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**Invention, Refinement and Patent Claim Scope:
A New Perspective on the Doctrine of Equivalents**

Michael J. Meurer

Craig Allen Nard

April 2004

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EXCHANGE: THE DOCTRINE OF EQUIVALENTS

Invention, Refinement and Patent Claim Scope: A New Perspective on the Doctrine of Equivalents

MICHAEL J. MEURER* AND CRAIG ALLEN NARD**

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* Professor of Law, Michaels Faculty Scholar, and Director, Institute for Business, Law and Technology, Boston University School of Law; meurer@bu.edu. © 2005, Michael J. Meurer and Craig Allen Nard. We thank Bob Bone, John Duffy, Mark Lemley, Doug Lichtman, Clarisa Long, and seminar participants at Boston University, Case Western Reserve University, University of Pittsburgh, Washington University, the 2003 Canadian Law & Economics Association meeting and the Intellectual Property Conference at Tulane University for their helpful comments. We also thank Matt Shiels, Phil Ducker, and Pete Cuomo for able research assistance.

** Tom J.E. and Bette Lou Walker Professor of Law, and Director, Center for Law, Technology & the Arts, Case School of Law, Case Western Reserve University; craig.nard@case.edu.

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INTRODUCTION

Perhaps no doctrine in patent law is as controversial¹ as the Doctrine of Equivalents (DOE),² a common law creation that allows a court to expand patent scope beyond the rights literally claimed in the patent.³ Despite nearly

1. *See, e.g.*, *Johnson & Johnston Assocs. v. R.E. Serv. Co.*, 285 F.3d 1046, 1056 (Fed. Cir. 2002) (en banc) (Rader, J., concurring) (“Few problems have vexed this court more than articulating discernible standards for non-textual infringement.”); *Litton Sys., Inc. v. Honeywell, Inc.*, 145 F.3d 1472, 1472 (Fed. Cir. 1998) (Plager, J., dissenting from Order declining suggestion for rehearing in banc) (“There is perhaps no question more important to the health of patents than the scope and application of the judicially-created doctrine of equivalents.”); Hon. Paul R. Michel, *The Role and Responsibility of Patent Attorneys in Improving the Doctrine of Equivalents*, 40 IDEA 123, 123 (2000) (calling the doctrine of equivalents “the most difficult and least predictable of all doctrines in patent law to apply”).

2. Throughout this Article, we refer to the Doctrine of Equivalents as the “DOE” or simply the “doctrine.”

3. *See Tate Access Floors, Inc. v. Interface Architectural Res., Inc.*, 279 F.3d 1357, 1367 (Fed. Cir. 2002) (“The doctrine of equivalents expands the reach of claims *beyond* their literal language.”). The claims of a patent define the metes and bounds of the patent owner’s right to exclude; thus, technically, it is perhaps more accurate to state that the DOE expands the statutory right to exclude, not necessarily the claims themselves. *See Wilson Sporting Goods Co. v. David Geoffrey & Assocs.*, 904 F.2d 677, 684 (Fed. Cir. 1990); *see also* Giles S. Rich, *Forward* to DONALD S. CHISUM ET AL., *PRINCIPLES OF PATENT LAW* at vi (3d ed. 2004). The doctrine of equivalents interacts with patent claim language to establish the exclusionary rights granted by a patent. A patent owner enjoys the right to exclude others from

two hundred years of development,⁴ patent law lacks a coherent vision of a doctrine that holds great intuitive appeal.⁵ Debate about the proper contours of the DOE is formal and unsatisfying because the doctrine lacks a strong normative foundation. This Article supplies a rigorous justification for the DOE that explains when it should apply and why its application should be “the exception . . . not the rule.”⁶

The traditional justification explains that the DOE prevents “an unscrupulous copyist” from skirting patent claim language by making insignificant, yet non-infringing, changes in the technology.⁷ This *fairness theory* seems to be loosely based on a Lockean notion that an inventor should be justly rewarded for her labors.⁸ One version of the fairness theory treats the DOE as a cure for mistakes by the Patent Office that improperly limit patent scope.⁹ Another

making, using, and selling the invention that it claimed in the patent. *See* 35 U.S.C. § 271(a) (2000). Infringement of these rights is judged initially by asking whether the defendant’s activities fall literally within the scope of the patent claims. A defendant who does not literally infringe still may be liable for infringement under the DOE if its product or process is equivalent to the product or process claimed by the patent owner. Thus, the doctrine serves strictly to expand the rights of the patent owner.

4. *See infra* Part I.A and accompanying notes.

5. The most recent example of the emotional force of the DOE is reflected in the seven filed opinions in *Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co.*, 234 F.3d 558 (Fed. Cir. 2000) (en banc), vacated by 535 U.S. 722 (2002); *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, 681 (1989) (describing wide swings in Federal Circuit treatment of the doctrine of equivalents during the first decade of the court’s existence). The competing policies between the clear claim requirements of 35 U.S.C. § 112 (2000) and the DOE are extensively set forth in the additional opinions of *Pennwalt Corp. v. Durand-Wayland, Inc.*, 833 F.2d 931, 940–75 (Fed. Cir. 1987). The patent bar strenuously opposed the restriction on the DOE imposed by the Federal Circuit in *Festo*. Patent attorneys felt the court disrupted settled expectations linked to a generous doctrine of equivalents and modest role for prosecution history estoppel. The absolute bar chosen by the Federal Circuit forced changes in patent prosecution practice that disrupted established practices of the patent bar. More cynically, both patent prosecutors and patent litigators profit from a vigorous doctrine of equivalents. Broad patent scope obtained through the doctrine of equivalents raises the expected value of patents and hence demand for patent prosecution. Uncertainty created by the doctrine increases the probability of patent disputes and the demand for the services of patent litigators.

6. *London v. Carson Pirie Scott & Co.*, 946 F.2d 1534, 1538 (Fed. Cir. 1991).

7. *See, e.g.*, *Laitram Corp. v. Cambridge Wire Cloth Co.*, 863 F.2d 855, 857 (Fed. Cir. 1988) (stating the “doctrine . . . ‘temper[s] unsparing logic and prevent[s] an infringer from stealing the benefits of an invention’”) (quoting *Graver Tank*); *Graver Tank & Mfg. Co. v. Linde Air Prods. Co.*, 339 U.S. 605, 608 (1950) (adopting Judge Hand’s “unsparing logic” language); *Royal Typewriter Co. v. Remington Rand, Inc.*, 168 F.2d 691, 692 (2d Cir. 1948) (Hand, J.) (noting that courts “resort to the ‘doctrine of equivalents’ to temper unsparing logic and prevent an infringer from stealing the benefit of the invention”).

8. *See, e.g.*, *Nelson v. Batson*, 322 F.2d 132, 135 (9th Cir. 1963) (noting “the degree of protection afforded beyond the language of the claims will vary directly with the value of the inventor’s contribution to the art”) (citing *Royal Typewriter*); R. Polk Wagner, *Reconsidering Estoppel: Patent Administration and the Failure of Festo*, 151 U. PA. L. REV. 159, 201 (2002) (noting but not endorsing the view that the doctrine of equivalents “is justified on the grounds that it better reflects the intellectual contribution of the inventor”); Scott P. Zimmerman, *Hughes Aircraft and the Warner-Jenkinson Presumption: The Certiorari That Should Have Been*, 40 IDEA 131, 133 (2000) (stating the “doctrine of equivalents evolved so that an inventor’s contribution to society is protected against insubstantial changes falling outside the literal terms of the patent claim”).

9. *See infra* Part I.C.1 and accompanying notes.

version treats the DOE as a way to reverse the unjust enrichment of a competitor who profits from the patent and does little or nothing to advance the technology.¹⁰

Recent decisions have moved away from a deontological fairness theory because it is inconsistent with the Supreme Court's insistence that patent law has a utilitarian foundation.¹¹ Unfortunately, the courts have not replaced the fairness theory with a new normative account that explains when and how the DOE contributes to social welfare. What began as an equitable doctrine designed to correct unjust copying now has an expanded but ill-defined role in the patent system. To the extent that a modern justification for the doctrine can be inferred, it apparently starts with the belief that the patent system generally works to give inventors patent claims with the proper breadth, but sometimes frictions in the system cause patent claims to be too narrow.¹² The proper role of the DOE is to overcome these frictions and restore the proper breadth. We label this justification the *friction theory*.

The friction theory offers various explanations of why an inventor fails to obtain the full breadth of rights she was entitled to during the patent application process (known as patent prosecution). The most common explanation asserts that the "inherent limitations of language" prevent patent prosecutors from fully

10. This version is consistent with *Graver Tank* and its progeny. See, e.g., *Applied Materials, Inc. v. Advanced Semiconductors Materials Am., Inc.*, 98 F.3d 1563, 1574 (Fed. Cir. 1996) (stating that the DOE prevents competitors from 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, and hence outside the reach of law") (citing *Graver Tank*).

11. See *Warner-Jenkinson Co. v. Hilton Davis Chem. Co.*, 520 U.S. 17, 34–35 (1995) (implying that the DOE was utilitarian, and rejecting the notion that the doctrine was purely equitable). The preamble to the intellectual property clause, Article I, Section 8, Clause 8 of the Constitution, "To promote the progress of the . . . useful Arts," is expressed in utilitarian terms and has been interpreted as such during the twentieth century. See Yochai Benkler, *Siren Songs and Amish Children: Autonomy, Information, and Law*, 76 N.Y.U. L. REV. 23, 59 (2001) (noting that "the basic ideological commitment of American intellectual property is actually heavily utilitarian, not Lockean or Hegelian"); Linda R. Cohen & Roger G. Noll, *Intellectual Property, Antitrust and the New Economy*, 62 U. PITT. L. REV. 453, 453–61 (2001) (asserting that "the conceptual model underlying American intellectual property law is utilitarian: rights are granted for social objectives (advancing knowledge and producing useful products)"). Nevertheless, the fairness rationale holds continuing appeal. See, e.g., *K-2 Corp. v. Salomon S.A.*, 191 F.3d 1356, 1368 (Fed. Cir. 1999) (stating that "the doctrine of equivalents operates to 'prevent an infringer from stealing the benefit of an invention'"); *Multiform Desiccants, Inc. v. Medzam, Ltd.*, 133 F.3d 1473, 1480 (Fed. Cir. 1998) (stressing the need to balance "fairness to inventors lest the patent be unjustly circumvented, against the purpose of patent claims to state clear boundaries of the patent grant"). For a discussion of the dominant fairness orientation of the courts in the nineteenth century, see *infra* Part I.A and accompanying notes.

12. The patent code reflects the underlying assumption that applicants receive proper claim scope from the PTO (or claim scope to which the applicants were entitled), but "who had for some reason failed to claim complete protection for their discoveries." *Graver Tank & Mfg. Co. v. Linde Air Prods. Co.*, 339 U.S. 605, 614 (1950) (Black, J., dissenting). This assumption is found in the reissue provisions of the patent code, which allow patentees to broaden claim scope due to *their* good faith error, not the PTO's error. See 35 U.S.C. § 251 (2000); see also Wagner, *supra* note 8, at 163, 201 (explaining that commentators treat policy toward the DOE as a question of optimal patent scope).

claiming an invention.¹³ Other explanations point to mistakes by the patent prosecutor,¹⁴ and future developments in complementary technology that are not foreseen at the time of patent prosecution.¹⁵

The friction theory suffers from three main weaknesses. First, the theory is implausible on empirical grounds. The frictions that supposedly block proper claim breadth are missing from the leading cases. Second, there is not a convincing answer to the question of why the doctrine of equivalents, rather than some other doctrinal approach, should be used to overcome the frictions. The frictions can be overcome, or at least mitigated, for example, by astutely amending claims during prosecution; a more aggressive use of continuation practice, and request for continuing examination; through a reissue proceeding after the patent issues;¹⁶ or through artful claim drafting as an initial matter.¹⁷ Third, proponents of a far-reaching DOE fail to pay adequate attention to the notice function of patent claims and are insufficiently sensitive to patent law's delicate incentive dynamic.¹⁸

We develop a better explanation of why claim breadth falls short of the maximum breadth allowed by patent law. Our explanation replaces the passive prosecutor depicted in the friction theory with active inventors and prosecutors who are capable of responding effectively to the frictions identified above.¹⁹ Patent law allows an inventor to claim the embodiments of the invention she actually achieved before application, *and* any other embodiments she enables through the disclosure provided in the patent. The enablement standard requires that a person having ordinary skill in the art be able to make and use the embodiments claimed in the patent without undue experimentation.²⁰ Some inventors do not claim everything they have enabled because they do not know or cannot (or did not) articulate everything they have enabled. Whether an inventor obtains the broadest permissible claim breadth depends mostly on the talent and effort of the inventor and prosecutor in identifying what has been

13. See *infra* Part I.C.2 and accompanying notes.

14. See *infra* Part I.C.1 and accompanying notes.

15. See *infra* Part I.C.3 and accompanying notes.

16. See 35 U.S.C. § 251 (2000); see also *infra* Part IV.A.

17. See *infra* Part II.A (discussing drafting techniques).

18. We believe the second and third problems can be addressed and a plausible friction theory can be developed, but limits to language and other frictions are usually not a significant impediment to effective claim drafting, and the friction theory should have only a secondary role in developing patent policy toward the doctrine of equivalents.

19. Wagner argues that patent law should pay attention to the incentives it creates for patent prosecutors. His analysis differs from ours because it focuses mostly on the prosecution history estoppel doctrine, and on the incentive of inventors to disclose information (an adverse selection problem in the jargon of economics). See generally Wagner, *supra* note 8; see also F. Scott Kieff, *The Case for Registering Patents and the Law and Economics of Present Patent-Obtaining Rules*, 45 B.C. L. REV. 55, 109–10 (2003) (noting the negative effect of the DOE on the incentive to draft high quality patent claims). Our broader study of the DOE focuses mostly on the incentive of inventors to gather information through refinement (a moral hazard problem in the jargon of economics).

20. See *AK Steel Corp. v. Sollac*, 344 F.3d 1234, 1244 (Fed. Cir. 2003).

enabled.²¹ The frictions facing inventors and prosecutors are no more vexing than similar problems facing attorneys who deal with other complex legal problems. A good patent agent or attorney predicts the embodiments that could be chosen by infringers and finds appropriate language to draft a suitably broad claim. This task is quite familiar to transactional lawyers—identifying relevant contingencies.

We believe that inventors fail to obtain the full claim breadth to which they are entitled because they fail to refine their claims sufficiently during patent prosecution.²² We define refinement as the process of identifying and claiming the broadest patentable set of embodiments enabled by the disclosure in the patent specification. Managers and researchers from the inventor's firm often join the inventor and the patent prosecutor in the refinement process. They work together to visualize strategies that third parties might use to imitate the invention.²³ Refinement efforts work to uncover alternative versions of the inventor's original embodiment, alternatives made possible by substituting equivalent elements for a structure in a product invention or a step in a process invention. The patent prosecutor then revises the claims to include these newly identified embodiments.²⁴ A profit-maximizing patent applicant stops refinement when the marginal costs of refinement (from legal fees and the implicit

21. This message was strongly implied in recent Federal Circuit and Supreme Court DOE and prosecution history estoppel decisions. Cases such as *Festo*, *Warner-Jenkinson*, and *Johnson & Johnston* reveal a policy of devolution of responsibility from the courts and PTO to the inventor and her attorney.

22. We use the term "prosecution" to include the filing of continuation and continuation-in-part ("CIP") applications. See 35 U.S.C. § 120 (2000); 37 C.F.R. § 1.53 (2005); PATENT & TRADEMARK OFFICE, U.S. DEP'T OF COMMERCE, MANUAL OF PATENT EXAMINING PROCEDURE §§ 201.07 & 201.08 (8th ed. 2001, rev. 2005). Continuation and CIP applications are commonly employed to claim further refinements and improvements discovered after the original filing date. An important distinction between a continuation and a CIP is that the latter allows an applicant to add broadening new matter. In addition to filing a continuation or CIP application, refinement may continue beyond prosecution and include the first two post-issuance years when it is possible to broaden the language in a patent claim through reissue. See 35 U.S.C. § 251 (2000).

23. We use the term *imitation* as the act of taking the teaching of the patent (or the portion not protected by patent law) to develop technology outside the literal scope of the patent claims, which, in our model, is embodiment *F*. See *infra* Part III.A. Commentators and courts often use the phrase "inventing around" the same way we use imitation. Imitation differs from refinement because the third party only needs to find *one* non-infringing embodiment, but he must also develop the embodiment so it can actually be used. A patent applicant does not have to develop embodiments in order to claim them; she only needs to enable the embodiments. Thus, refinement may be more costly than imitation because of the effort required to enumerate a long list of embodiments. On the other hand, imitation may be more costly because of development costs. See *id.*

24. At the same time, applicants revise claims to exclude prior art that gets identified during prosecution. Under the new matter doctrine, revisions to the written description that occur after an application is filed may jeopardize the priority date derived from that application. Thus, prosecutors should strive to finish revision of the written description before filing. See *Smithkline Beecham Corp. v. Excel Pharm., Inc.*, 356 F.3d 1357, 1364 (Fed. Cir. 2004) ("The new matter doctrine prevents an applicant from adding new subject matter to the claims unless the specification shows that the inventor had support for the addition at the time of the original filing."). The purpose of the new matter doctrine is to assure that the applicant was in possession of the claimed invention at the time of filing. The written description requirement under 35 U.S.C. § 112, ¶ 1 also serves this function. Importantly, an

cost of the effort of the inventor and others) equals the marginal benefit (from stronger patent claims).²⁵

Our theory, which we label the *refinement theory*, offers a compelling description of patent claiming and a social-welfare justification of the DOE.²⁶ According to the refinement theory, the DOE creates a social benefit by allowing patent applicants to avoid certain refinement costs during patent prosecution. The theory also reveals the limits that should be imposed on the doctrine. A socially optimal patent policy should balance refinement cost savings and innovation incentives created by the DOE against the harm to competition and rent-seeking costs created by the doctrine.²⁷

This Article contains four parts. In Part I, we trace the history of the DOE, highlighting its early reliance on fairness justifications and the transition to utilitarian justifications consistent with the friction theory. In Part II, we explain that while the friction theory adequately explains the rationale in recent DOE cases, it fails to provide a satisfactory justification for many of the leading DOE cases, such as *Graver Tank* and *Warner-Jenkinson*. We also recount the frustration felt by the Federal Circuit as it took ad hoc measures to constrain a bloated DOE. Although the court has failed to articulate a persuasive justification for the DOE, it has identified three reasons to limit application of the doctrine. First, the DOE displaces the judgment of the Patent Office and the Federal Circuit, and substitutes the judgment of the fact finder at trial regarding the breadth of patent rights.²⁸ Second, the uncertainty about patent rights created by the

applicant faced with a new matter or written description rejection may respond by filing a CIP application.

25. There may also be costs relating to traditional research and development because the refinement efforts of the inventor, patent attorney, and management may well lead to additional development activity. Thus, refinement and development are distinct but connected. As discussed in note 122, *supra*, continuation and continuation-in-part applications are commonly used to claim additional embodiments resulting from refinement and development.

26. Some Federal Circuit case law suggests our approach. See *Johnson & Johnston Assocs. v. R.E. Serv. Co.*, 285 F.3d 1046, 1057 (Fed. Cir. 2002) (en banc) (Rader, J., concurring) (“[T]he patentee has an obligation to draft claims that capture all reasonably foreseeable ways to practice the invention. The doctrine of equivalents would not rescue a claim drafter who does not provide such notice.”); *Sage Prods., Inc. v. Devon Indus., Inc.*, 126 F.3d 1420, 1425 (Fed. Cir. 1997) (“[A]s 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.”). And the Supreme Court’s recent *Festo* decision is consistent with this line of reasoning. See *Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co.*, 535 U.S. 722 (2002).

27. The doctrine can also be justified on process grounds. Arguably, courts should be allowed to expand claim scope at trial because the passage of time and the adversarial nature of the proceeding gives them better information than the earlier ex parte proceeding at the PTO. See Douglas Lichtman, *Rethinking Prosecution History Estoppel*, 71 U. CHI. L. REV. 151, 177–78 (2004); Kieff, *supra* note 19, at 72–73. Furthermore, a relatively small fraction of patents matter to competitors, see Mark Lemley, *Rational Ignorance at the Patent Office*, 95 NW. U. L. REV. 1495, 1500–08 (2001), thus perhaps it makes sense to delay careful consideration of patent scope until trial.

28. This point was made by Justice Campbell in his dissent in *Winans v. Denmead*, 56 U.S. (15 How.) 330 (1853) and by Justice Black in his dissent in *Graver Tank & Manufacturing Co. v. Linde Air Products Co.*, 339 U.S. 605 (1950). See *infra* Part I.B.

doctrine undermines the notice function of the patent.²⁹ Potential competitors have a difficult time competing aggressively by using technology that is adjacent to the technology controlled by the patent owner. And third, uncertainty promotes opportunistic and anticompetitive patent lawsuits.³⁰

Part III presents the refinement theory within an economic model of invention and patent prosecution. The model contains a single potential inventor/patentee and a single potential competitor. The inventor moves first and decides whether to try to invent *E*, a set of embodiments of a patentable invention. If an invention occurs, the inventor can draft a patent that claims *E* or she can make a further investment to refine her understanding of the invention and draft a broader patent that claims *E* plus an additional set of embodiments *F*. The set *F* can only be obtained after *E*. If the inventor obtains *E* but not *F*, then the competitor has a chance to develop an embodiment in *F* and use the embodiment in competition with the inventor.

We incorporate a stylized version of the DOE in the model and compare equilibrium outcomes with and without the doctrine. Under the DOE, the inventor simply claims *E* and has the right to exclude the competitor from making and using any embodiment in *E* or *F*; thus, the doctrine allows the inventor to avoid literally claiming *F* and incurring the cost of refinement. In contrast, in the version of the model without the DOE, the inventor must pay refinement costs and literally claim *F* to get protection over the embodiments in *F*.

The model demonstrates the social costs and benefits of the DOE. When refinement costs are high, social value arises from the DOE because it provides an important incentive to inventors, and because it promotes efficient investment in refinement. When refinement costs are low, the DOE offers neither of these benefits, and thus should be curtailed to increase certainty and decrease rent-seeking. Although critics of the DOE contend that the doctrine unduly

29. See, e.g., *Superior Fireplace Co. v. Majestic Prods. Co.*, 270 F.3d 1358, 1371 (Fed. Cir. 2001) (emphasizing the importance of patent law's notice function); *SciMed Life Sys., Inc. v. Advanced Cardiovascular Sys., Inc.*, 242 F.3d 1337, 1347 (Fed. Cir. 2001) (stating that "the patentee cannot be allowed to recapture the excluded subject matter under the doctrine of equivalents without undermining the notice function of the patent"); see also *Warner-Jenkinson Co. v. Hilton Davis Chem. Co.*, 520 U.S. 17, 29 (1997) ("[T]he doctrine of equivalents, when applied broadly, conflicts with the definitional and public-notice functions of the statutory claiming requirement.").

30. As Judge William Bryson noted in *Litton Systems, Inc. v. Honeywell, Inc.*, 87 F.3d 1559, 1580 (Fed. Cir. 1996):

Patent counselors should be able to advise their clients, with some confidence, whether to proceed with a product or process of a particular kind. The consequences of advice that turns out to be incorrect can be devastating, and the costs of uncertainty—unjustified caution or the devotion of vast resources to the sterile enterprise of litigation—can be similarly destructive.

See also *Winans*, 56 U.S. at 347 (Campbell, J., dissenting) ("Nothing, in the administration of this law, will be more mischievous, more productive of oppressive and costly litigation, of exorbitant and unjust pretensions and vexatious demands, more injurious to labor, than a relaxation of [the clear claim requirements]."); Michael J. Meurer, *Controlling Opportunistic and Anticompetitive Intellectual Property Litigation*, 44 B.C. L. REV. 509 (2003).

inhibits competition, surprisingly, we show that often the degree of competition is unaffected by the presence or absence of the DOE. The inventor can block competition in the absence of the DOE by investing in refinement and drafting broad patent claims. We call this “preemptive” refinement because its sole purpose is to preempt competition. Preemption tends to be socially harmful because the inventor controls the embodiments in *E* and *F* under either regime; and society loses the value of the refinement costs paid by the inventor to deter competition in the regime without the DOE.³¹

We apply these results to policy issues in Part IV. We begin by embracing the reissue proceeding as an alternative to the DOE. Reissue, which allows patentees to broaden their claims within two years of issuance, is an under-utilized proceeding that has many of the advantages of the DOE with relatively few of its drawbacks. Thereafter, we explain when pioneer patents should get more generous protection under the DOE. We reject the standard explanation that reasons that claim drafting is harder for pioneer patents. We argue instead that the DOE provides a valuable boost to the incentive to invent a pioneering technology that offsets the combined costs of invention and refinement.

