251 (Fed. Cir. 1989).

> *core* (**c_2**) formed of *fused silica* (**s_2**) to which *a dopant material* (**d_2**) on at least an elemental basis has been added to a degree in excess of that of the cladding layer so that the index of refraction thereof is of a value greater than the index of refraction of said cladding layer, said core being formed of at least 85 percent by weight of fused silica and an effective amount up to 15 percent by weight of said dopant material.[155]

The Corning waveguide contained a certain amount of a positive dopant in the cladding layer and a larger amount of a positive dopant in the core to produce a higher refractive index in the core than in the cladding layer. With a positive dopant, the refractive index increases with dopant concentration whereas with a negative dopant, the refractive index decreases as dopant concentration increases. The accused Sumitomo waveguide contained a negative dopant in the cladding layer and no dopant in the core, but produced the same difference in refractive index between the core and the cladding as the Corning waveguide. Define the refractive indices of the cladding layer and core in Corning waveguide as **RI_1** and **RI_2** respectively, where **$RI_1 < RI_2$**, to produce a refractive index difference of **ΔR**. Sumitomo's waveguide contained a negative dopant (fluorine) in the core (so Sumitomo's **RI_2** was less than Corning's **RI_2**) and no dopant in the cladding layer (so Sumitomo's **$RI_1=0$**) to still maintain the same **ΔR**. Sumitomo decreased the positive dopant concentration in the core of the Corning waveguide while simultaneously increasing the negative dopant concentration in the cladding layer by the same magnitude, thus resulting in the same **ΔR** as Corning.

The Federal Circuit found that the Sumitomo waveguide did not literally infringe claim 1, but it infringed under the doctrine of equivalents.[156] Noting that all of the limitations of the cladding layer of claim 1 of the '915 patent read on the Sumitomo waveguide,[157] the court focused on the phrase "*a core* formed of fused silica to which *a dopant material* on at least an elemental basis has been added to a degree in excess of that of the cladding layer so that the index of re-

155. U.S. Patent No. 3,659,915 (issued May 2, 1972) (emphasis and text in parenthesis added).

156. *Corning Glass*, 868 F.2d at 1261. The *Corning Glass* decision does not harmonize with the Supreme Court decision in *Festo* if the claim is narrowed because the reason provided by *Corning Glass* for finding equivalency is that "the substitution of an ingredient known to be an equivalent to that required by the claim presents a classic example for a finding of infringement under the doctrine of equivalents." *Id*. (citing *Graver Tank*, 339 U.S. at 609).

157. *Id*. at 1259–60.

fraction thereof is of a value greater than the index of refraction of said cladding layer" in the '915 patent.[158] The court said:

> "Element" may be used to mean a single limitation, but it has also been used to mean a series of limitations which, taken together, make up a component of the claimed invention. In the All Elements rule, "element" is used in the sense of a *limitation* of a claim. . . . Sumitomo's analysis is faulty in that it would require equivalency in components, that is, the substitution of something *in the core* for the absent dopant. However, the determination of equivalency is not subject to such a rigid formula. An equivalent must be found for every limitation of the claim somewhere in an accused device, but not necessarily in a corresponding component, although that is generally the case.[159]

The Federal Circuit agreed with the district court's factual analysis that the use of a negative dopant in the cladding layer performed substantially the same function in substantially the same way as the use of a positive dopant in the core to produce the same result of creating the claimed refractive index differential between the cladding layer and core. Effectively, *Corning Glass* determined that the dopant in the cladding layer and the dopant in the core should be construed as a single element, but did not clearly explain why.

Applying the mathematical formulation for equivalency to the optical waveguide (**W**) of the '915 patent thus reveals at least four elements: a cladding layer ($\mathbf{c_1}$), a dopant in the cladding layer ($\mathbf{d_1}$), a core ($\mathbf{c_2}$), and a dopant in the core ($\mathbf{d_2}$). One might thus assume that claim 1 is represented as $\mathbf{W = \{c_1, d_1, c_2, d_2\}}$. However, the correct analysis shows that the optical waveguide comprises a cladding layer ($\mathbf{c_1}$) and a core layer ($\mathbf{c_2}$). Thus,

$$\mathbf{W = \{c_1, c_2\}} \qquad (4)$$

Because the claim recites, "*a cladding layer* ($\mathbf{c_1}$) formed of a material selected from the group consisting of *pure fused silica* ($\mathbf{s_p}$) and *fused silica* ($\mathbf{s_1}$) to which *a dopant material* ($\mathbf{d_1}$) on at least an elemental basis has been added," $\mathbf{c_1 = \{s_p, s_1, d_1\}}$. The claim also recites "*a core* ($\mathbf{c_2}$) formed of *fused silica* ($\mathbf{s_2}$) to which *a dopant material* ($\mathbf{d_2}$) . . . has been added," which means $\mathbf{c_2 = \{s_2, d_2\}}$. The parameters that define the relative amounts of fused silica and dopant in the core