In addition, we reject the popular notion that the DOE is especially appropriate in the case of unforeseeable, later-developed technology because this justification focuses on the wrong question. The label “unforeseeable” confuses the analysis because, in fact, there are gradations of foreseeability; some later-developed technologies are more and some are less foreseeable. The question should not be whether the technology is foreseeable; rather the question should be how difficult is it to identify embodiments and write a claim that covers them? Under our refinement theory, the DOE is inappropriate when refinement costs are low vis-à-vis later-developed technology. It must seem counterintuitive to non-patent lawyers that refinement costs could be low, but often patent applicants can capture unforeseen embodiments through greater conceptual effort and the use of various claim drafting strategies.³² Application of the DOE to later-developed technology can be justified only as a means of discouraging excessive investment in refinement. In other words, the doctrine should be used to block socially wasteful expenditures when inventors find it profitable to exert considerable effort identifying and claiming later-developed embodiments simply to preempt entry by a competitor. Surprisingly, this rules out application of the DOE to startlingly new equivalents, because these types of equivalents are conceptually unattainable no matter the amount of time and money spent on refinement efforts. Patent applicants would not refine their claims to cover these equivalents, and inventors’ incentives are not much affected by a minute probability of loss of effective patent protection.

Finally, we analyze three doctrines that constrain the DOE: the all-elements

31. But preemption may be socially desirable when the embodiments in *F* are quite differentiated from the embodiments in *E*, and society values diversity highly. See *infra* Part III.A.

32. See *infra* Part II.B and accompanying notes.

rule, the public dedication doctrine, and prosecution history estoppel. The all-elements rule has the desirable effect of preserving the narrow scope of patents in fields crowded with prior art. Thus, this rule works to complement the rule favoring application of the DOE to pioneers. Similarly, a disclosure that trips the dedication doctrine reveals a low refinement cost. And we defend a rigorous prosecution history estoppel doctrine because amendments or arguments made during patent prosecution often show that the refinement cost is low to literally claim patent scope sought through the DOE.

I. THE DOCTRINE OF EQUIVALENTS: FROM FAIRNESS TO FRICTION

A. THE NORMATIVE BASIS OF PATENT LAW SHIFTS FROM FAIRNESS TO EFFICIENCY

Two related notions of fairness have dominated legal thought about patents for much of the history of American patent law. First, an inventor deserves a property right in her invention as a reward for her labor.³³ And second, competitors should not unjustly enrich themselves by using a patented invention without permission.³⁴ Nineteenth century judges, particularly during the first half of the century, construed patent law “benignly in favour of patentees,”³⁵ and viewed the inventor as having a natural property right in his invention.³⁶

33. A Lockean “just desert” theory holds considerable influence in intellectual property theory, particularly in Europe. *See, e.g.*, Justin Hughes, *The Philosophy of Intellectual Property*, 77 GEO. L.J. 287 (1988); Wendy J. Gordon, *A Property Right in Self-Expression: Equality and Individualism in the Natural Law of Intellectual Property*, 102 YALE L.J. 1533 (1993). Although the “just desert” rationale is reflected in antebellum patent cases, American patent law is firmly grounded in notions of utilitarianism. *See* Benkler, *supra* note 11, at 59 (noting that the “basic ideological commitment of American intellectual property is actually heavily utilitarian, not Lockean or Hegelian”).

34. Theories of corrective justice that focus on unjust enrichment also play an important role in intellectual property theory. *See, e.g.*, Wendy J. Gordon, *On Owning Information: Intellectual Property and the Restitutory Impulse*, 78 VA. L. REV. 149 (1992).

35. *Whitney v. Emmett*, 29 F. Cas. 1074, 1082–83 (C.C.E.D. Pa. 1831) (No. 17,585) (stating that “congress have declared the intention of the law to be to promote the progress of the useful arts by the benefits granted to inventors; not by those accruing to the public, after the patent had expired, as in England”); *see* B. ZORINA KHAN, *THE DEMOCRATIZATION OF INVENTION: PATENTS AND COPYRIGHTS IN AMERICAN ECONOMIC DEVELOPMENT, 1790–1920*, at 81 (2005) (stating “[n]umerous reported decisions before the early courts clearly and repeatedly declared that patent rights were ‘sacred’ and to be regarded as the just recompense to inventive ingenuity”); EDWARD C. WALTERSCHEID, *TO PROMOTE THE PROGRESS OF USEFUL ARTS: AMERICAN PATENT LAW AND ADMINISTRATION, 1798–1836*, at 244 (1998) (noting that William Thornton, the Superintendent of Patents from 1802 to 1828, “like many of his contemporaries . . . viewed the patent system not so much as being imbued [sic] with a public interest, but rather as a mechanism for rewarding legitimate inventors and protecting their rights”).

36. Catherine Fisk writes that, during the nineteenth century, the notion that an inventor had a property right in his idea “was so widely accepted as to seem a matter of natural right.” Catherine L. Fisk, *Removing the ‘Fuel of Interest’ from the ‘Fire of Genius’: Law and the Employee-Inventor, 1830–1930*, 65 U. CHI. L. REV. 1127, 1142 (1998). The natural rights justification was also used by courts as a basis for justifying patent term extensions, not only at the behest of inventors, but also his assignees or heirs. As the court in *Brooks v. Bicknell* stated:

The same reason that would give a renewal to the patentee, would be equally strong in behalf of his heirs. If the term of the original grant had not given an adequate remuneration for “the time, ingenuity, and expense” of the patentee; on every principle of public policy, in the event

Modern notions relating to the public domain and the social costs of patents were not well formulated, and thus did not moderate the goals of serving and rewarding inventors. For instance, Justice Story, the leading patent law jurist of the century, stated, “[t]he inventor has . . . a property in his inventions; a property which is often of very great value, and of which the law intended to give him the absolute enjoyment and possession.”³⁷ Accordingly, he expressed a reflexive hostility toward free-riders: “let the damages be estimated as high, as they can be, consistently with the rule of law on this subject, if the plaintiff’s patent has been violated; that wrong-doers may not reap the fruits of the labor and genius of other men.”³⁸

But by the mid-nineteenth century, there were signs of judicial recognition of the public costs associated with exclusive rights. As one court noted, these “sacred rights of genius and property . . . should be maintained in a manner not harsh towards other inventors, nor unaccommodating to the growing wants of the community.”³⁹ A good example of this cautionary turn is *O’Reilly v. Morse*,⁴⁰ an infringement action brought by Samuel Morse.

Morse sued to protect his right to his telegraph invention. There were eight claims in Morse’s patent; the first seven claimed various telegraphy processes. In the eighth claim, now famous in the annals of patent law, Morse stated that he did “not intend to limit” himself “to the specific machinery” set forth in the specification and the other seven claims. Rather, he sought protection for the “essence” of his invention, which was the use of “electro-magnetism, however developed, for making or printing intelligible characters or signs, at any distances”⁴¹

The Supreme Court invalidated claim eight as “too broad” because Morse sought “an exclusive right to use a manner and process which he has not described and indeed had not invented, and therefore could not describe when he obtained his patent.”⁴² The Court faulted Morse for not upholding his end of the bargain with the public, namely his duty to teach the public how to make

of his decease, there should be a renewal for the benefit of his heirs. That a man should be secured in the fruits of his ingenuity and labor, is a sound maxim of the common law.

4 F. Cas. 247, 251 (C.C.D. Ohio 1843) (No. 1944).

37. *Ex parte Wood*, 22 U.S. 603, 608 (1824).

38. *Lowell v. Lewis*, 15 F. Cas. 1018, 1019 (C.C.D. Mass. 1817) (No. 8568); *see also* *Blanchard v. Sprague*, 3 F. Cas. 648, 650 (C.C.D. Mass. 1839) (No. 1518) (Story, J.) (noting that “[p]atents . . . are clearly entitled to a liberal construction, since they are not granted as restrictions upon the rights of the community, but are granted ‘to promote science and useful arts’”).

39. *Woodworth v. Edwards*, 30 F. Cas. 567, 570–72 (C.C.D. Me. 1847) (No. 18,014). Morton Horwitz observed a shift in the perception of monopolies during this time, noting that “[t]hrough earlier grants of monopoly privileges may have been necessary in an underdeveloped society in order to promote private investment, the restrictive consequences of these grants were becoming apparent by the second quarter of the nineteenth century.” MORTON HORWITZ, *THE TRANSFORMATION OF AMERICAN LAW 1780–1860*, at 130 (1977).

40. 56 U.S. (15 How.) 62 (1854).

41. *Id.* at 86.

42. *Id.* at 113.

and use what he sought to claim in claim eight. And significantly, the Court stressed the costs of overly broad claims to future inventors and the public:

For aught that we now know some future inventor, in the onward march of science, may discover a mode of writing or printing at a distance by means of the electric or galvanic current, without using any part of the process or combination set forth in the plaintiff's specification. His invention may be less complicated—less liable to get out of order—less expensive in construction, and in its operation. But yet if it is covered by this patent the inventor could not use it, nor the public have the benefit of it without the permission of this patentee.⁴³

Another important Supreme Court mid-century case is *Hotchkiss v. Greenwood*,⁴⁴ or what has come to be known as the “doorknob case.” The invention in *Hotchkiss* related to an old method of making doorknobs whereby the doorknob had a certain shaped hole for the fastening of a shank. The only difference was that the inventor substituted a clay or porcelain knob for a metallic knob. Although the invention was new, the Court declined the patent, stating that:

The difference is formal, and destitute of ingenuity and invention . . . ; for unless more ingenuity and skill in applying the old method of fastening the shank and the knob were required in the application of it to the clay or porcelain knob than were possessed by an ordinary mechanic acquainted with the business, there was an absence of that degree of skill and ingenuity, which constitute essential elements of every invention.⁴⁵

The *Hotchkiss* case is widely regarded as creating an additional patentability hurdle, above and beyond novelty and utility, which required an inventor to display “more ingenuity and skill” than that possessed by the “ordinary mechanic.”

While *Morse* and *Hotchkiss* can be viewed as placing constraints on patent scope and raising the level of inventive contribution, the post-1836 judicial attitude toward patents remained quite positive,⁴⁶ and continued to emphasize

43. *Id.*

44. 52 U.S. (11 How.) 248 (1850).

45. *Id.* at 266.

46. Indeed, the *Morse* case must be kept in context. The main question before the Court was whether Morse was the “first and original inventor” of the telegraph and whether O'Reilly's use of the Zook-Barnes Columbian telegraph infringed Morse's patent. The Court, in a thirty-seven page opinion, found that Morse's inventive efforts antedated those of Davy, Steinheil, and Wheatstone and that the Zook-Barnes Columbian telegraph infringed Morse's patent because the former was substantially similar to Morse's claimed invention. Thus, while the invalidation of claim eight denied Morse a total victory, he not only won on infringement and was declared the first original inventor of the telegraph, but he subsequently secured a seven-year patent term extension for his patent. See KENNETH SILVERMAN, LIGHTNING MAN: THE ACCURSED LIFE OF SAMUEL F.B. MORSE 320–24 (2003).

notions of fairness.⁴⁷ In fact, one year after *Morse*, the Supreme Court decided the first significant DOE case, *Winans v. Denmead*.⁴⁸ As we explain below, the dissent in *Winans* was uneasy about the social costs of broad patent scope, but the majority was strictly concerned with the fair treatment of the inventor, and punishing the putative unscrupulous behavior of the infringer.⁴⁹

By the late nineteenth century, however, the favorable attitude toward patents and the heroic inventor receded and courts voiced greater skepticism of patents as rewarding not the hard labor of the inventor, but rather, the scheming of would-be monopolists.⁵⁰ For example, in *Atlantic Works v. Brady*,⁵¹ Justice Bradley recognized that patent law calls for a utilitarian balancing of social costs and benefits. He agreed that the patent laws were designed to benefit inventors “who make some substantial discovery,” but contended that patents on “every trifling device . . . tends rather to obstruct than to stimulate invention” and “creates a class of speculative schemers who . . . lay a heavy tax upon the industry of the country, without contributing anything to the real advancement of the arts.”⁵²

Moreover, the economy became more industrialized and the inventive process more complex. Inventors increasingly became employees and carried on their inventive endeavors under the auspices of their employers, which in turn gave rise to ownership disputes between the employer and the employee-inventor. In these ownership disputes, the courts, while remaining sympathetic to the inventor, gave employers greater rights in the invention. Many scholars have argued that by focusing on the public costs associated with patent grants and by granting the employer greater control in the invention, the late nine-

47. During this time, the judicial perception of the inventor as heroic genius took hold. See Fisk, *supra* note 36, at 1135, 1161 (“Patent law . . . adopted the Romantic notion of the individual as the inventor or originator of an idea, and turned it into a legal category that supported a whole system of property rights The popular understanding of the hero-inventor’s importance in the Industrial Revolution permeated the discourse of patent law . . . throughout the nineteenth century.”). For a discussion of the “heroic inventor” in American patent law, see Mark D. Janis, *Patent Abolitionism*, 17 HIGH TECH. L.J. 899, 904–22 (2002). For a British perspective on this motif, see Christine MacLeod, *Concepts of Invention and the Patent Controversy in Victorian Britain*, in TECHNOLOGICAL CHANGE: METHODS AND THEMES IN THE HISTORY OF TECHNOLOGY 137–53 (Robert Fox ed., 1996). See generally ROGER BURLINGAME, MARCH OF THE IRON MEN: A SOCIAL HISTORY OF UNION THROUGH INVENTION (1938). Several scholars have disputed the heroic inventor narrative. See, e.g., S.C. GILFILLAN, THE SOCIOLOGY OF INVENTION 77 (1935) (“The popular belief in individual, single, great inventors for things has been grotesquely developed by the same process as that which built all the classic mythologies to account for the origins of this and that, so that our traditional great inventor . . . are still . . . mythic heroes in our school-propagated national epos.”). But see JOEL MOKYR, THE LEVER OF RICHES: TECHNOLOGICAL CREATIVITY AND ECONOMIC PROGRESS 12 (1990) (asking “is it not possible to go too far in the other direction and give too little credit to major inventions made by a vital few?”).

48. 56 U.S. (15 How.) 330 (1853).

49. See *infra* Part I.B and accompanying notes.

50. See LAWRENCE M. FRIEDMAN, A HISTORY OF AMERICAN LAW 380 (1973) (“Toward the end of the [nineteenth] century, the courts seemed to become keenly aware that a patent could be used to stifle competition [and] [t]hey became quite stingy with preliminary injunctions against infringement.”).

51. 107 U.S. (17 Otto) 192 (1883).

52. *Id.* at 200.

teenth century courts began to turn away from a natural rights justification for patents, and adopted a utilitarian approach that focused on efficiency and economic development.⁵³

B. THE DOCTRINE OF EQUIVALENTS AND THE LINGERING INFLUENCE OF
FAIRNESS CONCERNS

During the twentieth century, courts shifted largely to an economic understanding of the patent system.⁵⁴ But fairness concerns continued to dominate thinking about the doctrine of equivalents.⁵⁵ In fact, the Federal Circuit has reiterated that the doctrine was “judicially devised to do equity.”⁵⁶ Some courts advocate the DOE as a means to block the unjust enrichment of “unscrupulous copyists” who avoid patent claims by incorporating “colorable differences” into the infringing technology.⁵⁷ Other courts see the DOE as a means of fully and fairly rewarding inventors for their labors, regardless of whether the defendant behaved badly.⁵⁸

53. See Fisk, *supra* note 36, at 1162–63; WALTERSCHEID, *supra* note 35, at 18 (asserting that in the late eighteenth and first half of the nineteenth centuries, patent law was “perceived to be primarily for the purpose of rewarding inventors with public benefits accruing only incidentally to this primary purpose The modern view that [t]he patent law is directed to the public purposes of fostering technological progress’ would have been almost completely foreign”).

54. See, e.g., *Diamond v. Chakrabarty*, 447 U.S. 303, 307 (1980) (noting the patent system promotes progress by offering an exclusive right as an incentive to innovate); *Bonito Boats, Inc. v. Thunder Craft Boats, Inc.*, 489 U.S. 141, 146 (1989) (stating the patent system must balance innovative incentives against the costs of monopoly).

55. See, e.g., *Multiform Desiccants, Inc. v. Medzam, Ltd.*, 133 F.3d 1473, 1480 (Fed. Cir. 1998) (“The doctrine of equivalents, of common law origin, serves to prevent a ‘fraud on the patent.’”); *Pall Corp. v. Micron Separations, Inc.*, 66 F.3d 1211, 1220 (Fed. Cir. 1995) (the DOE “serves to guard against ‘fraud on a patent’ by enabling fair protection of the patentee’s contribution” (citation omitted)); *Perkin-Elmer Corp. v. Westinghouse Elec. Corp.*, 822 F.2d 1528, 1532 (Fed. Cir. 1987) (“[T]he doctrine of equivalents is designed . . . to relieve an inventor from a semantic strait jacket when equity requires.”).

56. *Hilton Davis Chem. Co. v. Warner-Jenkinson Co.*, 62 F.3d 1512, 1521 (Fed. Cir. 1995) (en banc) (“[I]n doctrine of equivalents cases, this court’s allusions to equity invoke equity in its broadest sense—equity as general fairness.”), *rev’d on other grounds*, 520 U.S. 17 (1997). The court maintained this view from its creation. See *Kinzenbaw v. Deere & Co.*, 741 F.2d 383, 389 (Fed. Cir. 1984) (“The doctrine of equivalents is designed to protect inventors from unscrupulous copyists.”); *Int’l Visual Corp. v. Crown Metal Mfg. Co.*, 991 F.2d 768, 774 (Fed. Cir. 1993) (noting that the court has emphasized the equitable nature of the DOE).

57. The archetype case for this line of reasoning is *Graver Tank & Manufacturing Co. v. Linde Air Products Co.*, 339 U.S. 605, 607 (1950) (“[T]o permit imitation of a patented invention which does not copy every literal detail would be to convert the protection of the patent grant into a hollow and useless thing. Such a limitation would leave room for—indeed encourage—the unscrupulous copyist to make unimportant and insubstantial changes.”). The issues raised in *Graver Tank* and the Court’s rationale continue to resonate today. See, e.g., *Tex. Instruments, Inc. v. U.S. Int’l Trade Comm’n*, 805 F.2d 1558, 1572 (Fed. Cir. 1986) (DOE serves the equitable purpose of “prevent[ing] an infringer from stealing the benefit of an invention”). Emphasis on anti-social behavior by the defendant potentially could affect the scope of the DOE, but the Supreme Court recently rejected a role for intent in the doctrine. See *Warner-Jenkinson Co. v. Hilton Davis Chem. Co.*, 520 U.S. 17, 35 (1997) (“Application of the doctrine of equivalents . . . is akin to determining literal infringement, and neither requires proof of intent.”).

58. See, e.g., *Nelson v. Batson*, 322 F.2d 132, 135 (9th Cir. 1963) (stating the “purpose of the doctrine of equivalents is to give the inventor an opportunity to secure a just reward for his invention”).

A brief history of the DOE will bring out some of the finer points of the doctrine and allow us to convey various fairness arguments developed in support of the doctrine. The exact date of the creation of DOE is difficult to discern because the role of claims in patents has changed over time. The doctrine works to expand patent scope beyond the rights given by the claims, thus there could not be a DOE until rights were firmly associated with claims. Claims were not mentioned in the Patent Act of 1793;⁵⁹ they first appear in the 1836 Act.⁶⁰ Prior to the 1836 Act, however, patent attorneys as a norm began to include claim-type language in the patent specification.⁶¹

To understand why this norm developed, one must appreciate that in the first half of the nineteenth century, courts helped inventors gain broad patent scope by setting generous standards for patent infringement—a precursor to the DOE.⁶² Early patent cases⁶³ fleshed out the inchoate patent right by focusing on the “principle” of the invention. These decisions used such equitable language as “colorable differences,”⁶⁴ “copyist,” and “pirated,”⁶⁵ and created linguistic

59. Patent Act of 1793, ch. 11, 1 Stat. 318 (1793).

60. Patent Act of 1836, ch. 357, 5 Stat. 117 (1836). *See generally* William R. Woodward, *Definiteness and Particularity in Patent Claims*, 46 MICH. L. REV. 755 (1948); Karl B. Lutz, *Evolution of Claims of U.S. Patents (Part I)*, 20 PAT. OFF. SOC'Y 134 (1938).

61. *See* John F. Duffy, *The Festo Decision and the Return of the Supreme Court to the Bar of Patents*, 2002 S. CT. REV. 273, 309–10.

62. For example, Circuit Justice Marshall stated that “the constitution and law, taken together, give to the inventor, from the moment of invention, an inchoate property therein, which is completed by suing out a patent.” *Evans v. Jordan*, 8 F. Cas. 872, 873 (C.C.D. Va. 1813) (No. 4564); *see also* *Hilton Davis Chem. Co. v. Warner-Jenkinson Co.*, 62 F.3d 1512, 1516 (Fed. Cir. 1995) (en banc), *rev'd*, 520 U.S. 17 (1997); *on remand*, 114 F.3d 1161 (Fed. Cir. 1997) (“Courts have applied the doctrine of equivalents to protect the substance of the patentee’s right to exclude since the first few decades after enactment of the Patent Act of 1790 . . .”). Significantly, patent applications were not examined under the 1793 statute, thus non-literal patent infringement was analytically similar to contemporary non-literal copyright infringement. *See Pennwalt Corp. v. Durand-Wayland, Inc.*, 833 F.2d 931, 970 (Fed. Cir. 1987) (Newman, J.) (noting that “[d]etermination of equivalency is not unlike determination of substantial similarity in copyright law”). Many infringement cases focused on the “principle” of the invention as highlighted by the patent claim and adopted equitable language such as “colorable differences” or “substantial identity” to gauge infringement. *See* cases cited *infra* note 64.

63. From 1804 through 1835 there were sixty-eight reported patent cases, ten of which were handed down by the Supreme Court. Remarkably, of the fifty-eight reported lower court cases, forty were written by Justices Bushrod Washington and Joseph Story, two Supreme Court justices riding circuit.

64. *See, e.g.*, *Odiome v. Winkley*, 18 F. Cas. 581, 582 (C.C.D. Mass. 1814) (No. 10,432) (Story, C.J.) (“Mere colorable differences, or slight improvements, cannot shake the right of the original inventor.”); *Barrett v. Hall*, 2 F. Cas. 914, 921 (C.C.D. Mass. 1818) (No. 1047) (Story, C.J.) (“Slight or colorable differences will not protect the defendants in their infringement, or defeat the right of the patentee.”); *see also* *Sloat v. Spring*, 22 F. Cas. 330, 334 (C.C.E.D. Pa. 1850) (No. 12,948A) (“Mere colorable alterations, or adroit evasions by substituting one mechanical equivalent for another in the combination which constitutes the machine, should never be allowed to protect a party.”).

65. *See, e.g.*, *Blanchard v. Reeves*, 3 F. Cas. 638, 640 (C.C.E.D. Pa. 1850) (No. 1515) (Grier, C.J.) (“We can not shut our eyes to the fact that the defendants have pirated the invention of the complainant in all its essential parts. Whether the changes made constitute an improvement of the plaintiff’s machine we need not inquire.”); *Wyeth v. Stone*, 30 F. Cas. 723, 728 (C.C.D. Mass. 1840) (No. 18,107) (Story, C.J.) (“Of course, if either machine is new, and is the invention of Wyeth, and it has been actually pirated by the defendants, the plaintiff is entitled to maintain a suit therefore . . .”).

The notion of copying and piracy implies intent on the part of the defendant. The relevance of intent,

tests such as “substantially the same”⁶⁶ or “substantial identity”⁶⁷ to gauge infringement. During litigation, the jury would peruse the written description to determine the principles underlying the inventive concept. The jury, however, had the difficult job of comparing the accused product with the patentee’s disclosed invention because the jury was required to discern abstract principles of the invention from the patent document’s textual description and schematic representations. As such, jurors may “find no infringement because they see so many superficial differences between the defendant’s machine and the description of the patented invention.”⁶⁸ Therefore, according to John Duffy, the claim was developed by the patent bar to provide guidance for jurors as to the patentee’s invention and “to call attention to what the inventor considered the salient features of his invention.”⁶⁹

however, has been discounted recently by the Supreme Court. *See Warner-Jenkinson Co. v. Hilton Davis Chem. Co.*, 520 U.S. 17, 35 (1997). *Cf. Graver Tank & Mfg. Co. v. Linde Air Prods. Co.*, 339 U.S. 605, 609 (1950) (recognizing the importance of known interchangeability).

66. *See, e.g., Le Roy v. Tatham*, 55 U.S. 156, 176 (1852) (“[T]he test of infringement is, whether the defendants have used substantially the same process to produce the same result . . .”).

67. The use of the word “substantially” in the context of patent infringement can be traced to the 1817 cases of *Gray v. James*, 10 F. Cas. 1015, 1016 (C.C.D. Pa. 1817) (No. 5718) and *Lowell v. Lewis*, 15 F. Cas. 1018, 1021 (C.C. Mass. 1817) (No. 8568). In the former, Circuit Judge Washington charged the jury that discerning differences in principle between two machines can be difficult, “[b]ut we think it may safely be laid down as a general rule, that where the machines are substantially the same, and operate in the same manner, to produce the same result, they must be in principle the same.” 10 F. Cas. at 1016. In *Lowell*, Circuit Justice Story instructed the jury that “whether the defendant has violated the patent-right of the plaintiff . . . depends upon the fact, whether the pumps of Mr. Perkins and of Mr. Baker are substantially the same invention. I say substantially the same invention, because a mere change of the form or proportions of any machine cannot, per se, be deemed a new invention.” 15 F. Cas. at 1021; *see also Wilson v. Barnum*, 49 U.S. 258, 261 (1850) (“It is a question as to the substantial identity of the two machines”); *Sanitary Refrigerator Co. v. Winters*, 280 U.S. 30, 41–42 (1929) (“There is a substantial identity, constituting infringement, where a device is a copy of the thing described by the patentee, ‘either without variation, or with such variations as are consistent with its being in substance the same thing.’”); *Van Hook v. Wood*, 28 F. Cas. 1007, 1007 (C.C.N.Y. 1844) (No. 16,855) (“But supposing the proof establishes the substantial identity of the two machines, the fact of infringement, I think, is fully made out by the complainant.”).

68. Duffy, *supra* note 61, at 309.

69. *Id.* In this regard, John Duffy notes that the claim was created “to protect and to expand the rights of patentees.” *Id.* at 308; *see also RIDSDALE ELLIS, PATENT CLAIMS 3* (1949) (contending that nineteenth century claims “served merely to call attention to what the inventor considered the salient features of his invention”). Central claiming was so common that when the Patent Act of 1836 was passed, it was “understood as merely codifying the existing law which had been developed by the courts.” Lutz, *supra* note 60, at 143.

The word “claim” found its way into the 1836 Patent Act and as a result assumed greater importance. Nevertheless, the claim was still not regarded as the central feature of the patent document, even though applicants began to draft claims more specifically by expending a “great deal of effort . . . in formulating claims, and the practice grew of presenting a profusion of claims of varying form and scope.” Woodward, *supra* note 60, at 764. In 1870, Congress, for the first time, specifically required the patent applicant to claim his invention distinctly and with particularity. *See Patent Act of 1870*, ch. 230, § 26, 116 Stat. 198, 201 (1871). This new requirement, which came to be known as “peripheral claiming,” highlighted the notice function of the claim and provided the applicant with more autonomy in setting forth the outer boundaries (periphery) of his invention. The public, it was thought, would now have more confidence about where the patentee’s proprietary boundaries reside because peripheral

In *Odiorne v. Winkley*,⁷⁰ one of the earliest cases to focus on the “principle” of the invention, the owner of a patent for cutting and heading nails, although conceding “there were some differences in the structure and operations” between his invention and the accused product, brought an infringement action.⁷¹ Circuit Justice Story noted that “[m]ere colorable differences, or slight improvements, cannot shake the right of the original inventor.”⁷² As such, the jury was instructed that the patent would be infringed if “the machines used by the defendant are substantially, in their principles and mode of operation, like the plaintiff’s machines.”⁷³

As the prominence of claims increased, the equitable standards for non-literal patent infringement coalesced into the doctrine of equivalents. Instead of searching for the principle of the invention, courts gradually shifted to a two-part analysis: first, interpret the claims and look for literal infringement; and second, expand patent rights as required by equitable considerations. The 1853 landmark decision *Winans v. Denmead*⁷⁴ established the parameters of the DOE debate that remain applicable today. The patentee, Winans, developed a railroad car for carrying coal. This car, “in the form of a frustum of a cone,” allowed for far greater load bearing capacity than the typical box-shaped cars. The defendants, “in view for a call for cars from the mining roads near Cumberland,”⁷⁵ dispatched their draftsman, a Mr. Cochrane, “to get up a car that would suit their purposes.”⁷⁶ After Cochrane visited Winans’ shop where he “examined and measured” a model car built by Winans, the defendants built a railroad car having the same weight and material as plaintiff’s, differing only in shape. Whereas Winans’ cars were cylindrical and conical, the defendants’ cars were octagonal and pyramidal.⁷⁷

claiming reduced the need for the DOE. Central claiming was officially dead, and the patent claim from 1870 to the present day has held center stage. *See, e.g.,* *Merrill v. Yeomans*, 94 U.S. 568, 570 (1876) (asserting that the claim is of “primary importance” in ascertaining exactly what is patented).

70. 18 F. Cas. 581 (C.C.D. Mass. 1814) (No. 10,432).

71. *Id.* at 582.

72. *Id.*

73. *Id.* One year before, in *Park v. Little*, 18 F. Cas. 1107, 1107–08 (C.C.D. Pa. 1813) (No. 10,715), the plaintiff owned a patent for alarm bells that were attached to fire engines. The defendant, who also attached alarm bells to a fire engine, argued, *inter alia*, that its bells were based “on an entirely different principle from those of the plaintiff.” *Id.* at 1108. In instructing the jury regarding the relevant issues, Circuit Justice Washington stated: “Are the defendants’ bells an improvement in the principle or in the form? If the former, then it is no invasion of the plaintiff’s privilege—if the latter, it is.” *Id.* It is a basic tenet of patent law that an improvement of an invention claimed in an extant patent may itself be patented, yet also infringe the earlier patent. *See* Robert P. Merges & Richard R. Nelson, *On the Complex Economics of Patent Scope*, 90 COLUM. L. REV. 839, 843–44 (1990) (asserting “the law should attempt at the margin to favor a competitive environment for improvements, rather than an environment dominated by the pioneer firm”).

74. 56 U.S. (15 How.) 330 (1853). The first opinion to use the phrase “doctrine of equivalents” is *McCormick v. Talcott*, 61 U.S. (20 How.) 402, 405 (1857).

75. *Winans v. Denmead*, 56 U.S. (15 How.) 330, 332 (1853).

76. *Id.*

77. *Id.*

The plaintiff requested the trial judge to instruct the jury that in determining infringement, similarity of form is less important than whether the “defendants . . . constructed cars which, substantially, on the same principle and on the same mode of operation, accomplished the same result.”⁷⁸ The judge refused and essentially limited the scope of Winans’ invention to conically-shaped railroad cars⁷⁹—a position that would be received warmly by today’s Federal Circuit.⁸⁰

The Supreme Court, in a 5-4 decision, reversed and held that the jury instruction prayed for by Winans was appropriate.⁸¹ The majority accepted the notion that the claims play the primary role in determining patent scope, but also insisted on a general role for equitable considerations that could expand patent scope.⁸² Essentially, the Court incorporated earlier caselaw relating to the “principle of the invention” into its developing doctrine of equivalents.⁸³

78. *Id.* at 334.

79. The Circuit Justice instructed the jury as follows:

That while the patent is good for what is described therein; a conical body in whole or in part, supported in any of the modes indicated for a mode of sustaining a conical body on a carriage or truck, and drawing the same, and for those principles which are due alone to conical vehicles and not to rectilinear bodies; and it being admitted that the defendant’s car was entirely rectilinear, that there was no infringement of the plaintiff’s patent.

Id. at 336.

80. *See, e.g., Johnson & Johnston Assocs. Inc. v. R.E. Serv. Co.*, 285 F.3d 1046, 1054 (Fed. Cir. 2002) (en banc).

81. The Court noted that the “first part” of the jury instruction was nearly verbatim with the jury instruction given in the English case of *Walton v. Potter & Horsfall*, 1 Webs. Pat. Cas. 585, 587 (1841). But whereas the *Walton* tribunal asked the jury if the defendants “availed themselves of the plaintiff’s invention,” the *Winans* Court went further and created the “same principle” test.

82. *Winans v. Denmead*, 56 U.S. (15 How.) 330, 332–33 (1853). According to the Court:

There being evidence in the case tending to show that other forms do in fact embody the plaintiff’s mode of operation, and, by means of it, produce the same new and useful result, the question is, whether the patentee has limited his claim to one out of the several forms which thus embody his invention. Now, while it is undoubtedly true, that the patentee may so restrict his claim as to cover less than what he invented, or may limit it to one particular form of machine, excluding all other forms, though they also embody his invention, yet such an interpretation should not be put upon his claim if it can fairly be construed otherwise, and this for two reasons: 1. Because the reasonable presumption is, that, having a just right to cover and protect his whole invention, he intended to do so. . . . 2. Because specifications are to be construed liberally, in accordance with the design of the Constitution and the patent laws of the United States, to promote the progress of the useful arts, and allow inventors to retain to their own use, not any thing which is matter of common right, but what they themselves have created.

Id. at 341.

83. For example, the Court said:

The exclusive right to the thing patented is not secured if the public is 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.

Id. at 343.

Cases following *Winans* continued to expand the scope of the patent to protect the principle

The principle embodied in Winans's invention was not the conical shape of the car, but a shape that increased the volume of the car given a fixed surface area.⁸⁴ Justice Curtis, stated:

[T]he moment a practical, scientific man is furnished with the idea of giving to the car a shape which will . . . enable him to make lighter in proportion to its load, than it has ever been made before, he can multiply without end the forms in which this principle can be made to operate. He can make the car a polygon of a hundred sides, of twenty sides, or of eight sides. He can vary the angle of the cone, or pyramid, through which the coal is discharged, *ad infinitum*. . . . Still the question must always be, whether, whatever the shape he adopts, he is not availing himself of the principle first suggested by the patentee. . . . Where form and substance are inseparable, it is enough to look at the form only. Where they are separable; where the whole substance of the invention may be copied in a different form, it is the duty of courts and juries to look through the form for the substance of the invention.⁸⁵

In addition to the fact that Cochrane “examined and measured”—implicitly copied—plaintiff’s invention, the Court was influenced by the defendant’s insignificant inventive contribution, which was a mere change in the form of the patentee’s car. Such a minor change, according to the Court, is the “work of a constructor, not of an inventor.”⁸⁶ To permit such a defendant to escape infringement by asserting that the patentee only recited one form in his specification would render the property of inventors “valueless.” The Court said little about how or why patent scope should be expanded beyond the claims, but we infer notions of fairness were critical to this inquiry. We reach this inference because

underlying the invention. *See, e.g.*, *Nat'l Cash Register Co. v. Boston Cash Indicator & Recorder Co.*, 156 U.S. 502, 517 (1895) (“While the details of the defendant’s machine are quite different from that of the plaintiff, the underlying principle . . . is precisely the same.”); *Consol. Safety-Valve Co., v. Crosby Steam Gauge & Valve Co.*, 113 U.S. 157, 178 (1885) (“When the ideas necessary to success are made known, and a structure, embodying those ideas, is given to the world, it is easy for the skillful mechanic to vary the form by mechanism which is equivalent, and is, therefore, in a case of this kind, an infringement.”); *Ives v. Hamilton*, 92 U.S. 426, 428–29 (1875) (“One machine is the same in substance as another if the principle be the same in effect, though the form of the machine be different.”).

84. The Court described the “eminent advantages” of the Winans’s car as follows:

[The patentee’s railroad car] increased the available power of the locomotive engine, looking to revenue on coal as a freight, from 50 to 100 per cent. were to be attributed to the peculiar shape of the car body, consisting of a frustum of a cone, which permitted the use of iron, as thin as has been described, lessening, in proportion, the weight of the car, or the weight, the transportation of which by the locomotive gave no return in revenue.

Winans, 56 U.S. at 332.

85. *Id.* at 336, 343; *see also* *Blanchard v. Reeves*, 3 F. Cas. 638, 639 (C.C.E.D. Pa. 1850) (No. 1515) (Grier, C.J.) (“[I]t is impossible to enumerate, in a specification, all the various modes by which the machine may be made to operate, so as to produce a useful result. Many of its parts may be changed or substituted by other mechanical equivalents or devices, which either improve or deteriorate its value, while the original idea, principle, or mode of operation of the inventor is manifestly preserved.”).

86. *Winans*, 56 U.S. at 341.

the Court focuses on the merit of the inventor and the bad motives of the defendant, rather than the consequences of its decision.

Writing for the dissent was Justice Campbell,⁸⁷ who argued that the text of Winans' patent confined his right to the conical form. In language that foreshadowed modern concern about the costs of uncertainty created by the DOE, Justice Campbell remarked:

The patentee is obliged, by law, to describe his invention, in such full, clear, and exact terms, that from the description, the invention may be constructed and used. . . . Nothing, in the administration of this law, will be more mischievous, more productive of oppressive and costly litigation, of exorbitant and unjust pretensions and vexatious demands, more injurious to labor, than a relaxation of these wise and salutary requisitions of the act of Congress.⁸⁸

The drama of *Winans* was replayed nearly one hundred years later in *Graver Tank & Manufacturing Co. v. Linde Air Products Co.*⁸⁹ The Supreme Court ruled against a defendant who made a composition that infringed a patent covering a welding flux. The defendant did not literally infringe because its flux contained an ingredient that was missing from the relevant claims.⁹⁰ The court applied the DOE because the defendant's extra ingredient was a known substitute.⁹¹ The arguments marshaled by the majority and dissent in *Graver Tank* echoed the jousting between Justice Curtis and Justice Campbell. Reminiscent of *Winans*' "valueless" language, the *Graver Tank* majority warned that suppressing the DOE would "convert the protection of the patent grant into a hollow and useless thing" that would be at the mercy of the "unscrupulous copyist."⁹²

The role of the patent claim as guidepost had become increasingly important

87. Joining the dissent was Chief Justice Taney, who was no stranger to the nuances of patent law and the concerns engendered by too generous a reading of a patentee's proprietary scope. Justice Taney wrote the majority opinion in *O'Reilly v. Morse*, 56 U.S. (15 How.) 62 (1854).

88. *Winans v. Denmead*, 56 U.S. (15 How.) 330, 347 (1853).

89. 339 U.S. 605 (1950). The story of *Graver Tank* has been told many times. See, e.g., Paul Janicke, *Heat of Passion: What Really Happened in Graver Tank*, 24 AIPLA Q.J. 1 (1996); Arthur Swanson, *Discussion of Application of Doctrine of Equivalents in Graver Tank v. Linde Case*, 33 J. PAT. OFF. Soc'y 19 (1951).

90. The claim at issue covered a flux used in electric welding. The patent claimed a combination of an alkaline earth metal silicate and calcium fluoride. The accused flux contains calcium fluoride, calcium silicate (an alkaline earth metal silicate), and manganese silicate (which is not an alkaline earth metal silicate). Thus, there was no literal infringement. *Graver Tank*, 339 U.S. at 611-12.

91. The Court emphasized that one ingredient might be considered the equivalent of another. A chemist skilled in this art would know of the interchangeability of manganese silicate for an alkaline earth metal silicate. Evidence of interchangeability was found in publications and patents. The accused compound was substantially identical in operation and result to the claimed compound. The Court concluded the differences "colorable only." *Id.* 339 U.S. at 612.

92. *Id.* at 617. The Court famously wrote:

One who seeks to pirate an invention . . . may be expected to introduce minor variations to conceal and shelter the piracy. Outright and forthright duplication is a dull and very rare type of infringement. To prohibit no other would place the inventor at the mercy of verbalism and would be subordinating substance to form. It would deprive him of the benefit of his invention

by the time *Graver Tank* was decided. In fact, for some time prior to the decision, patent applicants no longer set forth their claims within the crowded specification as Winans did; rather, claims were placed at the end of the patent document. The specification remained an important interpretive guide, but it was relegated to a secondary role and remains there today.⁹³ Perhaps for this reason, the majority began its analysis by noting that “[i]n determining whether an accused device or composition infringes a valid patent, resort must be had in the first instance to the words of the claim.”⁹⁴ The dissent would have stopped with those words.

Dissenting Justice Black embraced a utilitarian view of the DOE and warned of the social cost caused by straying too far from a patent’s claim language.⁹⁵ He found the balance of equities favored the defendant: “I heartily agree with the Court that ‘fraud’ is bad, ‘piracy’ is evil, and ‘stealing’ is reprehensible. But in this case . . . petitioners are not charged with any such malevolence”⁹⁶ He argued the DOE should be limited to cases in which the differences between the accused compound and the claims are insignificant. Like Justice Campbell in *Winans*, he feared that the uncertainty engendered in broad application of the DOE created a grave threat to competition.⁹⁷

C. THE MODERN FRICTION THEORY

In 1997, the Supreme Court finally brought the DOE into conformity with modern patent law by rejecting a fairness rationale in *Warner-Jenkinson Co. v. Hilton Davis Chemical Co.*⁹⁸ The Court disallowed a “judicial exploration of the equities of a case before allowing application of the doctrine of equivalents,”⁹⁹ and ruled that intent plays no role in the doctrine’s application.¹⁰⁰

and would foster concealment rather than disclosure of inventions, which is one of the primary purposes of the patent system.

Id.

93. See ELLIS, *supra* note 69, § 3 (“The idea that the claim is just as important if not more important than the description and drawings did not develop until the Act of 1870 or thereabouts.”). Judge Giles S. Rich, one of the two most influential twentieth century patent law jurists, famously quipped, “the claim is the name of the game.” Kieff, *supra* note 19, at 102.

94. *Graver Tank & Mfg. Co. v. Linde Air Prods. Co.*, 339 U.S. 605, 607 (1950).

95. *Id.* at 614 (Black, J., dissenting).

96. *Id.* at 612–13.

97. *Id.* at 617 (“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. To burden business enterprise on the assumption that men possess such a prescience bodes ill for the kind of competitive economy that is our professed goal.”). Moreover, Justice Black argued the DOE raises separation of powers concerns because Congress “entrusted the Patent Office, not the courts, with initial authority to determine” claim scope, and Congress created a reissue proceeding that the DOE seems to render irrelevant. *Id.* at 615.

98. 520 U.S. 17, 34–35 (1997).

99. *Id.* at 34.

100. *Id.* at 36. The defendant unsuccessfully argued that the DOE is an equitable doctrine that should be applied by the court. The Supreme Court declined to decide whether the judge or jury should apply

Surprisingly, after rejecting the fairness rationale, the opinion, while discussing the proper form for the test of DOE, failed to advance a positive justification for the doctrine.¹⁰¹ Five years later, the Court, in *Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co.*,¹⁰² hinted that the DOE should be justified in terms of the friction theory:¹⁰³

If patents were always interpreted by their literal terms, their value would be greatly diminished. Unimportant and insubstantial substitutes for certain elements could defeat the patent, and its value to inventors could be destroyed by simple acts of copying. For this reason, the clearest rule of patent interpretation, literalism, may conserve judicial resources but is not necessarily the most efficient rule.¹⁰⁴

We infer from this language that the doctrine is justified as an efficient response to frictions present in the claims drafting process. The DOE responds to these frictions to restore proper patent scope and provide the appropriate incentive to create and disclose inventions. The three main sources of friction are prosecution errors,¹⁰⁵ the “frailties of language and limitations on human foresight.”¹⁰⁶

1. Prosecutorial Mistakes

Mistakes committed when drafting and prosecuting a patent before the PTO are the first source of friction. Patent prosecutors have long viewed the DOE as a safety net available to mitigate the effect of their mistakes.¹⁰⁷ By responding to mistakes, the doctrine substantially overlaps with the function of the reissue proceeding.¹⁰⁸ A reissue proceeding allows a patentee to return to the PTO to

the DOE, but it commented favorably on the Federal Circuit’s view that the jury should apply it. *See id.* at 37–39.

101. *Id.* at 39–40.

102. 535 U.S. 722 (2002).

103. In its opening paragraph, the Court seemed to revert to a fairness theory when it wrote, “a patent protects its holder against efforts of copyists to evade liability for infringement by making only insubstantial changes to a patented invention.” *Id.* at 727.

104. *Id.* at 731–32.

105. *See supra* Part I.C.1 and text accompanying notes 95–97.

106. *SRI Int’l v. Matsushita Elec. Corp. of Am.*, 775 F.2d 1107, 1123 (Fed. Cir. 1985); *see supra* Parts I.C.2–3.

107. *See Adelman & Francione, supra* note 5, at 711 (“Most frequently, patent holders use the doctrine of equivalents to rectify what is effectively a ‘mistake’ in the process of drafting and prosecuting the application in the PTO. The patent holder argues that the failure to include something in the claim was an oversight.”); Paul M. Janicke, *When Patents are Broadened Midstream: A Compromise Solution to Protect Competitors and Existing Users*, 66 U. CINN. L. REV. 7, 42 (1997) (same); *cf. In re Wilder*, 736 F.2d 1516, 1519 (Fed. Cir. 1984) (“An attorney’s failure to appreciate the full scope of the invention is one of the most common sources of defects in patents.”).

108. *See* 35 U.S.C. § 251 (2000), which reads in relevant part:

Whenever any patent is, through error without any deceptive intention, deemed wholly or partly inoperative or invalid, by reason of a defective specification or drawing, or by reason of the patentee claiming more or less than he had a right to claim in the patent, the Director shall, on the surrender of such patent and the payment of the fee required by law, reissue the patent

correct mistakes, including drafting too narrowly, that were made in good faith during a prior prosecution.¹⁰⁹ The reissue proceeding has been around since at least 1832,¹¹⁰ and it was codified in 1836.¹¹¹

2. Limitations of Language

The Supreme Court particularly emphasized the limitations of language in *Festo*, stressing language's "imperfect fit for invention" and noting that the "doctrine of equivalents is premised on language's inability to capture the essence of innovation."¹¹² By way of elaboration, the Court quoted the following passage from *Autogiro Co. of America v. United States*:

An invention exists most importantly as a tangible structure or a series of drawings. A verbal portrayal is usually an afterthought written to satisfy the requirements of patent law. This conversion of machine to words allows for unintended idea gaps which cannot be satisfactorily filled. Often the invention

for the invention disclosed in the original patent, and in accordance with a new and amended application, for the unexpired part of the term of the original patent. No new matter shall be introduced into the application for reissue.

Id.; see also *infra* Part IV.A (discussing relationship between reissue and DOE).

Importantly, the rationale for reissue is grounded on the notion that patent drafting is a difficult endeavor, replete with pitfalls. See *Topliff v. Topliff*, 145 U.S. 156, 171 (1892):

To hold that a patent can never be reissued for an enlarged claim would be not only to override the obvious intent of the statute, but would operate in many cases with great hardship upon the patentee. The specification and claims of a patent, particularly if the invention be at all complicated, constitute one of the most difficult legal instruments to draw with accuracy; and, in view of the fact that valuable inventions are often placed in the hands of inexperienced persons to prepare such specifications and claims, it is no matter of surprise that the latter frequently fail to describe with requisite certainty the exact invention of the patentee, and err either in claiming that which the patentee had not in fact invented, or in omitting some element which was a valuable or essential part of his actual invention.

See also 37 C.F.R. § 1.175(a) (2005) (requiring a general statement that errors involved no deceptive intent).

109. 37 C.F.R. § 1.175. Notably, a mistake for reissue purposes does not include subject matter "previously surrendered in order to obtain allowance of original patent claims." *Mentor Corp. v. Coloplast, Inc.*, 998 F.2d 992, 995 (Fed. Cir. 1993); see also *Ball Corp. v. United States*, 729 F.2d 1429, 1436 (Fed. Cir. 1984) ("The recapture rule bars the patentee from acquiring, through reissue, claims that are of the same or of broader scope than those claims that were canceled from the original application." (emphasis omitted)).