158. *Id.* at 1256 (emphasis added).
159. *Id*. at 1259 (emphasis in original) (footnotes omitted).

would be represented in set theory notation as "**$d_2 > d_1$ where $RI_1 < RI_2$, $s_2 \geq 85$ wt.%, and $d_2 \leq 15$ wt.%**." Substituting for c_1 and c_2 in Equation (4) and further adding the limitations of the claim in the equation for **W** gives the following equation:

$$\mathbf{W = \{c_1 = \{s_p, s_1, d_1\}, c_2 = \{s_2, d_2\}: d_2 > d_1 \text{ where } RI_1 < RI_2, s_2 \geq 85 \text{ wt.\%, and } d_2 \leq 15 \text{ wt.\%}\}} \quad (5)$$

If in the optical waveguide, the pure fused silica (s_p) and the fused silica (s_1) are indistinguishable in the cladding layer, then, $s_p = s_1$ and Equation (5) reduces to:

$$\mathbf{W = \{\{s_1, d_1\}, \{s_2, d_2\}: d_2 > d_1 \text{ where } RI_1 < RI_2, s_2 \geq 85\text{wt.\%, and } d_2 \leq 15 \text{ wt.\%}\}} \quad (6)$$

Note that d_1 and d_2 are not independent variables, and therefore do not have individual degrees of freedom. Instead, they are interdependent such that **ΔRI** depends on **Δd**, where **Δd** refers to the difference in the dopant concentration in the cladding layer and the core. Therefore, Equation (6) can be further simplified and represented as:

$$\mathbf{W = \{\{s_1\}, \{s_2\}, \Delta d: d_2 > d_1 \text{ where } RI_1 < RI_2, s_2 \geq 85\text{wt.\%, and } d_2 \leq 15 \text{ wt.\%}\}} \quad (7)$$

In Equation (7), the notation "**$\{s_1\}$, $\{s_2\}$, Δd**" within the set **W** means that s_1 and s_2 are elements of **W** but within subsets, namely, c_1 and c_2, while **Δd** is an element *directly* within **W**. In short, determining infringement of the Corning optical waveguide under the doctrine of equivalents involves only *three* elements: the fused silica (s_1) that forms the cladding layer, the fused silica (s_2) that forms the core, and **Δd**.

In light of the *Corning Glass* decision, there has been considerable debate among legal scholars as to whether the "All Elements Rule" requires that there be a one-to-one correspondence between claim elements and elements in an accused product or process. For example, at the 1997 Symposium on Intellectual Property Law at the University of Washington, Judge Paul Michel of the Federal Circuit said:

> The second quandary is whether the accused device has to be exactly in parallel with the claimed invention. Sometimes the word "corespondence" [sic] is used to describe this notion. And people ask, "Does there have to be one-to-one correspondence?["] Or sometimes it's phrased in terms of whether there has

> to be "strict correspondence." And my answer again is: look at the existing case law, indeed look at *Corning Glass* itself and how it has been interpreted subsequently. And I think the answer is no, it doesn't have to be an exact parallel. However, every function that is identified in the claim has to be found somewhere in the accused device, in such a setting that it obtains substantially the same result in substantially the same way.[160]

On the other hand, Professor Donald S. Chisum wrote in *Principles of Patent Law*:

> A significant post-*Pennwalt* decision, *Corning Glass*, recognized that the "all elements" rule did not require that there be a one-to-one correspondence between claim limitations and elements in an accused product or process. *Corning Glass* may have reached a sensible conclusion on its facts, but its analysis invited subversion of the "all elements" rule; creative patentees can be expected to always postulate some match between claim limitations and single or combined elements in the accused product or process. But decisions subsequent to *Corning Glass* have carefully confined its scope and have stressed that equivalency cannot embrace a structure that is specifically excluded from the scope of the claims. For example, in *Forest Labs v. Abbott Labs*, 239 F.3d 1305, 1313 (Fed. Cir. 2001), the Federal Circuit, in no uncertain terms, stated that "[i]n *Corning Glass*, we did not dispense with the need for one-to-one correspondence of limitations and elements."[161]

Thus patent attorneys have been confused as to whether *Corning Glass* did or did not dispense with the need for one-to-one correspondence of claimed elements and elements of the accused device. This Article's analysis was not a product of "postulat[ing] some match between claim limitations and single or combined elements in the accused product or process."[162] Instead, this Article's analysis is based on set theory, so that elements in the claim are properly defined and

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160. Paul Michel, *What* Warner-Jenkinson *Has Told Us*, *in* 3 INTERNATIONAL PERSPECTIVES ON INTELLECTUAL PROPERTY 92, 94 (Kraig M. Hill & Toshiko Takenaka eds., 1997).

161. DONALD S. CHISUM ET AL., *supra* note 11 at 901 (internal citation omitted).

162. *Id*.

the All Elements Rule is rigorously applied *without* dispensing with the need for one-to-one correspondence of claim elements and elements of the accused device. This Article's analysis proves that *Corning Glass* applied the All Elements Rule while still requiring that there be a one-to-one correspondence between elements of claim 1 of the '915 patent and elements of Sumitomo's waveguide. Thus Professor Chisum's statement that the *Corning Glass* "analysis invited subversion of the 'all elements' rule"[163] is not correct.

B. The "t"-Test to Determine Substantially the Same Result and Function

1. The "t"-Test

The test for equivalency under the proposed modified tripartite test requires an element-by-element check if the function performed and the result obtained by an accused product or process are substantially the same as those of the claimed product or process. The "t"-test is a statistical method to assess whether two groups are from the same population (i.e., family or genus).[164] The "t"-test can therefore ascertain whether an accused product or process performs substantially the same function and produces substantially the same result as that of the claimed product or process. The "t"-test will only be applicable if the accused product or process receives an input and produces a result; understandably, there are some inventions, particularly mechanical and electrical inventions, which do not receive any input or produce any output, thus likely rendering the proposed "t"-test inapplicable.

The "t"-test judges the difference between the means of the two groups relative to the dispersion or variability in the two groups. The formula for the "t"-test is a ratio: the numerator is the difference between the means of the two groups, while the denominator is the measure of the variability. Formulas for calculating the "t" value of

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163. *Id*.

164. *See, e.g*., ROBERT V. HOGG & JOHANNES LEDOLTER, APPLIED STATISTICS FOR ENGINEERS AND PHYSICAL SCIENTISTS 236 (Robert W. Pirtleed, ed., 1992); ROGER PORKESS, THE HARPERCOLLINS DICTIONARY OF STATISTICS 220–22 (1991); Rodger Marion, *Interpreting Statistics — Differences*, *at* http://www.sahs.utmb.edu/pellinore/intro_to_research/wad/differences.htm (last visited Mar. 1, 2003). The "t"-test was developed at the start of the 20th century by William Sealy Gossett (1876–1937). A short background provides insight into why it look a long time for the "t"-test to be widely accepted as a test for determining statistical similarity between groups. Gossett worked at Guinness brewery in Dublin as a chemist, but he was "never hired as a statistician." He wanted to understand the conditions of brewing and determine if they made a statistical difference on the quality of beer. Based on his research on brewing beer, he anonymously wrote a paper on the "t"-test during his spare time under the pseudonym "Student," hence the name "Student's 't'-test." *See* Engin A. Sungur, *William Sealey Gossett at* http://www.mrs.umn.edu/~sungurea/introstat/history/w98/gosset.html (last visited Mar. 1, 2003).

the "t"-test are widely available in textbooks and on the Internet.[165] The following are the steps for applying the "t"-test to determine whether an accused product or process produces substantially the same result as that of the claimed product:

> (1) Operate the accused product or process over a range of values of **I**, particularly the range of **I** where the accused product or process is operated by the accused infringer, while recording the values of the results (**R***). Obtain enough data points for **I** and **R*** to ensure a statistically valid sample.[166]
>
> (2) Take only one element of the accused product or process that is outside the literal scope of the claim and replace it with an element recited in the claim. Then, carry out the operations in step (1) to obtain values of **R**.
>
> (3) For the results with the accused product or process and the results with the accused product or process with an element changed (namely, **R*** and **R** respectively), calculate the actual t value ($\mathbf{t_{actual}}$) using the "t"-test.
>
> (4) Having found the t value, then determine the critical t at the specified confidence level. A level of 95% confidence, is considered to be an appropriate level in most scientific research.[167] Tables of the critical t at 95% confidence ($\mathbf{t_{critical\text{-}95\%}}$) from charts available in textbooks.[168]

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165. *See* HOGG & LEDOLTER, *supra* note 164, at 236; PORKESS, *supra* note 164, at 220–22; Marion, *supra* note 164.