110. See *Grant v. Raymond*, 31 U.S. (6 Pet.) 218 (1832).

111. See Patent Act of 1836, ch. 357, 5 Stat. 117.

112. *Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co.*, 535 U.S. 722, 734, 738 (2002); see also *Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co.*, 234 F.3d 558, 624 (Fed. Cir. 2000) (Linn, J., concurring in part and dissenting in part) ("The problems . . . regarding the inherent limitations of language . . . have provided justification for the lengthy history of applying the doctrine of equivalents to all claim language to adequately protect the patentee's right to his invention . . ."); Joseph S. Cianfrani, *An Economic Analysis of the Doctrine of Equivalents*, 1 VA. J.L. & TECH. 1, 30-31 (1997) ("Implicit in the recognition that literal infringement alone is sometimes inadequate to protect the patentee is the recognition that the literal claim language did not fully capture the patentee's contribution to the art. . . . The inability of language to accurately capture the invention is one type of information cost that the doctrine of equivalents is used to overcome.").

is novel and words do not exist to describe it. The dictionary does not always keep abreast of the inventor. It cannot. Things are not made for the sake of words, but words for things.¹¹³

3. Unforeseen Technical Developments

The third source of friction arises from the difficulty foreseeing technical developments relevant to the patented technology.¹¹⁴ Accordingly, patent prosecutors are not expected to claim unforeseeable equivalents. While notions of foreseeability are present in some older cases, in 1997, the Federal Circuit made foreseeability a crucial factor in its DOE analysis:

[A]s 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. . . . This court recognizes that such reasoning places a premium on forethought in patent drafting. Indeed this premium may lead to higher costs of patent prosecution. However, the alternative rule—allowing broad play for the doctrine of equivalents to encompass foreseeable variations, not just of a claim element, but of a patent claim—also leads to higher costs.¹¹⁵

And the Supreme Court solidified the role of foreseeability in *Festo*:

The patentee, as the author of the claim language, may be expected to draft claims encompassing readily known equivalents. A 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. . . . There are some cases, however, where the amendment cannot reasonably be viewed as surrendering a particular equivalent. The equivalent may have been unforeseeable at the time of the application¹¹⁶

113. 384 F.2d 391, 397 (Ct. Cl. 1967) (quoted in *Festo*, 535 U.S. at 731). Interestingly, the court focused on the inventor's vocabulary and verbal acumen. While it is proper to think of patents as technical documents, they are almost invariably written by patent attorneys, especially litigated patents.

114. See *Kinzenbaw v. Deere & Co.*, 741 F.2d 383, 389 (Fed. Cir. 1984) (explaining that doctrine of equivalents expands claim scope to cover unanticipated equivalents). The enablement requirement is relaxed in the context of later-developed technology. See *In re Hogan*, 559 F.2d 595, 606 (C.C.P.A. 1977) ("To now say that appellants should have disclosed in 1953 the amorphous form which on this record did not exist until 1962, would be to impose an impossible burden on inventors and thus on the patent system."); *Adelman & Francione*, *supra* note 5, at 714–15 ("In the 'new technology' context, the patent cannot teach the actual enablement, which becomes possible only as the result of technological development. . . . Whether a broad claim that would cover both the original teachings and the new technology would be enabled would then depend on the predictable or not predictable nature of the art to which the invention pertains.").

115. *Sage Prods., Inc. v. Devon Indus., Inc.*, 126 F.3d 1420, 1425 (Fed. Cir. 1997) (citations omitted).

116. *Festo*, 535 U.S. at 740; see also Matthew J. Conigliaro, Andrew C. Greenberg & Mark A. Lemley, *Foreseeability in Patent Law*, 16 BERKELEY TECH. L.J. 1045, 1066–68 (2001) (recounting support for the foreseeability approach in the case law).

II. A NEW PERSPECTIVE: FROM FRICTION TO REFINEMENT

A. THE FALSE PREMISE OF THE FRICTION THEORY

The modern justification of the DOE rests on the flawed assumption that certain inventors are blocked from claiming the full scope of their inventions by exogenous frictions. The three types of friction discussed above are all plausible; but treating them as exogenously fixed is not. Limits of language, problems of foreseeability, and the risk of mistake can be mitigated through the efforts of the inventor and her patent prosecutor.¹¹⁷ We concede there are cases in which no amount of effort would overcome these frictions, but we think such cases are unusual—and certainly not represented by the leading DOE cases.¹¹⁸

The exogeneity premise is most clearly wrong in the case of mistakes. Inventors can reduce the likelihood of mistakes by spending more time and money on prosecution, choosing a prosecutor with a good reputation, and effectively monitoring the prosecution.¹¹⁹ The DOE should not offer routine relief for mistakes because such a policy undercuts the incentive of the inventor

117. Empirical evidence consistent with our view comes from John R. Allison, Mark A. Lemley, Kimberly A. Moore & R. Derek Trunkey, *Valuable Patents*, 92 GEO. L.J. 435 (2004). They show that litigated patents differ significantly from other patents. Specifically, they cite more prior art than non-litigated patents, and contain more claims. Assuming more valuable inventions tend to get litigated more, and patent prosecutors understand which inventions are more valuable, this result suggests prosecutors are sensitive to economic forces which influence the content of a patent. Kieff notes that inventors selectively invest varying amounts and intentionally choose varying quality levels for their patent applications. See Kieff, *supra* note 19, at 101–02.

Moreover, in a recent English patent case, Lord Hoffmann addressed the issue of claim drafting and non-literal infringement. He wrote:

The conventions of word meaning and syntax enable us to express our meanings with great accuracy and subtlety and the skilled man will ordinarily assume that the patentee has chosen his language accordingly. As a number of judges have pointed out, the specification is a unilateral document in words of the patentee's own choosing. Furthermore, the words will usually have been chosen upon skilled advice.

Kirin-Amgen, Inc. v. Hoechst Marion Roussel Ltd., [2004] UKHL 46, ¶ 34 (U.K.).

118. As Lord Hoffmann wrote in this regard, “[t]here will be occasions upon which it will be obvious to the skilled man that the patentee must in some respect have departed from conventional use of language or included in his description of the invention some element which he did not mean to be essential.” Yet he noted that “one would not expect that to happen very often.” *Kirin-Amgen*, [2004] UKHL46, ¶ 34.

119. Jay Thomas suggests that it may be difficult for the market to evaluate the ability of patent prosecutors. See John R. Thomas, *Claim Re-Construction: The Doctrine of Equivalents in the Post-Markman Era*, 9 LEWIS & CLARK L. REV. 153, 168 (2005). We are not aware of any empirical evidence on this point, but we doubt that evaluating the reputation of patent prosecutors differs very much from other markets for professional service.

Thomas also worries that restriction of the DOE will cause social harm because of increased patent drafting costs. *Id.* at 167–68. This is a reasonable concern especially since many patents are not commercially exploited or are allowed to lapse due to a willing failure to pay maintenance fees. See Kimberly A. Moore, *Worthless Patents* (George Mason Law & Economics, Research Paper No. 04-29, 2004), available at <http://papers.ssrn.com/abstract=566941>. Nevertheless, the increased drafting costs must be weighed against the social benefit from better-drafted patents. Thomas argues this benefit is small. We address that argument *infra* note 197. Furthermore, it is possible that overall or collective drafting costs might decline as firms decide to prosecute fewer patents.

(or her assignee) to invest in a high quality application and ignores the statutory reissue provision.¹²⁰ The Federal Circuit appears to be moving toward this view.¹²¹

The Federal Circuit also shows some awareness that the other frictions can be smoothed over,¹²² but progress on this front has been slowed by some disappointing signals from the Supreme Court. For instance, the Court in *Festo* wrote approvingly about the application of the doctrine in *Winans* and *Graver Tank*,¹²³ despite the likelihood that the patentees in those cases could have overcome the relevant frictions rather easily. If the *Festo* Court had a better appreciation of the possibilities for crafting claims to mitigate language and foreseeability problems, we think it would have shared our doubt about the correctness of the outcome in *Winans* and *Graver Tank*.

Recall that the patentee in *Winans* developed an improvement in the shape of railroad cars for transportation of coal and other materials.¹²⁴ He claimed that the body of his car is “in the form of a frustum of a cone”—that is, a cylindrical or conical form. The accused product employed an octagonal form. The majority, in applying the DOE, noted that “it is undoubtedly true that the patentee may restrict his claim as to cover less than what he invented . . . yet such an interpretation should not be put upon his claim” because the “reasonable presumption is, that so having a just right to cover and protect his whole invention, he intended to do so,” and because “specifications are to be construed liberally” consistent with the Constitution.¹²⁵

The dissent grasped the notion that a patent applicant can overcome prosecution frictions. Justice Campbell observed the patentee, in drafting his claim, “overlooked those facts which reduced its practical value to the level of cars of a form widely verient [sic, variant] from his own” and that the “object of this

120. See *supra* text accompanying notes 108–11.

121. See *PSC Computer Prods., Inc. v. Foxconn Int'l, Inc.*, 355 F.3d 1353, 1361 (Fed. Cir. 2004) (“The patentee, rather than the public, must bear the burden of inadvertent errors in the patent—including inadvertent dedications.”); *Amgen Inc. v. Hoechst Marion Roussel, Inc.*, 314 F.3d 1313, 1339 (Fed. Cir. 2003) (reversing the district court and applying prosecution history estoppel to block the DOE when the patent specification mistakenly disclosed a protein with 166 amino acids instead of 165).

122. See *Sage Prods., Inc. v. Devon Indus., Inc.*, 126 F.3d 1420, 1425 (Fed. Cir. 1997) (“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 [the] limitation at the time of its incorporation into the claim.”); *Vehicular Tech. Corp. v. Titan Wheel Int'l, Inc.*, 212 F.3d 1377, 1383–84 (Fed. Cir. 2000) (“[A]s 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 his failure to seek protection for this foreseeable alteration of his claimed structure.” (citing *Sage Prods.*, 126 F.3d at 1425)).

123. *Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co.*, 535 U.S. 722, 734, 732–33 (2002); see also *Warner-Jenkinson Co. v. Hilton Davis Chem. Co.*, 520 U.S. 17, 25–26 (1997) (reaffirming *Graver Tank*).

124. *Winans v. Denmead*, 56 U.S. (15 How.) 330, 332 (1853).

125. *Id.* at 341.

suit is to repair that defect of observation.”¹²⁶ He concluded the patentee must have excluded other forms “advisedly.”¹²⁷ Essentially, Justice Campbell recognized claim language is malleable and most frictions could be overcome with a reasonable effort. The patentee could have claimed any number of shapes, and despite the claims of the majority, it makes little sense to say the patentee intended to claim other forms when those forms were easy to discern.

In *Graver Tank*, the patent pertained to certain electric welding compositions known as fluxes, which facilitated the fusing of metals. Two sets of original claims were involved. One set of claims described a major element as any “silicate.” The other set of claims, which were narrower, described the element as any “alkaline earth metal silicate.” The Supreme Court held the first set of claims invalid for undue breadth. The narrower claims were upheld, and the question became whether those claims were infringed. The alkaline earth metal silicate claims included magnesium silicate. The accused product substituted a silicate of manganese, which is not an alkaline earth metal, for magnesium silicate.

The friction theory does not support application of the DOE in this case. The limitation of language friction does not apply because it was easy enough to specify manganese silicate. Likewise, the unforeseeable technology friction does not apply because the use of manganese silicate in welding fluxes was disclosed in the prior art. As Justice Black states in his dissent:

In view of the intense study and experimentation [by the patentee] with manganese silicate, it would be frivolous to contend that failure specifically to include that substance in a precise claim was unintentional. Nor does respondent attempt to give that or any other explanation for its omission. But the similar use of manganese in prior expired patents, referred to in the Court’s opinion, raises far more than a suspicion that its elimination from the valid claims stemmed from fear that its inclusion by name might result in denial or subsequent invalidation of respondent’s patent.¹²⁸

The *Graver Tank* Court offered no rationale for applying the DOE other than a fairness-based theory.¹²⁹ Sensible application of the friction theory would recognize that manganese silicate technology was readily available (as were other forms in *Winans*) and easily could have been inserted in the claims at issue. To permit application of the DOE in this setting provides claim drafters with perverse incentives to claim ambiguously without giving much thought to extant technology.

126. *Id.* at 346.

127. *Id.* at 347.

128. *Graver Tank & Mfg. Co. v. Linde Air Prods. Co.*, 339 U.S. 605, 616–17 (1950).

129. *Id.* at 607–08 (discussing the DOE’s role in preventing the theft of a patented invention). And the *Warner-Jenkinson* and *Festo* Courts uncritically accepted the outcome in *Graver Tank* without looking carefully at the alleged constraints on claim drafting. See *Warner-Jenkinson Co. v. Hilton Davis Chem. Co.*, 520 U.S. 17, 21 (1997); *Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co.*, 535 U.S. 722, 733 (2002)

In *Warner-Jenkinson*, the Supreme Court signaled its concern about the impact of the DOE on the notice function of claim language, but it offered little guidance about how the doctrine should be applied, and paid little attention to the claim drafting process. The Court sanctioned application of the DOE to a case in which frictions were quite small.¹³⁰ The patent claimed a dye purification process with “a pH from approximately 6.0 to 9.0.” The pH range of 6.0 to 9.0 formed part of an amendment made during prosecution to overcome the prior art Booth patent, which disclosed a pH of greater than 9. While it was readily understood why the patentee adopted an upper pH range of 9, it was less clear why a lower limitation was added.¹³¹ Warner-Jenkinson’s accused process used a pH of 5.

The traditional frictions do not fare well as an explanation of why the patentee needed the DOE in *Warner-Jenkinson*. It is hard to fathom that inherent limitations of language precluded Hilton Davis from claiming a pH lower than 6 or that the prosecuting attorney simply committed a mistake. Further, one would be hard pressed to make the case that a pH of 5 was an unforeseeable technology. Indeed, Warner-Jenkinson independently developed its accused process only a year after Hilton Davis’ patent issued.

The narrow claim language in the patents in these three cases and in other DOE cases is not explained by unavoidable frictions, and is likely explained by two other factors. First, prosecutors and inventors strategically choose narrow claims to limit disclosure to the examiner and avoid patentability problems, or because the inventor decides to seek a mix of patent and trade secret protection.¹³² Second, prosecutors simply fail to exert the effort required to construct broader claims. Often, inventors and patent attorneys fail to appreciate design alternatives or identify substitute components or ingredients because of lack of effort. For example, in *Sage Products, Inc. v. Devon Industries, Inc.*,¹³³ the patentee failed to refine his claims to obtain broader protection for his invention, a disposal container for hazardous material. According to the court:

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. . . . Instead, Sage left the PTO with manifestly limited claims that it now seeks to expand through the [DOE]. . . . This court recognizes that such reasoning places a premium on forethought in patent drafting. Indeed this premium may lead to higher costs of patent prosecution.¹³⁴

130. The Court did require the patent owner to clear a more rigorous prosecution history estoppel hurdle. See *Warner-Jenkinson Co. v. Hilton Davis Chem. Co.*, 520 U.S. 17, 33–34 (1997).

131. Hilton Davis argued that the patented process would be ineffectual using a pH of 5 or lower, but Warner-Jenkinson asserted that the process worked with a pH as low as 2.2. *Id.* at 22 n.2.

132. See James J. Anton & Denis A. Yao, *Start-Ups, Spin-Offs, and Internal Projects*, 11 J.L. ECON. & ORG. 362, 376 (1995).

133. 126 F.3d 1420 (Fed. Cir. 1997).

134. *Id.* at 1425.

B. OVERCOMING FRICTIONS THROUGH REFINEMENT

Patent prosecutors have access to a range of claim-drafting techniques that mitigate problems with language and later-developed technology. Contract and statute drafters ultimately choose particular language, but claim drafters can hedge their bets by filing multiple independent and dependent claims.¹³⁵ Although the Patent Act requires definite claim language, in practice the courts uphold patent claims using words of degree such as “substantially”¹³⁶ or “about,”¹³⁷ and will not invalidate claims unless “insolubly ambiguous.”¹³⁸ Patent law accommodates inventors who have an incomplete understanding of their invention, for example by allowing product-by-process claims.¹³⁹ Such a claim may be used by an inventor who cannot characterize a new compound, but who can describe the process that produces the compound. Finally, a core principle of claim construction states that an inventor can act as her own lexicographer, thus a claim drafter can coin words that are used in the claim and defined in the specification.¹⁴⁰

Sophisticated claim drafting mitigates two especially difficult problems. First, claim drafting can be burdensome because of the asymmetry between the patent applicant and the potential competitor. Apparently, the applicant has to enumerate and claim all the possible ways of practicing the invention, but the competitor only has to find one unclaimed way to practice the invention. We call this the enumeration problem.¹⁴¹ Second, prosecutors sometimes struggle to craft language that will cover equivalent technology that has not yet been developed.

Functional claim language is one technique that can avoid the enumeration problem.¹⁴² Section 112, paragraph 6 of the Patent Act permits “means-plus-function” claim language. For example, an applicant might claim component *x*, component *y*, and a means for fastening *x* to *y*. The applicant is required to disclose at least one such means in the written description, for example, a screw. The means-plus-function claim language is read to literally cover a screw and any equivalent fastener that serves an identical function (fastening in this example) such as a nail or a rivet.¹⁴³

135. See 35 U.S.C. § 112 (2000) (“A claim may be written in independent or, if the nature of the case admits, in dependent or multiple dependent form.”).

136. See *Verve, LLC v. Crane Cams, Inc.*, 311 F.3d 1116, 1119–20 (Fed. Cir. 2002).

137. See *W.L. Gore & Assocs., Inc. v. Garlock, Inc.*, 721 F.2d 1540, 1557 (Fed. Cir. 1983).

138. *Bancorp Servs., L.L.C. v. Hartford Life Ins. Co.* 359 F.3d 1367, 1371 (Fed. Cir. 2004).

139. See *MANUAL OF PATENT EXAMINING PROCEDURE*, *supra* note 22, §§ 2113, 2173.05(p).

140. See *Golight, Inc. v. Wal-Mart Stores, Inc.*, 355 F.3d 1327, 1332 (Fed. Cir. 2004).

141. Justice Curtis in *Winans* presumably was influenced by the enumeration problem. See *Winans v. Denmead*, 56 U.S. (15 How.) 330, 336, 343 (1853); *supra* notes 79–83 and accompanying text; see also *W. Elec. Co. v. LaRue*, 139 U.S. 601, 606 (1891) (“Since the case of *Winans v. Denmead*, . . . it has been the settled doctrine of this court . . . that ‘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 the law, deemed to claim every form in which his invention may be copied’”).

142. See *Kieff*, *supra* note 19, at 111–12.

143. See *Micro Chem., Inc. v. Great Plains Chem. Co.*, 103 F.3d 1538, 1547 (Fed. Cir. 1997) (concluding that literal infringement of a means-plus-function limitation requires “the accused device

Moreover, the applicant can use the *Markush* claiming format,¹⁴⁴ which “is a sort of homemade generic expression covering a group of two or more different materials (elements, radicals, compounds, etc.), mechanical elements, or process steps that will work in the combination claimed.”¹⁴⁵ The group, known as a *Markush* group, allows the applicant to list several alternative structures or species that can be used for the invention, but then claim only one of the possible structures or species as the invention.¹⁴⁶ For instance, a *Markush* claim may read: a composition of matter comprising C-H-C-R, wherein R is selected from a group consisting of 1, 2, 3, and 4 or a compound having heat resistant properties, wherein said compound is selected from a group consisting of A, B, C, and D.¹⁴⁷

Surprisingly, certain claim-drafting techniques allow inventors to claim technology that incorporates elements that have not been developed. Consider for example a patentable tennis racket that differs from previous rackets in terms of its shape and dimensions. The inventor must describe a suitable material for use in the racket, but should avoid limiting herself to a particular material. In recent years, rackets have become lighter and stronger, as manufacturers moved from wood to aluminum to graphite. An inventor, familiar with this trend, should describe the material used to make his racket in general terms, and then the patent claim will literally cover a racket of the same shape and dimension even

perform the identical function as that identified in the means clause and do so with structure which is the same as or equivalent to that disclosed in the specification”). Means-plus-function language cannot be stretched to cover later developed technology because the structural equivalents are determined at the time the patent issues, not the time of infringement. In other words, if the technology embodied in the accused product was available at the time the patent issued, then infringement under a § 112, ¶ 6 claim is deemed literal infringement because the “literal meaning of a claim is fixed upon issuance.” But if the accused technology was developed after the patent issued, infringement exists, if at all, under the common law DOE. See *Al-Site Corp. v. VSI Int’l, Inc.*, 174 F.3d 1308, 1320 (Fed. Cir. 1999); *Chiuminatta Concrete Concepts, Inc. v. Cardinal Indus., Inc.*, 145 F.3d 1303, 1310 (Fed. Cir. 1998) (“Even if such an element is found not to be a § 112, ¶ 6, equivalent because it is not equivalent to the structure disclosed in the patent, this analysis should not foreclose it from being an equivalent under the doctrine of equivalents.”). But see Mark D. Janis, *Who’s Afraid of Functional Claims? Reforming the Patent Law’s § 112, ¶ 6 Jurisprudence*, 15 SANTA CLARA COMPUTER & HIGH TECH. L.J. 231, 279 (1999) (arguing *Chiuminatta* was a mistake); Ronald D. Hantman, *Why Not the Statute? Revisited*, 83 J. PAT. & TRADEMARK OFF. SOC’Y 685, 703–04 (2001) (“[A] later invented equivalent ought to infringe a claimed invention (literal infringement) unless the later invented equivalent is so far changed from the claimed invention that it ceases to be an equivalent under § 112, ¶ 6.”).

144. See *Ex parte Markush*, 1925 C.D. 126 (Dec. Comm’r Pat. 1925).

145. ROBERT C. FABER, *LANDIS ON THE MECHANICS OF CLAIM DRAFTING* § 50, at 149 (3d ed. 1990).

146. See *In re Driscoll*, 562 F.2d 1245, 1249 (C.C.P.A. 1977):

It is generally understood that in thus describing a class of compounds an applicant is, in effect, asserting that the members of the *Markush* group do not fall within any recognized generic class, but are alternatively usable for the purposes of the invention, and therefore, regardless of which of the alternatives is substituted on the basic structure, the compound as a whole will exhibit the disclosed utility.

147. *Markush* claims can be particularly effective in the biotechnological and chemical arts. But it is sometimes used in the mechanical and electrical arts, as well. See FABER, *supra* note 145, § 50.

if it is made from a substance that was not known at the time of the patent application.¹⁴⁸ Of course, the inventor can also choose to file a continuation-in-part application¹⁴⁹ or take advantage of the reissue mechanism.¹⁵⁰ A computer-related example of later-developed technology that might have been claimed comes from *Hughes Aircraft Co. v. United States*.¹⁵¹ *Hughes* involved synchronous communications satellite technology that addressed attitude control or the need to orient the satellite in space. Williams, the inventor of the 3,758,051 patent (the “051 patent”), developed a ground-controlled satellite whereby sun pulses were provided to an external location (i.e., a ground crew on earth) sufficient to determine spin angle or ISA position. (The ISA position is the “measure of where the satellite is in its spin cycle at any instant of time.”)¹⁵² The ground crew would then use this information to simulate the rotation of the satellite and to calculate the satellite’s spin rate, sun angle, and ISA position. The sun pulses were known in real time, allowing the ground crew to transmit control signals for immediate execution. In the accused products, the sun pulses were transmitted to an on-board computer, not a ground crew. The computer calculated the spin rate and transmitted it to earth (as well as other information) from which the ground crew calculated the sun angle. Moreover, real-time execution based on receipt of control signals was absent from the accused products; instead, the on-board computer stored the control signals for later execution.

The *Hughes* court fully endorsed the fairness theory and applied the DOE, even though it recognized the inventor could have claimed the later-developed technology. The court opined that later-developed technology, in this case computers, should not permit the “accused spacecraft to escape the ‘web of

148. See, e.g., *SmithKline Beecham Corp. v. Excel Pharms., Inc.*, 214 F. Supp. 2d 581, 592 (E.D. Va. 2002):

[W]hen redrafting claims 14–15 and 18–19, the patentee could have attempted to claim all hydrogel-forming polymers as the mechanism to control the release rate of bupropion hydrochloride, rather than claim only HPMC. This more broadly drafted limitation would also have encompassed yet-to-be discovered hydrogel-forming polymers. Because PVA, like HPMC, is a hydrogel-forming polymer, the redrafted claims would have literally encompassed PVA. For this reason, the court concludes that at the time of the claim amendments, one skilled in the art could have reasonably drafted the claims to encompass PVA

149. A continuation-in-part repeats much of the content of an earlier application but also bolsters the disclosure with new matter. New claims are entitled to the priority date of the earlier application unless they depend on the new matter. While continuation practice provides socially valuable opportunities to refine claims, it can be strategically abused. Ideally, continuation practice should be reformed so the problems created by an overly generous DOE do not resurface in that setting. See Mark A. Lemley & Kimberly A. Moore, *Ending Abuse of Patent Continuations*, 84 B.U. L. Rev. 63 (2004).

150. See *supra* notes 108–11 and accompanying text.

151. 717 F.2d 1351 (Fed. Cir. 1983). For a discussion of the application of the DOE to industry-specific settings, see Dan L. Burk & Mark A. Lemley, *Is Patent Law Technology-Specific?*, 17 BERKELEY TECH. L.J. 1155 (2002); Dan L. Burk & Mark A. Lemley, *Policy Levers in Patent Law*, 89 VA. L. REV. 1575 (2003).

152. *Hughes Aircraft*, 717 F.2d at 1360.

infringement.”¹⁵³ Williams, who was working closely with NASA and other government entities (soon to become defendants), filed his initial patent application in 1960 and filed a CIP in 1964. The patent issued in September of 1973, and Hughes, Williams’ assignee, filed an infringement against the United States one month later. Assuming the use of an on-board computer was not feasible at the time Williams filed his applications, he nonetheless could have drafted claim language to capture the accused devices without resort to the DOE. Both the ’051 claimed invention and the accused devices were ground controlled, even though the accused devices employed an on-board computer, a post-Williams development. Thus, Williams could have drafted claim language that rendered on-board later-developed technology irrelevant for purposes of infringement. In fact, the court stated that “Williams did not submit claims broadly covering all ground controllable spacecraft, *as he might have*,” but “[h]ad he done so . . . literal infringement would have been present here.”¹⁵⁴

C. THE NOTICE THEORY AS A CONSTRAINT ON THE DOCTRINE OF EQUIVALENTS

One of most common objections to the DOE is the doctrine’s negative effect on the notice function of patent claims. Good patent policy should balance the benefits created by expanded patent scope against the costs of expanded scope and fuzzy property rights. To be sure, both the fairness and friction theories preclude application of the DOE to extend patent protection over technology in the public domain.¹⁵⁵ But the theories fail to address the uncertainty created by the doctrine.¹⁵⁶ DOE case law tries to strike an ad hoc balance between patent owners’ interests and costs to the public, including the cost of uncertain property rights. Recently, the balance has shifted increasingly in favor of public

153. *Id.* at 1365. According to the court, “[o]nce an on-board computer became available, . . . any intelligent engineer designing [the accused device] would say ‘Look, I don’t need to send the value of that ISA position to the ground, it’s right there in the spacecraft. I’ll just key my firing signal to that on board the spacecraft.’” *Id.* at 1364–65 (internal quotation marks omitted).

154. *Id.* at 1363 (emphasis added). Moreover, arguably Williams, as a person skilled in the art of satellite control, should have understood the equivalence of on-board microprocessors and predicted their success as a substitute for ground-based computers. *Id.* at 1365; *see also* Laura A. Handley, *Refining the Graver Tank Analysis with Hypothetical Claims: A Biotechnology Exemplar*, 5 HARV. J.L. & TECH. 31, 38 (1991).

155. *See* *Wilson Sporting Goods Co. v. David Geoffrey & Assocs.*, 904 F.2d 677, 684 (Fed. Cir. 1990) (stating that “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”); *Burk & Lemley, supra* note 151, at 1594 (stating that “a patentee is not permitted to capture claim scope under the doctrine of equivalents that she would not have been permitted to capture at the time of prosecution”).

156. It is important to realize that patent litigation would still be quite uncertain even if the DOE were abolished. *See* Kimberly A. Moore, *Are District Court Judges Equipped to Resolve Patent Cases?*, 15 HARV. J.L. & TECH. 1, 4 n.10 (2001):

In 1999, I conducted a survey at the annual conference of the Association of Corporate Patent Counsels. On a scale of 1–10 (with 10 being very confident), respondents’ confidence in the jury’s ability to understand the technology in patent cases was only 3.7. One Chief Patent Counsel with more than thirty years experience wrote ‘JURIES JUST PLAIN CAN’T DECIDE PATENT CASES PERIOD. . . . THIS IS HOPELESS.’ Interestingly, the respondents

costs as the Federal Circuit has bolstered various notice-based rules to brake the expansion of the DOE and reduce the uncertainty it creates. Three particularly important rules are: (1) the all-elements rule; (2) the public dedication rule; and (3) the prosecution history estoppel rule. We believe the Federal Circuit is strengthening constraints on the DOE because it is starting to appreciate the endogenous nature of claim-drafting frictions, and the negative effects of the doctrine on the incentive to draft high quality applications.

1. The All-Elements Rule

Historically, infringement was determined by looking at the claimed invention as a whole.¹⁵⁷ But beginning in the late 1980s, the Federal Circuit grew wary of this approach because of its failure to give adequate weight to each claim limitation and its inability to cabin jury discretion. This evolution culminated in *Pennwalt Corp. v. Durand-Wayland, Inc.*¹⁵⁸ An en banc Federal Circuit emphasized the importance of each claim limitation when determining infringement under the DOE, noting that “each limitation must be viewed in the context of the entire claim.”¹⁵⁹ To this end, the court, over a vigorous dissent, adopted what has been called the “all-elements rule” or “all-limitations rule,”¹⁶⁰ whereby a DOE inquiry compares the accused product to each claim limitation instead of the invention as a whole.¹⁶¹ As Judge Nies added in a concurring opinion, “If an accused device does not contain at least an equivalent for each limitation of the claim, there is no infringement because a required part of the claimed invention is *missing*.”¹⁶² In support, the court cited the following language from a prior opinion:

did not have much more confidence in the ability of district court judges to understand the technology in patent cases. On a scale of 1–10, their confidence in judges was only 5.6.

157. See, e.g., *Hughes Aircraft*, 717 F.2d at 1364; *Perkin-Elmer Corp. v. Westinghouse Elec. Corp.*, 822 F.2d 1528, 1532–33 (Fed. Cir. 1987).

158. 833 F.2d 931 (Fed. Cir. 1987) (en banc).

159. *Id.* at 935.

160. The Federal Circuit has expressed a preference for the word “limitation” (instead of “element”) when referring to claim language, and “element” when referring to the accused device. See *Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co.*, 234 F.3d 558, 563 n.1 (Fed. Cir. 2000) (en banc) (“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.”). To this end, the court has also noted that the “All Elements rule might better be called the All Limitations rule.” *Ethicon Endo-Surgery, Inc. v. U.S. Surgical Corp.*, 149 F.3d 1309, 1317 n.1 (Fed. Cir. 1998).

161. The operation of the all-elements rule is illustrated in the following example. Suppose a patent claims a process comprising step 1, followed by step 2, followed by step 3. Suppose an alleged infringer gets the process to work using step 1 followed by step 3 with step 2 omitted. Then there is no literal infringement because step 2 is omitted. Similarly, the all-elements rule of *Pennwalt* precludes application of the DOE because step 2 is omitted. Under the old rule, a finding of infringement under the DOE was possible when courts looked at the invention as a whole.

162. *Pennwalt*, 833 F.2d at 949 (Nies, J., concurring).

One must start with the claim, and though a “non-pioneer” invention may be entitled to some range of equivalents, a court may not, under the guise of applying the doctrine of equivalents, erase a plethora of meaningful structural and functional limitations of the claim on which the public is entitled to rely in avoiding infringement. . . . Though the doctrine of equivalents is designed to do equity, and to relieve an inventor from a semantic strait jacket when equity requires, it is not designed to permit wholesale redrafting of a claim to cover non-equivalent devices, i.e., to permit a claim expansion that would encompass more than an insubstantial change.¹⁶³

The rationale behind the all-elements rule is that a particularized DOE analysis will better serve the notice function. The Supreme Court in *Warner-Jenkinson Co. v. Hilton Davis Chemical Co.*, recognizing that “[t]here can be no denying that the doctrine of equivalents . . . conflicts with the definitional and public-notice functions of the statutory claiming requirement,”¹⁶⁴ adopted the element-by-element test for the DOE.¹⁶⁵

2. The Public Dedication Rule

Recent Federal Circuit panels have jostled over the question of whether the DOE is barred when the alleged equivalent is expressly disclosed in the patent, but not literally claimed.¹⁶⁶ In *Maxwell v. J. Baker, Inc.*,¹⁶⁷ the patent concerned a system for attaching mated pairs of shoes. The patent’s claims required an “extended separate tab” arrangement. An accused product used an “under the sock lining” arrangement. The patent disclosed an “under the sock lining” arrangement as an alternative embodiment. The Federal Circuit reversed a judgment of infringement based on a jury verdict.¹⁶⁸ The court reasoned that to allow an equivalency finding in such a case would permit patentees to file broad disclosures and then escape PTO examination by presenting only narrow

163. *Id.* at 935 (quoting *Perkin-Elmer Corp. v. Westinghouse Elec. Corp.*, 822 F.2d 1528, 1532–33 (Fed. Cir. 1987)).

164. 520 U.S. 17, 29 (1997).

165. According to the Court:

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 individual element, is not allowed such broad play as to effectively eliminate that element in its entirety. So long as the doctrine of equivalents does not encroach beyond the limits just described, or beyond related limits . . . we are confident that the doctrine will not vitiate the central functions of the patent claims themselves.

Id. at 29–30.

166. The dedication rule dates back to the late nineteenth century. See *Miller v. Bridgeport Brass Co.*, 104 U.S. 350, 352 (1881) (“[T]he claim of a specific device or combination, and an omission to claim other devices or combinations apparent on the face of the patent, are, in law, a dedication to the public of that which is not claimed.”).

167. 86 F.3d 1098 (Fed. Cir. 1996).

168. *Id.* at 1112.

claims.¹⁶⁹ It noted that a patentee who claims too narrowly can seek reissue within two years of the patent's issuance.

Maxwell carefully distinguished the Supreme Court's *Graver Tank* decision, in which the alleged equivalent element (manganese silicate) was disclosed in the specification. In *Graver Tank*, the patent contained both a broad claim that included manganese silicates generically and a narrower claim that was limited to alkaline earth silicates, which excluded manganese silicates. The Supreme Court held that the broader claim was invalid but that the narrower claim was valid and was infringed under the DOE.¹⁷⁰ Thus, the disclosed equivalent was not in fact "unclaimed" and could not be said to have been dedicated to the public.¹⁷¹

Two years later, in *YBM Magnex, Inc. v. ITC*,¹⁷² the court rebuffed *Maxwell*. But the Federal Circuit eventually granted en banc review to resolve the *Maxwell/YBM* conflict. In *Johnson & Johnston Associates, Inc. v. R.E. Service Co.*,¹⁷³ the court sided with *Maxwell*:

As stated in *Maxwell*, when a patent drafter discloses but declines to claim subject matter, as in this case, this action dedicates that unclaimed subject matter to the public. Application of the doctrine of equivalents to recapture subject matter deliberately left unclaimed would "conflict with the primacy of the claims in defining the scope of the patentee's exclusive right."¹⁷⁴

3. Prosecution History Estoppel: An Absolute Bar Approach . . . Almost

In May of 2002, the United States Supreme Court decided *Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co.*,¹⁷⁵ one of the most significant patent law cases in recent history. Writing for a unanimous Court, Justice Kennedy emphasized the need to maintain, on the one hand, the integrity of one's proprietary interest, and, on the other hand, the need for competitors (and the public to a lesser extent) to enjoy a degree of certainty so that they may engage

169. *Id.* at 1117.

170. *Graver Tank & Mfg. Co. v. Linde Air Prods. Co.*, 339 U.S. 605, 612 (1950).

171. *See also* *Moore U.S.A., Inc. v. Standard Register Co.*, 229 F.3d 1091, 1107 (Fed. Cir. 2000) ("In *Maxwell* . . . we explained the contrary principle that 'subject matter disclosed in the specification, but not claimed, is dedicated to the public in determining infringement under the doctrine of equivalents.' . . . Having fully disclosed two distinct embodiments, one in which the first and second longitudinal strips extend a majority of the length of the longitudinal marginal portions, and one in which they do not, Moore is not entitled to 'enforce the unclaimed embodiment as an equivalent of the one that was claimed.'").

172. 145 F.3d 1317, 1320 (Fed. Cir. 1998) ("The Supreme Court's guidance in *Warner-Jenkinson* and *Graver Tank* does not permit the blanket rule that everything disclosed but not claimed is barred from access to the doctrine of equivalents, whatever the facts, circumstances, and evidence." (citations omitted)). In *Warner-Jenkinson* the Supreme Court did not directly address the issue of dedication by unclaimed disclosure. It did reject the opposite argument: that equivalents should be *limited* to equivalents disclosed in the patent.

173. 285 F.3d 1046 (Fed. Cir. 2002).

174. *Id.* at 1054.

175. 535 U.S. 722 (2002).

in improvement or design-around activity. In short, a “patent holder should know what he owns, and the public should know what he does not.”¹⁷⁶

The Court explored this “delicate balance” in the context of the DOE and Prosecution History Estoppel (PHE).¹⁷⁷ The former was reaffirmed, despite the uncertainty it engenders, “as the price of ensuring the appropriate incentives for innovation.”¹⁷⁸ But to ameliorate the problems associated with inevitable uncertainty, the Court also reaffirmed the role of PHE as an important interpretive, uncertainty-limiting tool. Along the way, the Court, while sympathetic to the Federal Circuit’s concern about the DOE’s destabilizing impact on the notice function, reversed the Federal Circuit’s absolute bar approach.¹⁷⁹ The “absolute bar” precluded application of the DOE with respect to a narrowed claim limitation regardless of the reason. The Supreme Court admonished the Federal Circuit “that courts must be cautious before adopting changes that disrupt the settled expectations of the inventing community.”¹⁸⁰ The Court settled on a compromise between the absolute bar and the earlier flexible bar approach.¹⁸¹

But the Court, clearly concerned about uncertainty in a property-rights system, established a rebuttable presumption, which begins with an understanding that a narrowing amendment is a “general disclaimer of the territory between the original claim and the amended claim.”¹⁸² Unless rebutted, PHE “bars a finding of equivalence.”¹⁸³ How can the patentee rebut the presumption? The patentee must show that at the time the application was filed, a person having ordinary skill in the art would have literally claimed the equivalent but did not because “[1] [t]he equivalent may have been unforeseeable at the time of the application; [2] the rationale underlying the amendment may bear no

176. *Id.* at 731.

177. Prosecution history estoppel precludes application of the DOE to recover subject matter that was surrendered during patent prosecution. *See id.* at 734.

178. *Id.* at 732.

179. *Id.* at 740–41.

180. *Id.* at 739 (citing *Warner-Jenkinson Co. v. Hilton Davis Chem. Co.*, 520 U.S. 17, 28 (1997)).

181. Accordingly:

The narrowing amendment may demonstrate what the claim is not; but it may still fail to capture precisely what the claim is. There is no reason why a narrowing amendment should be deemed to relinquish equivalents unforeseeable at the time of the amendment and beyond a fair interpretation of what was surrendered. Nor is there any call to foreclose claims of equivalence for aspects of the invention that have only a peripheral relation to the reason the amendment was submitted. The amendment does not show that the inventor suddenly had more foresight in the drafting of claims than an inventor whose application was granted without amendments having been submitted. It shows only that he was familiar with the broader text and with the difference between the two. As a result, there is no more reason for holding the patentee to the literal terms of an amended claim than there is for abolishing the doctrine of equivalents altogether and holding every patentee to the literal terms of the patent. This view of prosecution history estoppel is consistent with our precedents and respectful of the real practice before the PTO.

Id. at 738.

182. *Id.* at 740.

183. *Id.* at 741.

more than a tangential relation to the equivalent in question; or [3] . . . some other reason suggesting that the patentee could not reasonably be expected to have described the insubstantial substitute in question.”¹⁸⁴

The all-elements rule, public dedication rule, and the rebuttable absolute bar presumption¹⁸⁵ are all attempts by the Federal Circuit and the Supreme Court to elevate the importance of the patent law’s notice function. A laudable goal, but to what end? Of course, clarity is valuable, but these rules tell us nothing about how and when the DOE should apply. A critical theory, like the notice theory, must be complemented by a constructive theory justifying the DOE. We believe the refinement theory does just that.

III. A MODEL OF INVENTION, REFINEMENT, AND THE DOCTRINE OF EQUIVALENTS

A. BASIC MODEL

A simple game-theoretic model yields a rich, intuitive understanding of the role of the DOE in patent law. Our basic model features two players: an inventor and a competitor. The inventor decides whether to undertake invention, and whether to refine the invention. Following the inventor’s actions, the competitor may have an opportunity to imitate the invention, depending on the inventor’s actions and whether the DOE applies. Specifically, the inventor decides whether to invest w to invent the embodiments in set E .¹⁸⁶ Next, the inventor decides whether to invest x to refine the invention and obtain the embodiments in set F .¹⁸⁷ Finally, the competitor decides whether to invest y to

184. *Id.* at 740–41. The Court was careful not to call this presumption a “complete bar by another name,” but it will be interesting to see just how often patentees are able to successfully rebut the presumption.

185. In addition to these three rules, in the mid-1990s there was a strong push, ultimately unsuccessful, to take the equivalents inquiry away from the jury, which was thought to be too capricious for a well-functioning property-rights system. For example, in *Hilton Davis Chemical Co. v. Warner-Jenkinson Co.*, 62 F.3d 1512 (Fed. Cir. 1995) (en banc), the majority treated the DOE as a factual question for the jury, but the dissent argued that the DOE should be invoked at the court’s discretion as an equitable tool. *Id.* at 1549 (Lourie, J., dissenting) (noting that the DOE should only be applied in “unusual cases” and that the “fact-finder should principally be focused on claims Otherwise, the meaning of the claims is diminished, contrary to the statutory scheme that a patent specification shall conclude with claims that particularly point out and distinctly claim the invention”). Although the Supreme Court granted certiorari, it declined to address the jury issue. *See Warner-Jenkinson Co. v. Hilton Davis Chem. Co.*, 520 U.S. 17, 38–39 (1997) (“Because resolution of whether, or how much of, the application of the doctrine of equivalents can be resolved by the court is not necessary for us to answer the question presented, we decline to take it up Whether, if the issue were squarely presented to us, we would reach a different conclusion than did the Federal Circuit is not a question we need decide today.”).

186. We assume the inventor knows exactly how much to spend, and exactly what result she will obtain at both the invention and refinement stage. One can obtain results similar to those described above with a more general research technology, for example, a technology in which the probability of obtaining E is an increasing function of w (likewise for F and x).

187. *See Wagner, supra* note 8, at 236–37 (describing extra costs that would be imposed on patent applicants by restricting the DOE).

imitate the invention and develop an embodiment in F .¹⁸⁸ This section contains an intuitive discussion and the appendix contains the formal analysis of the model.

First, we analyze the model under a regime with the DOE. We suppose that the inventor cannot claim any invention unless she invests w . If she invests w , then she achieves an invention and enables two distinct sets of embodiments E and F . Notice that our assumption that set F is enabled does not imply the inventor “possesses” the embodiments in F or can claim F . (We assume that a claim to E and F satisfies novelty, non-obviousness and other patent requirements.) We implement the DOE by assuming the inventor only needs to claim the embodiments in E to get the rights to both sets of embodiments.¹⁸⁹ The competitor is deterred from using an embodiment in E or F because of the threat of a patent suit.

In the regime without the DOE the inventor’s rights are limited to the literal scope of her claim. She claims only the embodiments she obtains through invention and refinement. If she invents E but does not refine her invention, then her patent claim is limited to E . If she invents and refines, then she claims E and F . In a regime without the DOE the competitor never uses an embodiment in E because of the threat of suit, but may invest y to obtain an embodiment in F if the inventor chooses not to refine.

To properly interpret the model, the reader must understand exactly what we mean by refinement, and how we model patent claims, the enablement doctrine, and literal infringement. We define refinement as the process of identifying and claiming the broadest patentable set of embodiments enabled by the disclosure in the patent specification. We distinguish refinement from enablement and reduction to practice. The technical disclosure made in the patent application enables a person having ordinary skill in the art to practice a range of embodiments of the technology. In our model we always assume that the inventor has enabled sets E and F . In other words, the hypothetical person of ordinary skill can make and use the embodiments in E and F without undue experimentation.¹⁹⁰ Actual reduction to practice occurs when an inventor makes a physical embodiment of an invention and the invention works for its intended purpose.¹⁹¹ In general, patent rights are obtainable without actual reduction of an invention to practice as long as the written description and claims satisfy the

188. See *supra* note 23 for a discussion of how we define “imitation.”

189. See *Merges & Nelson, supra* note 73, at 845–60 (explaining how claim breadth and the doctrine of equivalents determine the scope of a claim).

190. See *AK Steel Corp. v. Sollac & Ugine*, 344 F.3d 1234, 1244 (Fed. Cir. 2003) (“The enablement requirement is satisfied when one skilled in the art, after reading the specification, could practice the claimed invention without undue experimentation.”).

191. *Mazzari v. Rogan*, 323 F.3d 1000, 1005 (Fed. Cir. 2003) (“To establish an actual reduction to practice, an inventor must prove that he constructed his claimed invention and that it would work for its intended purpose.”).

enablement and other disclosure requirements.¹⁹² Similarly, we allow the inventor in our model to literally claim set F , regardless of whether she actually reduced to practice the embodiments in F . Instead, the model allows the inventor to literally claim F after mentally identifying the embodiments in F as following from the same inventive principle that led to E .

The payoffs to the inventor and the competitor depend on the actions they choose and whether the DOE is available. Given invention and refinement, the inventor gets patent rights covering E and F , and earns the monopoly profit of M_2 . Given invention without refinement, the inventor gets patent rights covering E and F under the DOE regime, and earns a smaller monopoly profit of M_1 . The monopoly profit depends in part on whether the inventor has invested in refinement. Refinement gives the inventor a better understanding of the invention, a different source of value than patent scope, thus, M_2 is greater than M_1 . Given invention without refinement, the inventor gets patent rights covering E under the regime without the DOE. If the competitor develops an embodiment in F , then both parties earn a duopoly profit of D , and if the competitor does not develop an embodiment in F , then the inventor earns a profit of M_1 , and the competitor gets nothing.¹⁹³ We use the term monopoly for convenience and do not mean to imply that the inventor becomes a true monopolist for some new product. We simply intend that M_1 represents the profit attributable to the patent when the inventor does not refine and no other firm uses the invention. Similarly, D is the profit available to the inventor and the competitor when they both practice the technology.

192. This is known as “constructive reduction to practice,” which is usually accomplished by filing an enabling patent application with so-called “paper examples.” The Federal Circuit has described constructive reduction to practice as follows:

Paper examples meet the practical need of compliance with the requirement for specific embodiments of every invention, as well as with aspects of patent law such as the need to provide a full range of variables or to describe and enable alternatives or equivalents. To fulfill their legal purpose, such examples must be enabling of specific embodiments. For some inventions the detailed embodiments can be described and enabled by the inventor without conducting full laboratory experiments or building entire machines. The patent law authorizes that an invention may be constructively reduced to practice by filing a patent application, whether the embodiments were actually made or are constructed in the patent application.

“Constructive reduction to practice” is a legal status unique to the patent art. Unlike the rules for scientific publications, which require actual performance of every experimental detail, patent law and practice are directed to teaching the invention so that it can be practiced. The inclusion of constructed examples in a patent application is an established method of providing the technical content needed to support the conceived scope of the invention.

Hoffman-La Roche, Inc. v. Promega Corp., 323 F.3d 1354, 1377 (Fed. Cir. 2003).

193. The inventor receives M_1 under a DOE regime when he does not expend x and refine; or, under a no DOE regime when neither he refines nor the competitor imitates. Because the competitor does not imitate, the inventor in a no DOE world still earns M_1 (instead of D) even though his patent scope is limited to E . Therefore, the inventor’s profit in a no DOE regime is dependent upon whether the competitor expends y and imitates. If the competitor imitates, both parties earn monopoly profit D whereby $M_1 < D$.