166. Because "[v]ariability (or dispersion) in measurements and processes is a fact of life," random sampling minimizes statistical variability which otherwise would contribute to systematic errors. HOGG & LEDOLTER, *supra* note 164, at 1. Therefore, collect at least 20 data points for **I** and **R***.

167. *See* Marion, *supra* note 164. Note that 95% confidence level means the significance level (α) is 0.05.

168. *See* HOGG & LEDOLTER, *supra* note 164, at 449; PORKESS, *supra* note 164, at 220–22; Marion, *supra* note 164. The critical t value will depend on three factors: the total number of data points, the degree of confidence, and the number of directions in which equivalency is being tested (i.e. either a "one-tail test" in which equivalency is tested either above or below a claimed range, or a "two-tail test" in which equivalency is tested in *both* directions, above and below). Tables of t values are available depending on the number of data points, level of significance, and one- or two-tail tests. *See, e.g.,* PORKESS, *supra* note 164, at 248 (Table 2). One notices that $\mathbf{t_{critical\text{-}95\%}}$ tapers off at about 1.68 and 2.02 for one and two direction equivalency, respectively, when total number of data points of **R** and **R*** exceed 40. Therefore, the criteria for determining equivalency at the 95% confidence level are

> (5) If the absolute value of $\mathbf{t_{actual}}$ is less than the absolute value of $\mathbf{t_{critical\text{-}95\%}}$, then one can statistically conclude with 95% confidence that the accused product or process produces substantially the same *result* as that of the claimed product or process.

To check whether the accused product or process performs substantially the same function, plot the values of **R** and **R*** as a function of **I**. If the slopes of the curves of **R** and **R*** are substantially the same in the range of **I** where the accused product or process is operated by the accused infringer (see Figures 5(a) and 5(c)), then the accused product or process performs substantially the same *function* as that of the claimed product or process.

2. Uses of the "t"-Test

One important consideration for the acceptance of the proposed "t"-test for determining equivalency under the doctrine of equivalents is whether the "t"-test is too esoteric or burdensome for patent holders, potential infringers, administrative agencies, and courts to understand and implement. In reality, it is just the opposite. Statistics textbooks provide formulae for calculating "t" values; there are now scientific calculators, software programs, and numerous Internet sites where one can enter the values of **R** and **R*** as "Data For Group *A*" and "Data For Group *B*" and then click "Calculate Now" to automatically obtain the "t" value at 95% confidence.[169] Industry, academia, and the Federal government already use the "t"-test for comparing two independent groups of samples. A survey of the Federal Register reveals that various agencies, including the Environmental Protection Agency (EPA), Food and Drug Administration (FDA), Department of Transportation, and Department of Energy mention the "t"-test as a statistical method for determining statistical differences between data from two groups. An EPA Guideline suggests the use of the "t"-test for comparing effluent discharges on a year-to-year basis and determining whether the water and air from two sources are substantially the same.[170] The EPA specifically used the "t"-test to assess the prob-

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equivalency if $t < 1.68$ for one directional equivalency and equivalency if $t < 2.02$ for two directional equivalency.

169. *See, e.g.*, Tom Kirkman, *Data Entry: Student's* t-*test, at* http://www.physics.csbsju.edu/stats/t-test_bulk_form.html (last visited Mar. 1, 2003).

170. Coal Mining Point Source Category; Amendments to Effluent Limitations Guidelines and New Source Performance Standards, 67 Fed. Reg. 3,370 (January 23, 2002) (codified in 40 C.F.R. pts. 9 and 434), which states:

> EPA considers an adequate number of samples to be that number that would allow an appropriate statistical procedure to detect an increase of one standard deviation in the mean or median loading between a

ability that two groups of data were statistically similar within a probability of 0.75 or more.[171] The FDA used the "t"-test to check "[w]hether all users of phenylpropanolamine . . . had an increased risk of hemorrhagic stroke."[172]

3. Courts, Statistics, and the "t"-test

"Equivalence, in the patent law, is *not the prisoner of a formula* and is not an absolute to be considered in vacuum."[173] Literally accepting this guidance of the Court in *Graver Tank* may tempt one not to consider any formula–based determination of equivalency. *Graver Tank* does not state that a formula should not be used for the determination of equivalency; *Graver Tank* in fact takes a scientific, formulaic approach in the determination of equivalence by proposing the "function/way/result."[174] Thus *Graver Tank* does not foreclose the use of scientific methods, such as the "t"-test to aid the determination of equivalence under the doctrine of equivalents.

The Court in *Warner-Jenkinson*[175] noted that "the doctrine of equivalents, as it has come to be applied after *Graver Tank*, has taken on a life of its own, unbounded by the patent claims."[176] To restrain the application of the doctrine of equivalents, the courts applied three legal tenets: the All Elements Rule,[177] prosecution history estoppel,[178]

> baseline year and a monitoring year with a probability (power) of at least 0.75.
>
> The power analysis used in the proposed statistical procedures was based on a two-sample t-test. The t-test can be an appropriate statistical procedure for a yearly comparison . . . .

171. *See id*.

172. Phenylpropanolamine; Proposal to Withdraw Approval of New Drug Applications and Abbreviated New Drug Applications; Opportunity for a Hearing, 66 Fed. Reg. 42,665 (August 14, 2001), which states:

> Statistical comparisons were made using . . . the Student t-test for continuous variables. For the analyses of the primary endpoints, conditional logistic models for matched sets (with a variable number of controls per case) were used to estimate odds ratios, lower limits of the one-sided 95 percent confidence intervals, and p-values for the risk factors under investigation . . . .

The statistical study showed that that the risk of hemorrhagic stroke is substantially different between user and nonusers. *Id.*

173. Graver Tank & Mfg. Co. v. Linde Air Prods. Co., 339 U.S. 605, 609 (1950) (emphasis added).

174. *Id*. at 609. "[O]n the evidence . . . the Lincolnweld flux and the composition of the patent in suit are *substantially identical in operation and in result*." *Id*. at 611 (emphasis added).

175. Warner-Jenkinson Co. v. Hilton Davis Chem. Co., 520 U.S. 17 (1997).

176. *Warner-Jenkinson*, 520 U.S. at 28–29.

177. *See generally Pennwalt*, 833 F.2d at 934–35.

178. Southwall Techs., Inc. v. Cardinal IG Co., 54 F.3d 1570, 1576 (Fed. Cir. 1995) ("[T]he prosecution history limits the interpretation of claim terms so as to exclude any interpretation that was disclaimed during prosecution.").

and prior art.[179] In 1950, when the Supreme Court decided *Graver Tank*, possibly no statistical test for comparing similarity between two groups had been widely accepted. There is no indication in *Graver Tank* that the Supreme Court recognized the existence of the "t"-test or any other statistical test for mathematically analyzing any of the three prongs of the tripartite test and determining equivalency. This Article proposes the "t"-test as an analytical framework for analyzing the "function" and "result" prongs of the tripartite test, in accordance with *Graver Tank*'s determination of "substantially identical . . . operation and . . . result."[180] Thus, the proposed modified tripartite test for determining equivalents under the doctrine of equivalence may be viewed as a departure from the current implementation of the doctrine. The proposed test for equivalency will protect inventors from copyists trying to avoid the literal terms of a patent claim.

The judges at the Federal Circuit might be reluctant to endorse the proposed "t"-test because it is a statistical test. The Eighth Circuit however has already recognized the "t"-test as a measure to support a hypothesis of statistical similarity between two groups.[181] A problem with the acceptance of the test is overcoming a mathematics phobia in the United States; the primary question of a patent litigator reading the proposed test will be, "How will a jury understand and trust the conclusions based on the 't'-test?" Expert advice will be critical to assisting the jury. There are three possible sources of expert advice: 1) experts retained by the patentee and defendant; 2) independent experts who would serve a role similar to arbitrators in an arbitration; 3) experts hired by a government agency, e.g., the PTO, similar to the practices of the FDA, EPA, and other federal agencies.