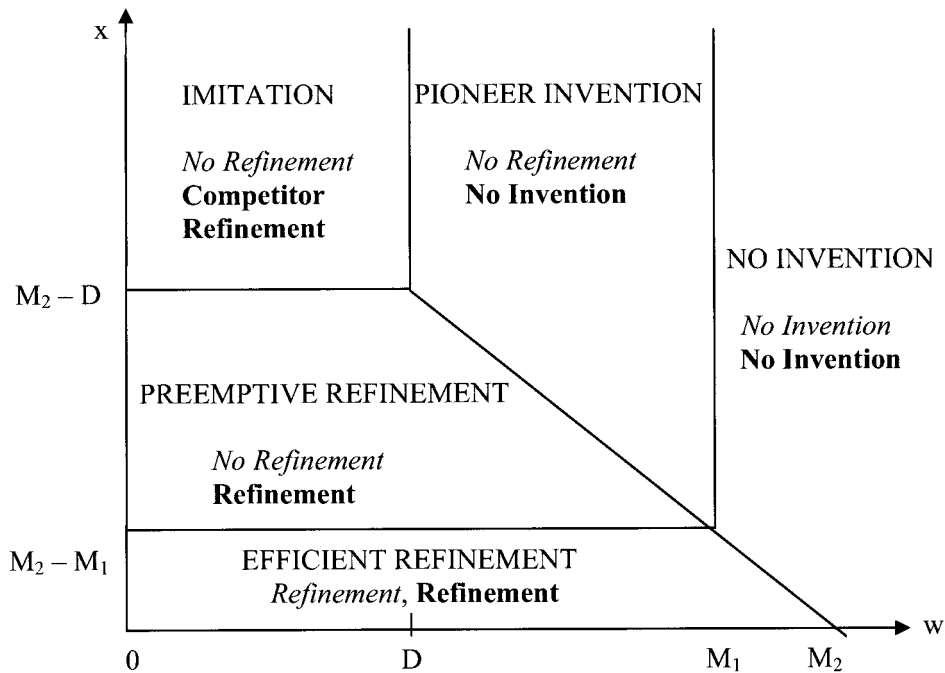


Figure 1

We designed the model so that the behavior under the DOE regime is very easy to understand. The competitor never uses the technology because of the threat of a patent suit. The inventor invents if the cost of invention w is not too high, and conditional on invention, refines if the cost of refinement x is not too high. Figure 1 displays the equilibrium outcomes under both regimes; outcomes under the DOE regime are listed in italics, and outcomes under the no DOE regime are listed in bold. The cost of invention is measured along the horizontal axis and the cost of refinement is measured along the vertical axis. The region labeled NO INVENTION indicates the inventor does not invent if the costs of invention plus refinement are high. The region labeled EFFICIENT REFINEMENT indicates the inventor efficiently invents and refines when invention and refinement costs are sufficiently low. We describe refinement as efficient because it is socially valuable and profitable regardless of strategic considerations. In the remaining three regions, IMITATION,¹⁹⁴ PIONEER INVENTION, and PREEMPTIVE REFINEMENT, the DOE regime leads to invention but no refinement because in these three regions the cost of refinement x is greater than the benefit from refinement $M_2 - M_1$. Equilibrium behavior is more complicated under the regime without the DOE, because the possibility of entry by the competitor influences the inventor's behavior. That possibility is missing from

194. See *supra* note 23 for a discussion of how we define "imitation."

the regime with the DOE because the inventor automatically gains rights over F when she obtains set E . Under the regime without the DOE, the inventor may refine the technology for strategic reasons rather than efficiency. In other words, the inventor may obtain F simply to block the competitor from developing an embodiment in F or to enhance his bargaining position in a cross-licensing negotiation.¹⁹⁵ We call this preemptive refinement.

Preemption is not an issue when the competitor does not pose a credible threat of entry. Even without the DOE, the competitor will not develop an embodiment in F if the cost of refinement is too high or the duopoly profit is too low. Precisely, if $D < y$ then competition is not credible and equilibrium behavior is the same under either regime. Figure 1 shows the equilibrium outcomes without DOE in the interesting case when $D \geq y$; thus, the competitor will find imitation profitable if he has the opportunity.

Figure 1 facilitates a policy comparison of the DOE and no DOE regimes. It shows that equilibrium outcomes are the same in the NO INVENTION and EFFICIENT REFINEMENT regions. The presence of a potential competitor is irrelevant for parameter values falling in these regions. In the NO INVENTION region invention is too costly regardless of whether the DOE is available. In the EFFICIENT REFINEMENT region refinement is profitable regardless of whether a competitor exists.

In the other three regions the DOE yields different outcomes from the regime without the DOE. The DOE induces invention in the region labeled PIONEER INVENTION, but there is no invention without it. The absence of the DOE induces refinement in the region labeled PREEMPTIVE REFINEMENT, but there is no refinement given the DOE. Finally, the absence of DOE allows entry in the region labeled IMITATION, while there is neither refinement nor imitation under the DOE.

The model yields four main results that have policy significance. We present these results in the following four propositions.

Proposition 1. The DOE does not strengthen patent rights when the inventor's cost of refinement is relatively small, or when a potential competitor does not pose a credible threat of entry. The two regimes give the same results when the inventor's refinement cost is less than or equal to the benefit from obtaining both sets of embodiments E and F , i.e., $x \leq M_2 - M_1$. This equivalence arises because the greater scope offered by the DOE is immaterial when the inventor gains a direct benefit from refinement. Likewise, the two regimes are equivalent when the potential competitor does not pose a credible threat of entry because the duopoly profit is small relative to the competitor's refinement cost, i.e., $D < y$. In these cases policy should be chosen on the basis

195. This type of behavior is quite common among certain industries. See generally Wesley M. Cohen, Richard R. Nelson, & John P. Walsh, *Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or Not)* (Nat'l Bureau of Econ. Research, Working Paper No. 7552, 2000) (empirical study demonstrating that certain industries seek patent protection to block rivals from developing technology or to enhance licensing bargaining position).

of considerations outside the scope of our model. For example, one might choose no DOE because the DOE creates fuzzier property rights and imposes greater litigation costs.¹⁹⁶

Proposition 1 helps identify conditions such that the notice concern about patent claims should weigh heavily in formulating patent policy.¹⁹⁷ Patent law appears to be roughly consistent with this goal; it constrains the use of the DOE when it is likely to create uncertainty costs with little offsetting benefits. For example, two doctrines properly limit the DOE based on prosecution activities. First, prosecution history estoppel creates a presumption against the DOE for embodiments ceded by amendment or argument.¹⁹⁸ Second, the public dedication doctrine precludes the use of the DOE to protect embodiments that inventors have described in their applications without claiming.¹⁹⁹ In both situations,

196. See *Hilton Davis Chem. Co. v. Warner-Jenkinson Co.*, 62 F.3d 1512, 1532 (Fed. Cir. 1995) (Newman, J., concurring) (“Persons who appropriate the patentee’s concept may add technologic value in a variety of ways: perhaps by developing a different path to the new markets opened by the patentee, perhaps by adapting later-developed technology to enhance that of the patentee, perhaps by perceiving alternatives and opportunities from a different perspective than that of the patentee. All of these activities would bear lower risk to the appropriator if the patentee’s claims were strictly limited to their literal scope, for the patentee’s access to the remedy of equivalency imposes upon the appropriator the risk of litigation, damages, and injunction.”). On the other hand, we note in footnote 156, *supra*, that litigation would be quite uncertain even if the DOE were abolished.

197. Thomas argues that the notice theory is flawed and that it should not play an important role in DOE policy. See Thomas, *supra* note 119, at 160–69. We find aspects of his argument persuasive, but reject his conclusion. Our disagreement arises in part because courts and commentators have not fully developed the notice theory, and the label is used in different ways by different authors. We perceive three social costs aggravated by uncertain patent scope: opportunistic and anticompetitive patent suits; licensing problems; and inadvertent infringement. Thomas focuses on the third problem, and argues that restricting the DOE has done little to reduce the problem of inadvertent infringement. In contrast, we emphasize that restrictions on the DOE likely reduce the first two costs significantly. We think the effect of the DOE on inadvertent infringement is an open question.

Thomas argues competitors find it difficult to avoid patent infringement when they introduce new technology because of the high number of enforceable patents, the secrecy of many pending applications, factors discouraging prior art search, and the obscurity of claim language. *Id.* at 161–63. He doubts that constraints on the DOE will make much difference in light of these other problems. It is possible, however, that restrictions on the DOE created, for example, by the public dedication rule might create safe harbors that will reduce the risk of inadvertent infringement. Ultimately, the effect of the DOE on inadvertent infringement presents an empirical question that will be difficult to answer. We are more confident that the clarity created by restricting the DOE significantly facilitates licensing. Obviously, the problems of secrecy and patent volume are not relevant when two parties negotiate a license. In addition, for patents in which the parties agree on the meaning of the claims, the DOE is the chief source of uncertainty and the main impediment to a licensing agreement.

Finally, our broader understanding of the notice theory suggests a different sort of benefit arises from restrictions on the DOE. Summary judgment in favor of the defendant is very difficult to achieve in patent lawsuits if the factual questions presented by the DOE are always in play. Legal questions that bar application of the DOE make it more likely that a defendant can prevail on summary judgment. Possibly, this promotes settlement in patent cases, and surely helps discourage opportunistic and anticompetitive patent litigation. See Meurer, *supra* note 30, at 530–35.

198. See *Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co.*, 535 U.S. 722, 741–42 (2002).

199. See *Johnson & Johnston Assocs. v. R.E. Serv. Co.*, 285 F.3d 1046, 1053 (Fed. Cir. 2002) (en banc); Matthew C. Phillips, *Taking a Step Beyond Maxwell To Tame the Doctrine of Equivalents*, 11 FORDHAM INTELL. PROP. MEDIA & ENT. L.J. 155, 180–81 (2000) (“The needed additional step is to

the cost of refining a claim to include such embodiments must be low.²⁰⁰

The DOE should also be limited or proscribed for minor inventions in crowded fields of technology. Competitors have little motivation to invent around a patent claim (i.e., develop an embodiment in *F*) when the prior art offers adequate substitutes. Patent law has taken steps to restrict the DOE in crowded fields of technology by precluding its application to accused devices in the prior art and those obvious in light of the prior art.²⁰¹

Proposition 2. Pioneer inventions should enjoy a presumption in favor of applying the DOE. The DOE induces inventions that would not occur in its absence. Prospective inventors may be discouraged from inventing when they face high invention and high refinement costs. The inventor can avoid refinement costs under the DOE, and this cost saving might be crucial to encouraging invention. Without the DOE, inventive incentives are dampened by the prospect of paying high refinement costs or alternatively the prospect of entry by a competitor. This insight helps justify the practice of rewarding pioneer inventors with broader application of the DOE.

Previous discussion of pioneer inventions conflates analysis of the DOE with the enablement doctrine. Courts and commentators have expressed a desire to give pioneers a bigger patent-based reward. The impulse to reward pioneers with broader patent scope seems natural. The enablement doctrine allows broad claim scope when a pioneer enriches society with a significant technological disclosure. Thus, generous treatment of pioneer inventions guides potential inventors to invest in socially important research.²⁰² This theory does not explain, however, generous treatment of pioneer inventions under the DOE. Patent law should be careful to avoid a double reward to pioneer inventions. Applying the DOE to pioneer inventions with low refinement costs would be redundant. The policy of granting more generous DOE protection only makes sense if pioneer inventions tend to have high refinement costs. The policy should be interpreted as using the pioneer status of an invention to create a presumption of high refinement costs, and that presumption should be rejected in the face of more direct evidence of low refinement costs.

Proposition 3. The DOE discourages preemptive refinement. Inventors

impute to a patent applicant knowledge of the prior art for the purpose of determining what she regards as her invention. That is, the dedication rule applied in *Maxwell* should be broadened to bar from equivalents unclaimed features that were disclosed or could have been disclosed by virtue of being known in the art at the time of filing.”).

200. See *infra* Part IV.E; see also Wagner, *supra* note 8, at 188 (“[P]atentees could take a number of steps to avoid any potentially deleterious consequences of a finding of prosecution history estoppel during litigation, such as conducting prior art research to determine the appropriate scope of the claims, drafting claims more carefully, either claiming more narrowly to avoid the prior art, or crafting claims that, when amended, maintain a broad scope of literal coverage.”).

201. See, e.g., *Wilson Sporting Goods Co. v. David Geoffrey & Assocs.*, 904 F.2d 677, 684 (Fed. Cir. 1990).

202. Jay Thomas observes that pioneer status as defined by patent law does not correlate very well with the social value of an invention. See John R. Thomas, *The Question Concerning Patent Law and Pioneer Inventions*, 10 HIGH TECH. L.J. 35, 52–58 (1995).

operating in a regime without the DOE have rights only over the embodiments they literally claim. They can only gain rights over the embodiments in F if they invest in refinement. We apply the label preemptive refinement when the inventor does not profit directly from claiming F , but indirectly profits by excluding a potential competitor.²⁰³ Preemptive refinement has no direct value to the inventor and thus will not occur under the DOE.

The social welfare effects of preemptive refinement are mixed, thus it is difficult to draw clear policy prescriptions. Social welfare is harmed because preemptive refinement causes profit to fall as refinement costs are expended.²⁰⁴ But the refinement discouraged by the DOE can be socially desirable even though it is unprofitable. It may be socially desirable if the increase in consumer surplus more than offsets the decline in profit. Refinement is most likely to be socially desirable when E and F are relatively differentiated, and refinement costs are low. When E and F are relatively differentiated, consumers who have a strong preference for F enjoy the benefit of refinement. If the two embodiments are close substitutes, then refinement is a social as well as a private loss. There is no social benefit from forcing an inventor to refine essentially redundant technology.²⁰⁵

Proposition 4. No DOE encourages imitation. Imitation never occurs under the DOE in our model. The no DOE regime offers potential social gains because it encourages imitation. High refinement costs make preemptive refinement unprofitable. Without the DOE competitors can imitate the patent if the inventor's refinement cost stops her from refining preemptively. The social gains flow from access to both embodiments, and also from competition between the inventor and competitor which drives down the price and increases the diffusion of the invention.²⁰⁶

203. We choose the term preemptive refinement to stress the similarity to the economic literature on preemptive invention. See JEAN TIROLE, *THE THEORY OF INDUSTRIAL ORGANIZATION* 350–52, 393 (1988). Preemption is possible in our model because the potential competitor chooses to avoid a narrow literal claim of E by choosing an embodiment in a clearly specified set F . The patentee can refine and claim all the embodiments in F , and preempt the potential competitor who has no other avoidance strategy available. In a more general model, there could be variegated avoidance strategies, some that are cheap and others that are costly. In such a world, an attempt to preempt the cheap avoidance strategies by claiming the relevant embodiments (presumably at a low refinement cost), would be met with a shift by the competitor to a more costly avoidance strategy (assuming the patentee finds further refinement unprofitable). Doug Lichtman makes a similar argument. See Lichtman, *supra* note 27, at 177. He uses the label “arms race” for his argument. We prefer “preemption” because “arms race” suggests a dynamic process that many commentators have observed in trade secret and software copyright protection settings but does not apply in the patent settings we have in mind.

204. In this model the incentive to invent is always adequate in the PREEMPTIVE REFINEMENT region, but in a more general model the incentive would suffer.

205. Inventors are likely to spend more refining claims to inventions they believe are more valuable. Hence the social cost of preemptive refinement may be greater for more valuable inventions. On the other hand, if inventors are poorly informed about the value of an invention at the time of patent application, they might spend relatively little on preemptive refinement. Thus, evidence that inventors have a good idea about which patents are most valuable, works in favor of a stronger DOE.

206. Those benefits are offset by the cost of refinement and the loss of innovative incentive attributable to the decline in the inventor's profit.

Critics of the DOE emphasize the competitive and innovative benefits associated with inventing around patents. Those benefits are real, but they can be exaggerated. Notice that curtailing the DOE may result in preemptive refinement by the inventor rather than competitive imitation. Gains from competition are lost if preemptive refinement occurs rather than imitation. Also notice that imitation by the competitor is limited in our model to cases in which the cost of invention is relatively low and the inventor's cost of refinement is relatively high. Now if the competitor's cost of development is also high, then the competitor will not pose a credible threat of entry. Thus, inventing around a patent depends on the competitor having a low development cost while the inventor has a high cost of refinement.²⁰⁷ Certain factors make such asymmetry plausible. The inventor might lack some expertise or asset held by the competitor that helps with development and refinement. No DOE is probably better in this case, but maybe not if the technologies are close substitutes or if the inventor could contract with the competitor for development services.

The social welfare case for imitation is strongest when the defendant develops an embodiment in F that improves on the technology in E .²⁰⁸ Merges and Nelson write approvingly about courts who highlight technical advances in the accused device as a way of limiting the scope of the DOE.²⁰⁹ This policy preference can be implemented when judges rule as a matter of law that an improved device does not satisfy the test of equivalency.²¹⁰ Regardless of whether the defendant is found to infringe, the possibility of patenting the improvement remains as a source of incentive for improvers.²¹¹

B. TWO PERIOD EXTENSION

We extend the basic model by adding a second period to the development and refinement process. As before, in the first period, the inventor enjoys an opportunity to refine the technology before the potential entrant has a chance to

207. Imitation is unlikely in a scenario with $x = y$. Preemption is the norm in this case because the inventor protects $M_I - D$ by investing x , while the entrant is trying to capture D with an investment of y . Normally, $M_I - D$ is bigger than D , if $x = y$ we should expect preemption.

208. Imitators often choose an inferior version of an invention to escape literal infringement. Possibly, the accused process in *Warner-Jenkinson* illustrates this tendency. The defendant's process operated at a lower pH, which might have been inferior because of problems with foaming. See *Warner-Jenkinson Co. v. Hilton Davis Chem. Co.*, 520 U.S. 17, 22 n.2 (1997). The DOE has a positive effect when it blocks deployment of an inferior technology, but the doctrine should not displace low cost refinement efforts by inventors who can easily claim inferior versions of their technology. Furthermore, an ideal policy also considers the benefits from ex post competition.

209. Merges & Nelson, *supra* note 73, at 854-60.

210. *Id.* at 857 (suggesting *Texas Instruments* as an example).

211. An improvement patent is valuable even if the imitator is infringing, because the owner of the earlier patent cannot practice the improvement without permission from the improver. The improver can profit by licensing or cross-licensing the first patent owner. The difficult policy question is whether the incentive provided by an improvement patent is adequate. See Merges & Nelson, *supra* note 73; Suzanne Scotchmer, *Standing on the Shoulders of Giants: Cumulative Research and the Patent Law*, 5 J. ECON. PERSP. 29 (1991).

imitate. In the second period, the two firms have a simultaneous chance to develop the technology with the possibility of lower development costs in the second period. What does the greater complication buy us? Originally we discussed the question of whether refinement was socially desirable—now we can ask the additional questions: who should refine and when? The extended model allows us to contribute to the debate about whether patent law should encourage centralized or decentralized development of technology. And it allows us to discuss the important policy question of whether the DOE should apply to later-developed technology.

Two related insights emerge from the two period model. First, the DOE encourages orderly development of an invention, which brings social benefits first recognized by Kitch.²¹² Kitch's prospect theory of patents favors broad patent scope because it discourages premature and redundant development of an invention by competitors.²¹³ Second, the benefits of centralized control are smallest when the nature of development and the identity of the most efficient developer is uncertain.²¹⁴ In such cases the central control facilitated by the DOE causes social harm, which leads us to oppose application of the DOE to unforeseeable later-developed technology.

Proposition 5. The DOE encourages orderly development. The DOE protects the inventor from entry and allows the inventor to defer refinement to a later date when the costs of refinement are lower. Furthermore, the entry barrier created by the DOE promotes licensing designed to assist the inventor develop an invention. The inventor may wish to contract for development of the invention by a competitor with lower costs. Absent the DOE the inventor loses the option of deferred refinement. The inventor has a natural lead-time advantage applicable to first period refinement. That advantage disappears in later periods. If there is no DOE, then the inventor must preempt in the first period, if at all. The DOE is socially desirable if it mitigates the harm arising because the inventor spends a lot of money refining inferior technologies. Notice the asymmetry here—when there is no DOE an imitator has to find only one desirable, unclaimed embodiment, but the inventor must claim them all.

Proposition 6. The DOE should not apply to unforeseeable later-developed technology. The appeal of fairness-based intuitions explains why courts and commentators strongly favor application of the DOE to later-developed technology. Later-developed technology cases involve defendants who avoid literal infringement by substituting an equivalent that did not exist at the time the claims were drafted. For example, the DOE has been applied in several cases to counteract the unforeseen effects of invention of the personal

212. See Edmund Kitch, *The Nature and Function of the Patent System*, 20 J. L. & ECON. 265 (1977).

213. *Id.* at 276–77; cf. TIROLE, *supra* note 203, at 402–03.

214. See Merges & Nelson, *supra* note 73; Roberto Mazzoleni & Richard R. Nelson, *The Benefits and Costs of Strong Patent Protection: A Contribution to the Current Debate*, 27 RES. POL'Y 273 (1998).

computer. Courts and commentators usually contend it is unfair to sacrifice claim scope on account of surprising and unforeseen technological developments. Our refinement theory suggests the opposite policy is efficient.

The DOE should not apply to unforeseeable later-developed technology because the benefit of centralized development is low, the cost of preemptive refinement is low, the loss of incentive to invent is low, and the ex post gain from imitation is high. Centralized development loses its value because the inventor cannot coordinate development along a pathway that depends upon unforeseen technology. Likewise, in the absence of the DOE, the inventor does not waste resources trying to preempt an unforeseeable strategy of imitation. Since entry is unforeseen and does not occur until the second period, the effect on the incentive to invent is muted. Therefore, society, not the inventor, should enjoy the windfall associated with the unforeseen development of an equivalent technology.

C. ADDITIONAL CONSIDERATIONS

Like any economic model, the model developed in this Article suppresses important features of the environment. In this section we present our conjectures about how the model would be affected by relaxing various assumptions. For example, we assumed that there was a single potential competitor. Suppose instead, a number of firms could enter the market and possibly develop an embodiment in F . This change would increase the motivation of the inventor to engage in preemptive refinement as described in Proposition 3. Preemptive refinement becomes more appealing in a regime without the DOE because competition from multiple imitators drives profit below the duopoly profit level.²¹⁵ This observation suggests the social value of the DOE is higher in a market with multiple potential competitors.

In contrast, if we relax the assumption that only one firm is capable of creating the invention, then the social value of the DOE is probably lower. A race to get a patent amplifies the incentive effect of a patent. Proposition 2 suggests the DOE creates social value because it induces inventors to make inventions with relatively high invention and high refinement costs they would not make absent the DOE. The incentive boost from the DOE is less needed (from a social perspective) when potential inventors feel pressure to move quickly to outrace their rivals.²¹⁶

The model could also be generalized to address trade secret protection. Clearly, weakening the DOE increases the incentive to choose trade secret

215. Furthermore, when there are multiple potential competitors with different development costs, the credibility of entry as discussed in Proposition 1 is greater, in other words, as more competitors appear, the probability grows that $D \geq y$ for at least one of them.

216. Actually, this statement holds in a more realistic model with stochastic research. In our model with deterministic research, if the sum of refinement and invention costs exceeds the value of a patent when there is only one potential inventor, then it will certainly hold when there is more than one potential inventor.

rather than patent protection. In particular, trade secret protection gives inventors in a no DOE regime a chance to avoid high refinement costs. Consequently, instead of imitation as described in Proposition 4, the outcome could be trade secret protection with attendant social losses from lack of disclosure and greater difficulty contracting for technology transfer.

There are two other features we would like to consider, but they pose tractability problems too great for us to handle in this Article. First, uncertainty and private information should play a role in the model. The notice function of claim language matters because of uncertainty and private information. Critics of the DOE contend the uncertainty created by the doctrine makes litigation more likely and licensing less likely. Unfortunately, our model cannot evaluate these concerns directly. Second, it would be interesting to add cumulative innovation to the model. Merges and Nelson argue that the DOE must be calibrated to promote optimal improvement as well as early stage invention.²¹⁷

IV. POLICY APPLICATIONS

A. REISSUE PROCEEDINGS

Inventors can broaden patent claims through a reissue proceeding at the Patent Office during the first two years after a patent grant.²¹⁸ Patent law offers little to explain why the DOE is necessary given reissue serves as a means of expanding claim scope.²¹⁹ The dissenters in *Graver Tank* concluded that patentees should be encouraged to invoke the reissue proceeding more often and use the DOE sparingly,²²⁰ but experience has proven otherwise. Indeed, the reissue proceeding, for all practical purposes, is in a state of desuetude.²²¹ When presented with the question of whether the DOE was in conflict with the statutory reissue mechanism, the Supreme Court either ignored the argument or expressly refused to address it,²²² and, to our knowledge, the Federal Circuit

217. See Merges & Nelson, *supra* note 73, at 882.

218. See text accompanying notes 108–11.

219. See Janicke, *supra* note 107, at 42 (“Courts and practitioners are told that ‘the claims define the invention,’ and that if a patentee has made a mistake and written the claims too narrowly or too broadly, corrective procedures are available [through a reissue proceeding]. At the same time, however, they are told that ‘insubstantial’ changes do not warrant going through the trouble of reissue and can be, in effect, corrected in litigation by asserting the doctrine of equivalents . . .”). In fact, as noted above, there is significant anecdotal evidence suggesting that prosecutors viewed the DOE as a safety net for prosecutorial mistakes. See Adelman & Francione, *supra* note 5, at 711.

220. See *Graver Tank & Mfg. Co. v. Linde Air Prods. Co.*, 339 U.S. 605, 612–19 (1950) (Black, J., dissenting).

221. In 2001, although 166,000 patents issued, only 480 reissue patents were granted by the Patent Office. U.S. Patent Statistics, http://www.uspto.gov/web/offices/ac/ido/oeip/taf/us_stat.pdf (last visited Oct. 16, 2005).