C. Equivalency, Prosecution History, and Prior Art

1. Prosecution History Estoppel Should be Limited to Patentee's Explicit Representations

For many inventions, the "t"-test could determine how far the literal scope of a claim could be extended such that the result produced by an accused product or process is substantially the same as that of a claimed product or process. For example, consider the allowed claims from Figure 2, which were represented by a square enclosed by line 2. The "t"-test allows us to define a new claim, the scope of which ex-

179. *Wilson Sporting Goods*, 904 F.2d at 684.

180. *Graver Tank*, 339 U.S. at 611.

181. *See* South Dakota Public Utils. Comm'n. v. Federal Energy Regulatory Comm'n., 643 F.2d 504, 513, n.13 (8th Cir. 1981). ("The 't'-test produces a significance level which measures the validity of using the relationships between variables to support a hypothesis.").

tends beyond the literal scope of the allowed claim, but that represents the boundary up to which the result produced by the accused product or process is equivalent with that of the claimed product or process; it may be thought of as the boundary up to which the doctrine of equivalents expands the right to exclude equivalents. Figure 2 is now revised to include this boundary, shown as line 6 in Figure 6.

Figure 6: Case 2 Modified to show the boundary of equivalents of the claim as defined by the "t"-test

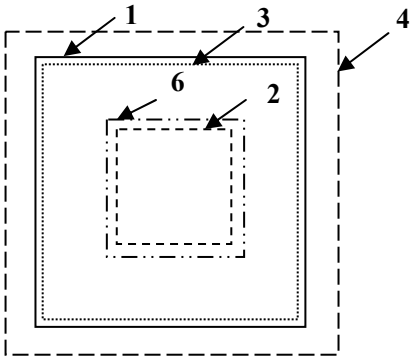

Figure 6 will be used to consider the relationship between prosecution history and equivalency. Recall Figure 2 demonstrates a case in which a patentee initially files a broad claim (line 4), but subsequently, to overcome prior art rejections, narrows the claim to the allowed claim (line 2). Under the Supreme Court decision in *Festo*, the "patentee's decision to narrow his claims through amendment may be presumed to be a general disclaimer of the territory between the original claim and the amended claim."[182] The Supreme Court applied this standard because of the "excessive uncertainty"[183] under the current application of the doctrine without an analytical test for equivalents to decide how far the rights to exclude equivalents of what is claimed should extend beyond the literal scope of the allowed claim (represented by line 2) in Figure 2.

Figure 6 demonstrates that by applying an objective standard for equivalency, one determines the boundary (shown by line 6) up to which the right to exclude equivalents of claims is available to the patentee. Thus it does not matter how much "territory between the original claim and the amended claim"[184] was given up. What matters for the purposes of the doctrine of equivalents is how much territory outside the allowed claim can be reclaimed to exclude equivalents.

The Court in *Graver Tank* stated that one factor in determining equivalency is "the particular circumstances of the case."[185] The "particular circumstances of the case" in *Graver Tank* does not take into account prosecution history because the outcome is based on scientific results comparing the claimed and accused products, not on prosecution history to support the claim interpretation. Under the objective test for equivalency, prosecution history should play the role of public

182. *Festo*, 122 S. Ct. at 1842.
183. *Id*. at 1840.
184. *Id*. at 1834.
185. *Graver Tank*, 339 U.S. at 611.

notice. If the patentee explicitly represents during prosecution that a certain "territory" is outside the scope of the claim, then the patentee should be held to his words and the public has a right to rely on what the patentee said during prosecution.

2. The Effect of Prior Art on the Doctrine of Equivalents

In the *Wilson Sporting Goods*[186] hypothetical claim analysis, a hypothetical claim is drafted based on broadening the literal language of the actual claim just enough such that the hypothetical claim would be literally infringed by the accused activity.

> [A] patentee should not be able to obtain, under the doctrine of equivalents, coverage which he could not lawfully have obtained from the PTO by literal claims. The doctrine of equivalents exists to prevent a fraud on a patent . . . , not to give the patentee something he could not lawfully have obtained from the PTO had he tried. Thus, since prior art always limits what an inventor could have claimed, it limits the range of permissible equivalents of a claim.[187]

Thus, if the patentee cannot prove that the hypothetical claim is patentable over the prior art, then the patentee could not claim that the accused product or process infringed under the doctrine of equivalents.

186. Wilson Sporting Goods Co. v. David Geoffrey & Assocs., 904 F.2d 677 Fed. Cir. 1990), *cert. denied*, 498 U.S. 992 (1990).

187. *Id.* at 684 (citation omitted).

Figure 7. Graphical Representation of the *Wilson Sporting Goods* hypothetical claim analysis

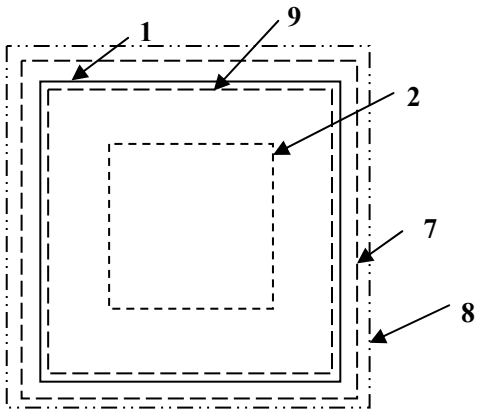

Figure 7 shows the relationship between the prior art (the space outside the square formed by continuous black line 1), the claimed invention (the space within the square formed by line 2), the maximum *possible* right to exclude equivalents of what is claimed without touching the prior art boundary (the space inside the square formed by line 9), the accused product or process (the space within the square formed by line 7) and the hypothetical claim literally covering the accused product or process (the space within the square formed by line 8). Under the *Wilson Sporting Goods* hypothetical claim analysis, "[t]he pertinent question then becomes whether that hypothetical claim could have been allowed by the PTO over the prior art."[188] This determination can by made by courts applying well-established tests for novelty and non-obviousness.[189] In Figure 7, the hypothetical claim, shown as the area enclosed by line 8, could not have been allowed by the PTO because it overlaps the prior art (space enclosed by line 1).

3. Doctrine of Equivalents Should be Free of the per se Rule of *Johnson & Johnston*

By applying an objective test for equivalency, there is no reason for maintaining a different scope of protection under the doctrine of equivalents depending on whether or not the equivalent is disclosed in the specification (see Cases 1 and 3).[190] Contrary to the decision in *Johnson & Johnston*, a patentee should be encouraged to disclose as

188. *Id.*
189. *See* 35 U.S.C. § § 102 and 103 (1996).
190. *See Festo*, 122 S. Ct. at 1834.

many known equivalents as possible so that the potential infringer would be on notice of known equivalents and could test them to avoid infringement. The fact that an equivalent is not disclosed in the specification would not provide notice to a potential infringer because it would be an unknown equivalent.

Another question that needs to be addressed is whether the proposed modified tripartite test for equivalency will address the problem of narrowly claiming an invention (as discussed *supra*, section III.A). The answer to this question is that unless Congress decides to "legislate the doctrine of equivalents out of existence,"[191] the uncertainty associated with the doctrine, particularly by narrowly claiming an invention, cannot be completely eliminated. The uncertainty can however be minimized by the adoption of the modified tripartite test for determining equivalency, combined with the "t"-test for analyzing the function and result prongs of the tripartite test. In addition, prosecution history estoppel as a restriction on the doctrine of equivalents should not be eliminated.[192] These changes could be judicially developed, as the doctrine was initially created, or legislatively adopted. The combined effect of these changes will greatly minimize any incentive for narrowly claiming an invention and the uncertainties regarding what is the broadened scope of a claim under the doctrine of equivalents.

Under the scheme proposed in this Article, there are however several disadvantages to narrowly claiming an invention. First, the literal scope of the claim will be narrow. Second, there will be fewer equivalents of the narrow claim, than for example of a broad claim that encompasses the narrow claim.[193] Thus the practice of initially drafting broad claims and then narrowing them during prosecution will continue by adopting the scheme proposed in this Article.

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191. *Id*. at 1838. (citing *Warner-Jenkinson*, 520 U.S. at 28).

192. *But see* John R. Thomas, *On Preparatory Texts and Proprietary Technologies: The Place of Prosecution History in Patent Claim Interpretation*, 47 UCLA L. REV. 183 (1999). The idea of eliminating prosecution history estoppel as a restriction on the doctrine of equivalents has been proposed by Professor Thomas. Thomas argues that notice is a poor justification for use of the prosecution history in patent claim interpretation because patents applications are held in secret by the PTO, and patentees not infrequently launch infringement actions on the day a patent issues. He also argues that an essential element of the traditional estoppel doctrine is reliance stating that at a minimum, the courts should determine whether the accused infringer actually relied upon the prosecution history in its technical decision-making, rather than turning to the file wrapper only after the patentee filed its infringement suit. Finally, Thomas contends that under the *Wilson Sporting Goods* line of cases, courts already possess techniques for accounting for the prior art in claim interpretation. Though I agree with Thomas that the use of prosecution histories serve as an inferior proxy for this established, objective method for restraining scope of equivalency, prosecution history still has a role to play in the determining equivalents. *See supra*, Sections III.B and IV.C.1.