222. In *Graver Tank*, the majority did not address the issue despite the dissent’s vigorous contention that the common law DOE is improperly supplanting the role of reissue as set forth by Congress. See *Graver Tank*, 339 U.S. at 612–19 (Black, J., dissenting). And in *Warner-Jenkinson*, the Court expressly refused to consider the issue, noting that the argument was made in *Graver Tank* and “failed to command a majority.” *Warner-Jenkinson Co. v. Hilton Davis Chem. Co.*, 520 U.S. 17, 26 (1997).

has not attended to the issue.

Within the current patent regime, the DOE offers inventors several advantages over reissue proceedings, but at a potentially high price from a social welfare perspective. Reissue also has advantages for the inventor—it is a relatively inexpensive, *ex parte* proceeding that allows for claim broadening; but it is more socially attractive than the DOE. The main disadvantages to the inventor are what also make reissue an attractive alternative to the DOE, namely the statutory limit of two years on new claims that broaden the scope of protection²²³ and the doctrine of intervening rights.²²⁴ This doctrine mitigates potential problems related to notice that could arise when claims are broadened post-issuance by excusing competitors who start to practice a technology before the reissue patent is granted (i.e., before notice), such that the technology is outside of the original claims, but covered by a reissue claim.²²⁵ Thus, reissue has much to recommend it. As Justice Black wrote in his *Graver Tank* dissent, reissue “adequately protects patentees from ‘fraud,’ ‘piracy,’ and ‘stealing,’” [while] “also protect[ing] businessmen from retroactive infringement suits and judicial expansion of a monopoly sphere beyond that which a patent expressly authorizes.”²²⁶

Plausibly, one could argue for abolition of the DOE,²²⁷ but we think there is a socially valuable role for both reissues and the DOE. In many cases, experience commercializing a technology reveals mistakes in the patent and reduces the cost of enumerating embodiments enabled by the invention. The two-year window allows further claim refinement via reissue after the costs of refinement have fallen, and the intervening rights doctrine assures that notice costs are not too great. For pioneer inventions, which are often commercialized more slowly, the DOE may be socially desirable because it avoids high-cost refinement that might otherwise occur.²²⁸ Likewise, the DOE may be preferable when the invention is in a field that is changing rapidly in a way that creates high refinement costs because of the high cost of predicting imitative strategies that might be used by competitors.

Relatedly, there was also a separation of power issue that was asserted by the dissent in *Graver*, 339 U.S. at 616 (Black, J., dissenting), but the issue was ignored by the majority. This issue relates to whether an Article III court’s decision to broaden the scope of a patent is inconsistent with the primacy of the PTO in issuing patents.

223. See 35 U.S.C. § 251 (2000) (“No reissued patent shall be granted enlarging the scope of the claims of the original patent unless applied for within two years from the grant of the original patent.”).

224. See 35 U.S.C. § 252 (2000) (setting forth intervening use rights).

225. See *Seattle Box Co. v. Indus. Crating & Packaging Inc.*, 731 F.2d 818 (Fed. Cir. 1984); *Seattle Box Co. v. Indus. Crating & Packaging Inc.*, 756 F.2d 1574 (Fed. Cir. 1985).

226. See *Graver*, 339 U.S. at 615 (Black, J., dissenting).

227. See, e.g., Joshua D. Sarnoff, *Abolishing the Doctrine of Equivalents and Claiming the Future After Festo*, 19 BERKELEY TECH. L.J. 1157 (2004).

228. A full exploration of the proper role of reissue proceedings in relation to the DOE would analyze the proper time limit on broadening reissues, and whether the notice based constraints on the two doctrines should be harmonized. In addition, one should pay attention to the procedural differences between the two schemes.

B. LATER-DEVELOPED TECHNOLOGY

The DOE allows patent scope to grow over time as technology advances. In particular, patent owners exert control over products and processes that incorporate technology developed after the patent issues, and thus do not literally infringe. Expansion of scope is possible because equivalents are evaluated at the time of infringement, not the time of invention, filing, or issuance.²²⁹

The possibility that competitors could skirt literal claim language by making a minor modification based on later-developed technology generates ardent support for the DOE.²³⁰ The leading case on this issue is *Hughes Aircraft Co. v.*

229. See *Warner-Jenkinson Co. v. Hilton Davis Chem. Co.*, 520 U.S. 17, 37 (1997) (“Insofar as the question under the doctrine of equivalents is whether an accused element is equivalent to claimed element, the proper time for evaluating equivalency—and thus knowledge of interchangeability between elements—is at the time of infringement, not at the time the patent was issued.”). The policy underlying measuring DOE infringement at time of infringement is that because of the cumulative and unforeseeable nature of complex and ramified technologies, the patentee has opened doors for subsequent inventors, doors that perhaps were not foreseeable at the time the patentee filed for a patent, yet was eventually made possible because of the patentee’s patent disclosure. In other words, the patentee is not required to predict all future developments that enable the practice of his invention in substantially the same way. See *Pennwalt Corp. v. Durand-Wayland, Inc.*, 833 F.2d 931, 941 n.4 (Fed. Cir. 1987) (“It is clear that an equivalent can be found in technology known at the time of the invention, as well as in subsequently developed technology.”); *Chiuminatta Concrete Concepts, Inc. v. Cardinal Indus., Inc.*, 145 F.3d 1303, 1310 (Fed. Cir. 1998) (“The doctrine of equivalents is necessary because one cannot predict the future. Due to technological advances, a variant of an invention may be developed after the patent is granted, and that variant may constitute so insubstantial a change from what is claimed in the patent that it should be held to be an infringement. Such a variant, based on after-developed technology, could not have been disclosed in the patent.”); Janis, *supra* note 143, at 277 (claim language can expand over time and should be interpreted in light of evolving technology).

230. For example, the *Warner-Jenkinson* Court cited a portion of the United States amicus brief in its discussion of prosecution history estoppel. *Warner-Jenkinson*, 520 U.S. at 31. The amicus brief, in the cited portion, contains, in a footnote, an argument, and an example concerning later-developed equivalents:

Of course, when an accused equivalent (meeting the objective standard of insubstantiality) could not have been known because it was developed or discovered only after the patent issued, the case for application of the doctrine of equivalents becomes especially clear. For example, a claim to a chemical composition might include an inactive filler as a minor, unimportant ingredient. After the patent issues, a competitor of the patentee might manufacture a composition exactly as claimed but use a different, inactive filler, unknown in the art at the time the patent application was filed, that performs exactly as those literally covered by the claim. Such a substitution, once it became available, might be known to persons of skill in the relevant art to be interchangeable with the claimed filler, and yet it would not have been possible to include the accused element in the patent because it did not exist at the time of issue.

Brief for the United States as Amicus Curiae 23 n.7, *Warner-Jenkinson Co. v. Hilton Davis Chem. Co.*, 520 U.S. 17, 37 (1997) (No. 95-728), 1996 WL 172221; see also Conigliaro et al., *supra* note 116, at 1064 (“The application of the *Festo* rule to later-developed technology is particularly disturbing, since in all likelihood the patentee had no intention of giving up ground that did not even exist at the time the amendment was made.”). Certain judges and commentators believe that later-developed technology is the only context justifying application of the DOE. See *Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co.*, 344 F.3d 1359, 1374 (Fed. Cir. 2003) (Rader J., concurring) (“The principle of foreseeability . . . focuses on the correct inquiries to preserve expectations for patent holders.”); Phillips, *supra* note 199, at 180–81 (“[T]he doctrine of equivalents should be barred from reaching all but later arising equivalents.”).

United States.²³¹ As discussed earlier,²³² *Hughes* involved an invention that controlled the position of a satellite in space. The patented invention required a ground-based computer to perform certain computations. Technology advanced after the patent issued, the defendant installed micro-electronic components on-board the satellite, and thereby rendered certain ground-based computing unnecessary. The fairness theory favors the DOE in cases like *Hughes* as a means to justly reward the inventor.²³³ The friction theory favors the DOE because the patent applicant could not predict developments in micro-electronics and draft claim language to cover an unknown equivalent.²³⁴

We believe the rationale offered by *Hughes* is faulty, and generally patent law's treatment of foreseeability is misguided. Courts mistakenly favor the patentee most strongly when the technology is least foreseeable. But unforeseeable technological developments do not justify application of the DOE, because the doctrine will not save refinement costs or significantly improve the incentive to invent in such cases.²³⁵ A patent applicant will not waste time refining claims to cover equivalents she cannot foresee. The DOE provides a social benefit when it diminishes the incentive for an inventor to invest in socially wasteful claim refinement. For instance, a patent applicant who could never imagine the use of graphite or lighter weight materials in tennis rackets will not waste resources refining a claim to cover it. But a patent applicant who understands that tennis racket composition is trending toward lighter, yet to be developed materials, should not find it too difficult to write a claim that will cover graphite, for instance.²³⁶ The cost of this sort of refinement seems low, and it does not depend on whether a *specific* graphite or light weight composition was foreseeable; rather, the important factor is a general, yet clear, appreciation of industry and technology trends. In these cases, the DOE provides little social benefit. The troubling case is the intermediate one where the applicant has a vague sense of these trends, then absent the DOE, the applicant could expend

231. 717 F.2d 1351 (Fed. Cir. 1983). The courts struggled with this case for over twenty years and finally found infringement under the DOE.

232. See *supra* text accompanying notes 151–54.

233. *Hughes Aircraft*, 717 F.2d at 1365.

Advanced computers and digital communications techniques developed since *Williams* permit doing on-board a *part* of what *Williams* taught as done on the ground. As one of our predecessor courts, the Court of Claims, has thrice made clear, that partial variation in technique, an embellishment made possible by post-*Williams* technology, does not allow the accused spacecraft to escape the “web of infringement.”

Id.

234. See *id.* at 1362 (stating a patent applicant “is not required to predict all future developments which enable the practice of his invention in substantially the same way”). It is far from certain that *Hughes* could not have drafted claims literally covering on-board computers. See *supra* notes 153–154.

235. Cohen and Lemley argue that the DOE is too generous when applied to later-developed software technology because the rapid pace of software innovation means a pioneer may control several generations of subsequent technology. See Julie E. Cohen & Mark A. Lemley, *Patent Scope and Innovation in the Software Industry*, 89 CAL. L. REV. 1, 46 (2001).

236. See *supra* Part II.B.

significant effort refining her claims to cover potential technological developments. The DOE provides the greatest refinement cost savings in this intermediate case, one with genuine but poorly understood trends.

Our second example, motivated by the fact pattern in *Hughes*, applies our analysis to a case in which later-developed technology allows a single component to perform the function previously performed by separate components. Suppose later developed technology allows the alleged infringer to perform multiple functions with a single structure, in particular, suppose an invention combines components *a*, *b*, and *c*, which perform three separate functions. Also, suppose the claim describes *a*, *b*, and *c*, as three separate claim limitations. Finally, suppose technology advances so that the two functions accomplished by *b* and *c* can now be accomplished using *d*. An alleged infringer who combines *a* and *d* might successfully argue that his technology does not read on the limitations associated with *b* and *c*. Then, because of the all-elements rule, there is no infringement literally or under the DOE. Thus, the all-elements rule induces patent applicants to visualize advances in technology like *d*; refine their claims to reduce the number of limitations; and craft the limitations so that they cover *d* and similar substitutions. Our earlier discussion of *Hughes* suggests the applicant in that case could have written claims broad enough to cover the accused satellite even without knowing the details of how computer technology would evolve.²³⁷ Once again, proper application of the DOE requires evaluation of the refinement costs that likely would be spent to claim *d*. Courts have discretion when applying the all-elements rule to favor patentees when expected refinement costs are large and favor alleged infringers otherwise.²³⁸

Besides refinement cost savings, DOE policy must also be sensitive to inventor profit and the incentive to invent. No doubt, restricting the DOE will reduce incentives to some degree, but this hazard is probably overstated. First, notice that when an inventor foresees a high probability of a particular future substitute, the cost of claiming that substitute is probably low. Second, an inventor's incentive is not harmed much when, ex post, she is denied patent scope over technology that she did not foresee ex ante. The real incentive problem arises if an inventor believes there are many remote possible substitutes and the aggregate probability of some later developed substitute appearing is high.²³⁹ There is no statistical evidence suggesting this is a serious problem, and our impression from the case law and the history of technology is that few inventors have much to fear.

237. See *supra* text accompanying notes 153–54.

238. The Federal Circuit held that claim limitations are not necessarily vitiated when multiple claim limitations are combined into a single element in the accused device as long as the differences remain insubstantial. See *Eagle Comtronics, Inc. v. Arrow Commc'n Labs., Inc.*, 305 F.3d 1303, 1317 (Fed. Cir. 2002). For more discussion of the flexibility inherent in the all-elements rule, see *infra* text accompanying notes 248–57.

239. It is also possible that incentives are seriously eroded by refinement efforts designed to capture later developed technology.

C. ALL-ELEMENTS RULE

Literal infringement requires every limitation in the claim be found in the accused device.²⁴⁰ The same rule applies to infringement under the DOE; it is known as the all-elements rule.²⁴¹ Infringement under the DOE requires the patentee show the accused product or process contains elements identical or equivalent to each claimed element of the patented invention.²⁴² Thus, the rule prevents the DOE from vitiating a claim limitation.²⁴³

The all-elements rule is difficult to apply, but useful as a method for constraining the DOE and promoting the notice function of claims.²⁴⁴ All-elements is a question of law giving judges the power to protect defendants from baseless patent infringement claims by entering a summary judgment of non-infringe-

240. See *Engel Indus., Inc. v. Lockformer Co.*, 96 F.3d 1398, 1405 (Fed. Cir. 1996).

241. The Federal Circuit has expressed a preference for the word "limitation" (instead of "element") when referring to claim language, and "element" when referring to the accused device. See *Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co.*, 234 F.3d 558, 563 n.1 (Fed. Cir. 2000) ("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." (citations omitted)). To this end, the court has also noted that the "All Elements rule might better be called the All Limitations rule." *Ethicon Endo-Surgery, Inc. v. U.S. Surgical Corp.*, 149 F.3d 1309, 1317 n.1 (Fed. Cir. 1998); see also Philip M. Nelson, *Definition for 'Limitation' in the Context of Prosecution History Estoppel and the All Elements Rule: A Proposed Solution to the Troubling Dictum in Kustom Signals v. Applied Concepts*, 2003 B.Y.U. L. REV. 353, 373 (arguing "all-limitations" is a better name than "all-elements" because the word element refers to both a claim limitation and a component of a device).

242. See *Warner-Jenkinson Co. v. Hilton Davis Chem. Co.*, 520 U.S. 17, 29 (1997) ("We concur with this apt reconciliation of our two lines of precedent. 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."); *Pennwalt Corp. v. Durand-Wayland, Inc.*, 833 F.2d 931, 935-36 (Fed. Cir. 1987) (adopting all-elements approach); *Lockheed Martin Corp. v. Space Systems/Loral, Inc.*, 324 F.3d 1308, 1321 (Fed. Cir. 2003) ("Under the all elements rule, there can be no infringement under the doctrine of equivalents if even one limitation of a claim or its equivalent is not present in the accused device.").

243. See *Insituform Techs., Inc. v. Cat Contracting, Inc.*, 99 F.3d 1098, 1109 (Fed. Cir. 1996). Thus, if a court determines that a finding of infringement under the doctrine of equivalents "'would entirely vitiate a particular claim[ed] element,' then the court should rule that there is no infringement under the doctrine of equivalents." *Bell Atlantic Network Servs., Inc. v. Covad Commc'ns Group, Inc.*, 262 F.3d 1258, 1280 (Fed. Cir. 2001) (quoting *Festo*, 234 F.3d at 587).

244. The constraining effect of the all-elements rule grows as the number of elements grows, because the patentee must prove identity or equivalence to each element. Pioneer patents usually have fewer limitations because there is less need for limitations that distinguish the invention from the prior art. Also certain technologies require fewer limitations. See Cohen & Lemley, *supra* note 235, at 44 ("The element-by-element approach . . . may not help in many software cases, where the software-related part of the invention is often described in a single element."); Antony L. Ryan & Roger G. Brooks, *Innovation vs. Evasion: Clarifying Patent Rights in Second-Generation Genes and Proteins*, 17 BERKELEY TECH. L.J. 1265, 1284-85 (2002) ("Some commentators suggest that each nucleotide in a gene patent and each amino acid in a protein patent may constitute a separate claim element. But most amino acids in any particular protein do not perform a known function of their own; rather, the amino acid sequence as a whole determines the protein's three-dimensional structure, which in turn is essential to its function. Thus, it makes no sense to consider each amino acid to be a separate claim element.").

ment.²⁴⁵ Some commentators suggest the rule also increases clarity regarding the scope of patent rights.²⁴⁶ Actually, the rule has mixed effects on clarity. On one hand, it constrains the DOE and reduces that source of uncertainty. On the other hand, it creates uncertainty about how a court will define the elements of a claim.²⁴⁷

For example, in *Sage Products, Inc. v. Devon Industries, Inc.*,²⁴⁸ the Federal Circuit used the all-elements rule to block application of the DOE to a patent when the inventor faced low refinement costs. The invention was a container for disposing of hazardous medical waste. The relevant claim language stated the invention comprised a container body, “an elongated slot at the top of the container body”²⁴⁹ The defendant made a similar container, but the slot for disposing the waste was within the container body.²⁵⁰ Both containers featured two constrictions that kept the waste securely within the container. The plaintiff argued “having two constrictions below the top of the container is the same, for purposes of infringement, as having one constriction above and one constriction below.”²⁵¹ The court found no literal infringement and ruled the all-elements rule would be violated if the patentee were allowed to show the slot within the

245. Some have argued that invoking the equitable powers of the court and having the judge serve as the DOE gatekeeper is preferable. *See, e.g., Festo*, 234 F.3d at 593 (Plager, J., concurring) (“A better solution would be to declare the doctrine of equivalents—a judge-made rule in the first place—to have its roots firmly in equity, and to acknowledge that when and in what circumstances it applies is a question of equitable law, a question for which judges bear responsibility.”); Michel, *supra* note 1, at 125 (“The all-limitations rule . . . holds that no equivalent infringement exists as a matter of law, if the allegedly infringing article lacks any claim limitation.”); Meurer, *supra* note 30, at 534–35.

246. *See, e.g., Anand Gupta, Patent Law: The Supreme Court Reinforces the Validity of the Doctrine of Equivalents in Warner-Jenkinson Co. v. Hilton Davis Chemical Co.*, 23 S. ILL. U. L.J. 123, 138–39 (1998) (“By adopting the all-elements test, the Court has given importance to the public notice and definitional functions of the patent laws. . . . Moreover, by requiring that each element in the patent have an equivalent in the accused invention, the Court has limited the scope and application of the doctrine of equivalents because fewer inventions should be found to infringe under this test than under the ‘as a whole’ test.”).

247. *See Phillips, supra* note 199, at 162 (“The definition of an ‘element’ is slippery and probably cannot be settled without some resort to arbitrariness. Presently, an element seems to be more than just a single word, but potentially less than an entire step in a method or an entire constituent part of an apparatus (as is typically demarcated by semicolons).”); *Kustom Signals, Inc. v. Applied Concepts, Inc.*, 264 F.3d 1326, 1333 (Fed. Cir. 2001) (conducting a DOE analysis and deciding that the word “or” is an element).

In addition, the all-elements rule does not imply “a one-to-one correspondence between components of the accused device and the claimed invention. An accused device may infringe under the doctrine of equivalents even though a combination of its components performs a function performed by a single element in the patented invention. The accused device must nevertheless contain every limitation or its equivalent.” *Dolly, Inc. v. Spalding & Evenflo Cos., Inc.*, 16 F.3d 394, 397–98 (Fed. Cir. 1994) (citations omitted). “Equivalency thus can exist when two components of the accused device perform a single function of the patented invention” or “when separate claim limitations are combined into a single component of the accused device.” *Id.*

248. 126 F.3d 1420 (Fed. Cir. 1997).

249. *Id.* at 1422.

250. *Id.* at 1423.

251. *Id.* at 1424.

container was equivalent to a slot at the top of the container.²⁵² This appears to be a case in which the applicant easily could have written claim language to literally cover the defendant's product, and the court appropriately used the all-elements rule to deny the availability of the DOE.²⁵³

In contrast, the court treated a pioneer inventor generously when applying the all-elements rule in *Corning Glass Works v. Sumitomo Electric U.S.A., Inc.*²⁵⁴ Corning researchers invented glass optical fibers hailed as pioneering because they made fiber optic telephone transmission possible.²⁵⁵ The patented fiber has a core of glass with a high refractive index surrounded by a glass coating with a lower refractive index. The differential in refractivity kept laser light within the core of the fiber. The claims called for a core of glass doped with titanium surrounded by pure glass. The titanium caused the core to have a higher refractive index than the outside coating. Sumitomo's accused fiber achieved a similar differential in refractivity by putting fluorine, a negative dopant, in the coating rather than a positive dopant in the core.

The court upheld a verdict finding infringement under the DOE and ruled that the all-elements rule was not violated.²⁵⁶ There was no literal infringement because the accused product lacked a positive dopant. The defendant argued that the positive dopant was an element missing from the defendant's product, and therefore, the all-elements rule was not satisfied. The court disagreed and identified the differential in the refractive indices between the core and the coating as the relevant limitation. It concluded that adding a negative dopant to

252. *Id.* ("Thus, for a patentee who has claimed an invention narrowly, there may not be infringement under the doctrine of equivalents in many cases, even though the patentee might have been able to claim more broadly. If it were otherwise, then claims would be reduced to functional abstracts, devoid of meaningful structural limitations on which the public could rely.").

253. *Id.* at 1425 ("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.").

The refinement theory also aids literal infringement analysis by helping courts apply the all-elements rule. Consideration of refinement costs can help courts choose the better of two competing claim interpretations. The invention in *Unique Concepts, Inc. v. Brown*, 939 F.2d 1558 (Fed. Cir. 1991), was a system of plastic pieces used to attach wall covering to a wall. The relevant claim language stated the invention comprised: "linear border pieces and right angle corner border pieces . . ." *Id.* at 1560. The defendant made the same plastic pieces, except the defendant substituted a pair of trapezoidal pieces with 45° cuts for a right-angled corner piece. *Id.* at 1561. The court ruled there was no literal infringement because the defendant's product lacked an element: a right angle corner piece. *Id.* at 1562-63. The court also refused to apply the DOE because the use of trapezoidal pieces to make the corner is a different and more complicated way to attach wall covering. *Id.* at 1563-64. The dissent would have found literal infringement by reading right-angled corner piece broadly enough to cover two trapezoidal pieces joined in a corner. *Id.* at 1568. The dissent's approach disregards the question of why the inventor failed to claim trapezoidal pieces explicitly. The patentee would argue that its claim language has at least two reasonable interpretations, and it intended the broader interpretation, therefore it did not need to specify trapezoidal pieces explicitly. Patent law should not tolerate this prosecution strategy; the costs of refining the claim to include the trapezoidal pieces would have been low.

254. 868 F.2d 1251 (Fed. Cir. 1989). Critics of *Corning* read this case as ignoring the all-elements rule in favor of the holistic approach to the DOE.

255. *Id.* at 1254-55.

256. *Id.* at 1257-61.

the coating is the same “way” of achieving the differential as adding a positive dopant to the core.²⁵⁷ We approve of this outcome and comment more on this case below in our discussion of pioneer inventions.

D. PIONEER INVENTIONS

Patent law rewards inventors of pioneer inventions with broader protection.²⁵⁸ The reward flows from two sources: the grant of broad patent claims, and generous application of the DOE.²⁵⁹ Courts often conflate analysis of these distinct sources of reward.²⁶⁰ The two versions of the pioneer invention doctrine are related, but patent law can be improved by disentangling them and conducting a separate normative analysis.

Pioneer inventions get broad patent scope on the theory they have a high

257. *Id.* at 1259 (“Sumitomo’s analysis illustrates the confusion sometimes encountered because of misunderstanding or misleading uses of the term ‘element’ in discussing claims. ‘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 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.”).

258. Pioneer status is determined by asking whether an invention makes a significant technological advance in the field. *See Westinghouse v. Boyden Power Brake Co.*, 170 U.S. 537, 561–62 (1898) (“To what liberality of construction these claims are entitled depends, to a certain extent, upon the character of the invention, and whether it is what is termed, in ordinary parlance, a ‘pioneer.’ This word, although used somewhat loosely, is commonly understood to denote a patent covering a function never before performed, a wholly novel device, or one of such novelty and importance as to mark a distinct step in the progress of the art, as distinguished from a mere improvement or perfection of what had gone before.”); *Universal Gym Equip. Inc. v. ERWA Exercise Equip. Ltd.*, 827 F.2d 1542, 1548 (Fed. Cir. 1987) (rejecting contention that invention was a pioneer entitled to a broad range of equivalents); *Hughes Aircraft Co. v. United States*, 717 F.2d 1351, 1362 (Fed. Cir. 1983) (same).