193. An equivalent of a narrow claim will always be within the literal scope of a broad claim or an equivalent of the broad claim. Under the proposed model for equivalency, no equivalents are lost due to narrowing of the claim.

V. CONCLUSION

Professor Donald S. Chisum wrote the following in *Principles of Patent Law*:

> As 150 years of judicial experience with the doctrine of equivalents has failed to evolve an acceptable, precise "linguistic framework," one might be skeptical whether satisfactory general standards or rules exist, and whether it may be a waste of intellectual energy to search for and refine an analytic test of equivalency, just as some commentators suggest it has been for the related "obviousness" standard of patentability.[194]

In accepting the challenge to define a precise framework, one must address, to the extent possible analytically, the concern of Judge Plager:

> [T]he indeterminacy inherent in the doctrine [of equivalents] remains, because it leaves unchanged the indeterminacy of "insubstantial differences" in cases in which the limitation at issue has not been amended. Thus, it creates a disincentive for the present system of negotiation between applicant and PTO examiner in arriving at agreed upon claim language, with probably some as of yet unforeseen consequences.
>
> The challenge remains: how to effectively cabin the use of the doctrine of equivalents, now raised in practically every infringement suit, so as to reduce the degree of indeterminacy throughout the system, while still protecting patentees from fakery by those

194. DONALD S. CHISUM ET AL., *supra* note 11 at 900–01 (2d. ed. 2001) (citation omitted). Some law review articles have suggested that non-obviousness should be the test for applying the doctrine of equivalents. *See, e.g.*, Qing Lin, *A Proposed Test for Applying the Doctrine of Equivalents to Biotechnology Inventions: The Nonobviousness Test*, 74 WASH. L. REV. 885 (1999); Scott P. Zimmerman, *The Doctrine of Equivalents: A Call for Congressional Reinvigoration*, 40 IDEA 599 (2000). However, because no analytic test for non-obviousness has been developed, it is difficult to imagine how non-obviousness could provide an analytic framework for determining equivalency.

> who prefer to steal another's invention rather than invest in their own research and development.[195]

Applying scientific principles, particularly set theory, an element in a claim was defined as a variable having a degree of freedom, and a mathematical representation of a claim was provided in terms of the elements. A mathematical model for the tripartite function/way/result test was developed for the determination of equivalency under the doctrine of equivalents. This proposed tripartite test performs an element-by-element analysis of whether the accused product or process infringes elements from pre-existing technology. Determination of whether the result of an accused product or process is substantially the same as a claimed product or process should be done with the "t"-test, which has found numerous scientific and legal applications. Whether the accused product or process and the claimed invention perform the same function may be analyzed by mathematically comparing how each relates inputs and outputs in the context of the input-output model. This proposed analytical framework should reduce the level of indeterminacy under at least the function and result prongs of the tripartite test for determination of equivalency under the doctrine of equivalents.

The determination of whether an accused and claimed product or process operate in the same way remains a question of fact that would be decided by the jury. If however, the accused product or process contains an element that is the product of after-arising technology, then the modified tripartite test, focusing only on function and result — and eliminating analysis of way — should be applied instead of the conventional tripartite test. This represents the foundation for a change in the definition of equivalency under the doctrine of equivalents, particularly for an accused product or process having an element that is the product of an after-arising technology.

"In law, as in science, the most profound of theories is usually the simplest. Simplification requires, demands, the deepest and truest understanding of basic principles; complexity reflects, more often than not, an insufficiency of understanding."[196] This Article provides a simple, workable scientific methodology for defendants in an infringement suit when infringement is alleged under the doctrine of equivalents. The proposed methodology is applicable to prove that an accused product or process does not produce substantially the same result and does not perform substantially the same function as that of a claimed invention.

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195. Plager, *supra* note 132, at 73–74.

196. Pauline Newman, *The Federal Circuit: Judicial Stability or Judicial Activism?*, 42 AM. U. L. REV. 683, 688 (1993).