259. *See Texas Instruments, Inc. v. United States Int’l Trade Com’n*, 805 F.2d 1558, 1572 (Fed. Cir. 1986) (“To achieve this purpose, equivalency is judicially determined by reviewing the content of the patent, the prior art, and the accused device, and essentially redefining the scope of the claims. This constitutes a deviation from the need of the public to know the precise legal limits of patent protection without recourse to judicial ruling. For the occasional pioneering invention, devoid of significant prior art—as in the case before us—whose boundaries probe the policy behind the law, there are no immutable rules.”). The DOE applies in proportion to the advance by the inventor. *See Warner-Jenkinson Co. v. Hilton Davis Chem. Co.*, 520 U.S. 17, 27 n.4 (1997) (“[J]udicial recognition of so-called ‘pioneer’ patents suggests that the abandonment of ‘central’ claiming may be overstated. That a claim describing a limited improvement in a crowded field will have a limited range of permissible equivalents does not negate the availability of the doctrine *vel non*.”); *Sun Studs, Inc. v. ATA Equip. Leasing, Inc.*, 872 F.2d 978, 987 (Fed. Cir. 1989) (“The concept of the ‘pioneer’ arises from an ancient jurisprudence, reflecting judicial appreciation that a broad breakthrough invention merits a broader scope of equivalents than does a narrow improvement in a crowded technology. But the ‘pioneer’ is not a separate class of invention, carrying a unique body of law. The wide range of technological advance between pioneering breakthrough and modest improvement accommodates gradations in scope of equivalency.”).

260. *See, e.g., Brothers v. United States*, 250 U.S. 88, 89 (1919) (“No question is made but that plaintiff’s invention was broadly new, a pioneer in its line, and the patent entitled to a broad construction and the claims to a liberal application of the doctrine of equivalents.”).

social value and therefore require strong patent-based incentives.²⁶¹ Broad claims are available to pioneers because they are less constrained by prior art,²⁶² and because they can make impressive disclosures that enable new fields of technology.²⁶³ Merges and Nelson caution against over-rewarding pioneers, however, lest cumulative innovation be discouraged because improvers have too little incentive and pioneers have too much control.²⁶⁴

Despite a solid theoretical basis for giving pioneers generous protection against literal infringement, it is not immediately clear that the high social value of pioneer inventions justifies special treatment under the DOE.²⁶⁵ If not for frictions, pioneers could get appropriately broad scope by relying on the claim language in their patents. In the absence of frictions that constrain claim scope, more generous treatment of pioneers under the DOE would over-reward pioneers and possibly stifle cumulative innovation.²⁶⁶ Hence, the only persuasive

261. See Thomas, *supra* note 202, at 58–59 (pioneer inventors should get a bigger reward); Mark A. Lemley, *The Economics Of Improvement In Intellectual Property Law*, 75 TEX. L. REV. 989, 1073 (1997) (pioneers should get broad claim scope).

262. See *Augustine Med., Inc. v. Gaymar Indus., Inc.*, 181 F.3d 1291, 1301–02 (Fed. Cir. 1999) (“Without extensive prior art to confine and cabin their claims, pioneers acquire broader claims than non-pioneers who must craft narrow claims to evade the strictures of a crowded art field. Thus, claim scope itself generally supplies broader exclusive entitlements to the pioneer.”); *Abbott Labs. v. Dey, L.P.*, 287 F.3d 1097, 1105 (Fed. Cir. 2002) (“A pioneer patent by definition will have little applicable prior art to limit it, whereas an improvement patent’s scope is confined by the existing knowledge on which the improvement is based.”).

263. Merges & Nelson, *supra* note 73, at 848–49.

264. *Id.* at 843–44 (“In many industries the efficiency gains from the pioneer’s ability to coordinate are likely to be outweighed by the loss of competition for improvements to the basic invention.”). Their work influenced many commentators who argue that the enablement standard, the experimental use doctrine, or the DOE should be used to fine-tune patent protection to pioneers vis-à-vis improvers. See Christopher D. Hazuka, *Supporting the Work of Lesser Geniuses: An Argument for Removing Obstructions to Human Embryonic Stem Cell Research*, 57 U. MIAMI L. REV. 157, 188–89 (2002) (upstream patents on pioneering inventions slow progress because they slow improvements).

Broad patent protection may inhibit the rate of technological improvement in industries characterized by cumulative invention. Most commentators assume that multiple research teams are more productive than a single research team with the same resources. They also assume that a single firm cannot coordinate multiple research teams as effectively as when those teams are independent. See James Bessen & Eric Maskin, *Sequential Innovation, Patents, and Imitation* (MIT Dep’t of Economics, Working Paper No. 00-01, 2000). For a discussion of the optimal allocation of rights between pioneers and inventors, see Howard F. Chang, *Patent Scope, Antitrust Policy, and Cumulative Innovation*, 26 RAND J. ECON. 34 (1995); Jerry R. Green & Suzanne Scotchmer, *On the Division of Profit in Sequential Innovation*, 26 RAND J. ECON. 20 (1995).

265. Jay Thomas shares our skepticism. See Thomas, *supra* note 202, at 52 (“The courts have offered little justification for the application of pioneer invention doctrine.”).

266. *But see In re Hogan*, 559 F.2d 595, 606 (C.C.P.A. 1977) (“To restrict [a patentee] to the . . . form disclosed . . . would be a poor way to stimulate invention, and particularly to encourage its early disclosure. To demand such restriction is merely to state a policy against broad protection for pioneer inventions, a policy both shortsighted and unsound from the standpoint of promoting progress in the useful arts, the constitutional purpose of the patent laws.”); Conigliaro et al., *supra* note 116, at 1059 (“In sum, enforcing the doctrine of equivalents and prosecution history estoppel in a manner that balances patents’ protective and notice functions is the optimal means of promoting the progress of the useful arts. Only through a careful balance of these functions will the law encourage innovation by both pioneering inventors and technological improvers.”). The Federal Circuit has since retreated from

argument courts or commentators have offered for special treatment of pioneer inventions under the DOE is that pioneer inventors face greater frictions than other inventors.²⁶⁷

The friction based defense of broader protection of pioneers under the DOE clashes with our central objection to the friction theory—there is little evidence that the frictions are really greater for pioneer inventions. In fact, claims to pioneer inventions may be easier to draft because a pioneer applicant has less difficulty drafting around the prior art, less need to amend, and therefore less reason to worry about PHE.²⁶⁸ Nevertheless, we think the case law is on the right track. Not surprisingly, we suggest that refinement costs, rather than frictions, may be larger for pioneers. In particular, we conjecture that many pioneer inventors face a tougher problem of visualizing and enumerating the many possible methods of imitating a pioneer invention.²⁶⁹

Hogan and its rhetoric on pioneer patents. See *Plant Genetic Sys., N.V. v. DeKalb Genetics Corp.*, 315 F.3d 1335, 1341 (Fed. Cir. 2003) (stating *Hogan's* statement that pioneer inventions deserve broad claims is “unconvincing” and “extended dicta”).

267. See Thomas, *supra* note 202, at 52 (noting courts rely on what we characterize as the friction theory to justify the pioneer invention doctrine within the DOE). Specifically, courts and commentators suggest that the limitations of language are more troubling for pioneers than for other inventors, or that pioneers are more troubled by later developed technology. See *Moore v. United States*, 211 U.S.P.Q. 800, 806 (Ct. Cl. 1981) (“The doctrine finds its roots in the judicial recognition that drafting the disclosure and claims for a pioneer patent is a difficult task because of the new scientific ground being broken by the unique invention.”); Faith S. Fillman, *Doctrine of Equivalents: Is Festo the Right Decision for the Biomedical Industry?*, 33 ST. MARY’S L.J. 493, 529 (2002) (“Future variations are difficult to predict and claim in written form, but since they come so rapidly, minor variations rob patents of their value. Biotechnology’s generic claims are often narrowed based on strict disclosure requirements of the PTO, which places the pioneer inventor in a losing situation.”); Anthony H. Azure, *Festo’s Effect on After-Arising Technology and the Doctrine of Equivalents*, 76 WASH. L. REV. 1153, 1181 (2001) (“Thus, under *Festo*, an inventor who needs to make a narrowing amendment due to the inherent difficulty of drafting claims for pioneering inventions may not be able to use the doctrine of equivalents in future litigation. *Festo’s* bright-line rule unfairly restricts the rights of pioneer inventors to literal infringement only.”); Lichtman, *supra* note 27, at 176 (suggesting language frictions are greater for “complicated or rapidly evolving technologies”). But it should be noted that the Federal Circuit has suggested that an enabling disclosure is more important when nascent technology is at issue “because a person of ordinary skill in the art has little or no knowledge independent from the patentee’s instruction.” *Chiron Corp. v. Genentech, Inc.* 363 F.3d 1247, 1254 (Fed. Cir. 2004); see also *Genentech, Inc. v. Novo Nordisk A/S*, 108 F.3d 1361, 1368 (Fed. Cir. 1997) (“Where, as here, the claimed invention is an application of an unpredictable technology in the early stages of development an enabling description in the specification must provide those skilled in the art with a specific and useful teaching.”). Thus, the court does not appear to be sympathetic to the claim that pioneers have greater linguistic obstacles to overcome.

268. See *Augustine Med., Inc. v. Gaymar Indus., Inc.*, 181 F.3d 1291, 1301–02 (Fed. Cir. 1999) (“[A] pioneer generally need not fear traditional limits on the application of the doctrine of equivalents such as prior art or prosecution history estoppel (because amendments or arguments to overcome the prior art are generally unnecessary in true pioneer applications)”); Thomas, *supra* note 202, at 56–57 (noting that with respect to claim drafting, pioneer inventions compare favorably with inventions with crowded prior art, and pioneer inventions are less likely to be subject to prosecution history estoppel in subsequent litigation).

269. Dan Burk and Mark Lemley favor a rejuvenated pioneer doctrine for biotech inventions, see Dan L. Burk & Mark A. Lemley, *Biotechnology’s Uncertainty Principle*, 54 CASE W. RES. L. REV. 691

The case of *Corning Glass Works v. Sumitomo Electric U.S.A., Inc.*²⁷⁰ illustrates a case in which a pioneer inventor failed to visualize and claim the competitor's imitative technology. Recall that the invention comprised glass fiber with a doped core, and that the imitator made a glass fiber with a doped cladding. Either approach achieved the same difference in the refractive indices between the cladding and the core which was the key to the invention. Although it is hard to be sure, we see this as a case of intermediate foreseeability in which it would have been difficult for Corning to visualize and literally claim Sumitomo's imitative fiber,²⁷¹ thus refinement costs would have been high.²⁷² Application of the DOE in this case offers two possible social benefits: avoidance of costly refinement expenditures, and a valuable incentive boost that encourages pioneering invention.²⁷³

E. PUBLIC DEDICATION RULE

The public dedication rule is the latest effort of the Federal Circuit to constrain the DOE. This rule holds that a patent drafter dedicates to the public disclosed, but unclaimed subject matter.²⁷⁴ For example, in *Moore U.S.A., Inc. v. Standard Register Co.*,²⁷⁵ the patent covered an envelope that can be manipulated to make a return envelope. The claim language described adhesive strips extending the majority of the length of two strips on the margins of the envelope. The defendant's envelope was similar to the claimed envelopes but

(2004), because of the difficulty claiming the "numerous functional equivalents of particular DNA sequences." *Id.* at 53.

270. 868 F.2d 1251 (Fed. Cir. 1989).

271. A clever method of imitating a pioneering invention, like Sumitomo's method, can be patented in its own right.

272. See discussion in Part IV.B., *supra*. We assume that refinement costs would be relatively high in this case and relatively low in *Hughes*. Certainly we could be wrong about both cases, but the resolution of these factual questions is separate from the analytic structure we provide for application of the DOE. We distinguish these cases on two grounds. First, the *Corning* invention was pioneering, and second, the accused device in *Hughes* functioned in the same way as the claimed technology.

273. Another example of a pioneer inventor who likely faced high refinement costs is provided by *International Nickel Co. v. Ford Motor Co.*, 166 F. Supp. 551, 563 (S.D.N.Y. 1958). The inventor patented a cast iron alloy containing magnesium which improved the quality of the cast iron. Magnesium added to cast iron does two things: (1) reacts with sulfur, and (2) makes graphite form spheres instead of flakes. The inventor discovered property (2), which makes cast iron more like steel. The relevant claim 1 called for about 0.04% as the minimum quantity of retained magnesium. The accused product had about 0.02% magnesium. Interestingly, this case is NOT a close analogue of *Warner-Jenkinson*. The minimum quantity in claim 1 is required for "normal" iron. The defendant cleaned the sulfur out of their iron, and then used the patented technology with less magnesium—enough to accomplish function (2) when function (1) was accomplished in advance. The magnesium that cleans up the sulfur in normal iron is not available to make graphite spheres.

274. *Johnson & Johnston Assocs. v. R.E. Serv. Co.*, 285 F.3d 1046, 1054 (Fed. Cir. 2002) (en banc); *Maxwell v. J. Baker, Inc.*, 86 F.3d 1098, 1106–07 (Fed. Cir. 1996). The panel in *YBM Magnex, Inc. v. ITC*, 145 F.3d 1317, 1320 (Fed. Cir. 1998), warns that this strong version of the dedication rule is inconsistent with *Warner-Jenkinson* and *Graver Tank*: "The Supreme Court's guidance in *Warner-Jenkinson* and *Graver Tank* does not permit the blanket rule that everything disclosed but not claimed is barred from access to the doctrine of equivalents, whatever the facts, circumstances, and evidence."

275. 229 F.3d 1091 (Fed. Cir. 2000).

the adhesive strips extended only a minority of the length of the margins. The patentee was denied a chance to apply the DOE to this claim element because it disclosed but did not claim adhesive strips that extended a minority of the length of the margin.²⁷⁶

The dedication rule makes sense under the refinement theory, and it is hard to dispute on fairness or friction grounds. The cost of drafting a claim to cover material the inventor has already described in the specification must be quite low. Mistake by the prosecutor serves as the most plausible reason to oppose the rule. But mistake is not a very appealing argument given that the reissue proceeding provides an opportunity for the patent owner to correct the mistake and broaden the claim language during the first two years after the patent issues.²⁷⁷ As the notice theory emphasizes, it is socially desirable that competitors can rely on disclosed and unclaimed embodiments described in a patent as a safe harbor.²⁷⁸

276. *Id.* at 1107 (“Having fully disclosed two distinct embodiments, one in which the first and second longitudinal strips extend a majority of the length of the longitudinal marginal portions, and one in which they do not, Moore is not entitled to ‘enforce the unclaimed embodiment as an equivalent of the one that was claimed.’”).

277. *Johnson & Johnston*, 285 F.3d at 1055 (“A patentee who inadvertently fails to claim disclosed subject matter, however, is not left without remedy. Within two years from the grant of the original patent, a patentee may file a reissue application and attempt to enlarge the scope of the original claims to include the disclosed but previously unclaimed subject matter. 35 U.S.C. § 251 (2000). In addition, a patentee can file a separate application claiming the disclosed subject matter under 35 U.S.C. § 120 (2000) (allowing filing as a continuation application if filed before all applications in the chain issue). Notably, *Johnston* took advantage of the latter of the two options by filing two continuation applications that literally claim the relevant subject matter.”).

278. See Ashita Doshi, *Johnson & Johnston Associates, Inc. v. R.E. Service Co.*, 18 BERKELEY TECH. L.J. 209, 226 (2003) (“*Johnson*’s strict application of the dedication rule places a burden on the patentee to literally claim all disclosed subject matter, or surrender the right to exclude the public from it. *Johnson* thus ensures that patent claims, and not the specification, give the PTO and the public adequate notice of an invention’s scope. The primary benefits of a strict application of the dedication rule are increased predictability of outcomes and certainty in determining an invention’s scope.”). But see Thomas R. Hipkins, *A Rebuttable Presumption of Dedication: Protecting the Hard-Luck Patentee from Johnson & Johnston’s Dedication Rule*, 87 MINN. L. REV. 779, 799 (2003) (“The *Johnson & Johnston* dedication rule purports to bolster the notice function by drawing a bright line, eliminating any zone of uncertainty. In some cases, however, the line is not nearly so bright as the *Johnson & Johnston* court would like to believe. The nature of language makes it impossible to eliminate all uncertainty from the scope of patent claims.”).

Lichtman argues that the minor friction in a case like *Johnson & Johnston* implies that notice cost is also small. Lichtman, *supra* note 27, at 177. Arguably, notice costs are small if a competitor is on notice that unclaimed embodiments can be captured through the DOE, because a competitor can read the specification and spot such embodiments. In a sense, this argument and the argument in *YBM* can be used to support a return to peripheral rather than central claiming. We oppose movement in that direction because we do not believe refinement and notice costs fall symmetrically on patentees and potential infringers. An inventor should not be allowed to intentionally claim narrowly and avoid enablement and prior art reviews of broader claims by the PTO with the hope of gaining broad coverage through the DOE at trial. Potential infringers are usually poorly positioned compared to the inventor to judge whether an embodiment would be blocked by enablement or prior arts constraints.

F. PROSECUTION HISTORY ESTOPPEL

Prosecution history, the public record of the “negotiation” between a patent applicant and the patent examiner, affects patent scope in two ways. First, it aids claim interpretation analogously to the way legislative history aids statutory interpretation.²⁷⁹ Information in the prosecution history can be used to support either a broad or narrow interpretation of a patent claim.²⁸⁰ Second, it limits scope by constraining use of the DOE. If the prosecution history reveals that a patent owner disclaimed certain embodiments during the application process, then she is estopped from recovering those embodiments at trial through application of the DOE.²⁸¹

Typically, estoppel applies when the patent applicant narrows a claim in response to an examiner’s contention that the original claim is not enabled or is unpatentable in view of the prior art.²⁸² Patent law equates this claim revision with an admission that the broader claim is unpatentable, and therefore, the DOE cannot properly extend scope to cover subject matter that was given up by amendment. The long-running controversy regarding PHE concerns the rigor of this policy.

We can illustrate the impact of PHE by supposing the patent applicant originally filed a broad claim to the embodiments contained in sets *E* and *F*, and then amended the claim by deleting set *F*. Estoppel bars use of the DOE to extend the patent scope to cover the embodiments contained in *F*. This narrow version of estoppel is not controversial. Controversy arises when the defendant makes an embodiment, *x*, that is not contained in sets *E* or *F*, but is arguably equivalent to the embodiments in *E*. Proponents of a strong DOE favor a flexible approach that gives courts discretion to apply the DOE to embodiments

279. See *Markman v. Westview Instruments, Inc.*, 52 F.3d 967, 987 (Fed. Cir. 1995) (comparing prosecution history to legislative history). The PTO makes the prosecution history public after a patent issues. See 37 C.F.R. § 1.11(a) (2005).

280. Claim interpretation is a relatively formal process. If a claim is clear on its face, then its meaning cannot be altered by the prosecution history, or information from any other source. See *Autogiro Co. of Am. v. United States*, 384 F.2d 391, 396 (Ct. Cl. 1967). If the claim is ambiguous, then various sources including the prosecution history may be consulted. The Federal Circuit established a hierarchy of interpretative sources favoring prosecution history, the patent specification, and drawings over extrinsic sources. See *Vitronics Corp. v. Conceptronics, Inc.*, 90 F.3d 1576, 1582–83 (Fed. Cir. 1996). Recently, the court has backed away from a strict hierarchy, and acknowledged that it may be difficult to evaluate the clarity of claims in isolation. See *Pitney Bowes, Inc. v. Hewlett-Packard Co.*, 182 F.3d 1298, 1308 (Fed. Cir. 1999).

281. See *Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co.*, 535 U.S. 722, 733–34 (2002); see also *Exhibit Supply Co. v. Ace Patents Corp.*, 315 U.S. 126 (1942); Conigliaro et al., *supra* note 116, at 1064–65 (“The concept of prosecution history estoppel is based on the equitable concept of an implied promise. The patentee is agreeing to narrow the scope of her claims in exchange for the grant of a patent, and should not be permitted to avoid that agreement by later claiming to own what she abandoned during prosecution.”).

282. A narrowing argument may also lead to estoppel. See *Cybor Corp. v. FAS Techs.*, 138 F.3d 1448, 1460 (Fed. Cir. 1998) (en banc).

like x that the patentee did not specifically cede during prosecution.²⁸³ In *Festo*, the Federal Circuit rejected flexibility in favor of a bright line, absolute bar.²⁸⁴ The “paramount” importance of the notice function of claims and the “need for certainty” were the driving policy considerations underlying the absolute bar.²⁸⁵

The Supreme Court reversed the Federal Circuit and chose a compromise between the absolute and flexible bars.²⁸⁶ The Supreme Court created a rebuttable presumption barring application of the DOE. A “decision [by a patent applicant] 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.”²⁸⁷ But the Court provided means by which the patentee can successfully rebut the presumption, the most significant being the unforeseeability of the alleged equivalent in question. In discussing the relationship between the DOE and PHE, the Court stated that “[t]here is no reason why a narrowing amendment should be deemed to relinquish equivalents unforeseeable at the time of the amendment.”²⁸⁸ The foreseeability concept is straightforward: estoppel does not apply to subject matter a reasonable applicant could not foresee she had given up at the time of application. Continuing our example, estoppel does not apply if x is not foreseeable in light of the embodiments in E or F .²⁸⁹

Our refinement theory suggests that the Supreme Court chose a sensible compromise, but PHE is better understood in terms of the refinement cost of drafting claims rather than foreseeability.²⁹⁰ Prosecution history is relevant to

283. See, e.g., *Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co.*, 234 F.3d 558, 624 (Fed. Cir. 2000) (Linn, J., concurring in part and dissenting in part). Bemoaning the Federal Circuit’s adoption of an absolute bar, Judge Linn wrote:

In my opinion, the majority’s new bright line rule eliminating all flexibility in the scope of claim limitations amended for a statutory purpose reflects an unjustified faith in the draftsman to select language to perfectly describe a new and unobvious invention at an early stage of the development process. The same limitations of language noted in selecting words to describe an invention in the first instance are no less present in selecting words to avoid an examiner’s rejection of that original language for one statutory reason or another.

Id.

284. *Id.* at 574–75.

285. *Id.* at 575; see also Wagner, *supra* note 8, at 165, 218–20 (arguing that prosecution history estoppel encourages clear claim drafting that minimizes problems arising from the limitations of language).

286. *Festo*, 535 U.S. at 739. But see Wagner, *supra* note 8, at 231 (“A close examination of the Court’s presumptive bar reveals that it . . . is little different from the pre-*Festo* Federal Circuit doctrine.”).

287. 535 U.S. at 740.

288. *Id.* at 738.

289. Under the absolute bar, if x differs from the embodiments in E , in terms of a limitation that distinguished F from E , then the DOE is barred. Many commentators exaggerate the effect of the absolute bar by stating it nullifies the DOE for amended claims. See Wagner, *supra* note 8, at 186–87 (arguing that the likely impact of an absolute bar has been greatly exaggerated). But see Jenny B. Davis, *Facing Up to Festo*, A.B.A. J., July 2002, at 30 (2002) (quoting Donald R. Dunner, a prominent patent lawyer, who says the foreseeability test forecloses the DOE in 95% of cases).

290. See *supra* Part I.B and accompanying notes. In addition to a foreseeability test, the Supreme Court stated that the presumption of estoppel can be overcome if “the rationale underlying the

the DOE because it provides information about refinement costs and that information should be used to optimally constrain the DOE. Even though the Supreme Court emphasized foreseeability, the details of its argument are consistent with a refinement cost approach. The Court observed: “The patentee must 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.”²⁹¹ And the “respondents may well prevail, for the sealing rings and the composition of the sleeve both were noted expressly in the prosecution history.”²⁹² Thus, the Court recognized that the prosecution history shows Festo’s patent attorney was conscious of possible equivalents to the sealing rings and the sleeve, and easily could have drafted a claim that would read on SMC’s device, assuming Festo was entitled to such a claim. The failure to draft a broader claim cannot be explained by some friction, and recourse to the DOE should be denied.²⁹³

CONCLUSION

The doctrine of equivalents has an important role to play in our patent system, but it has suffered from normative neglect by patent law theorists. The original equitable justification for the doctrine, while having intuitive appeal, is not sufficiently attentive to the notice function of patent claims and is inconsistent with patent law’s utilitarian grounding. Thus, while some courts to this day embrace the fairness theory, another rationale, the friction theory, has evolved that provides a more concrete justification for the DOE. The friction theory offers various explanations of why an inventor fails to obtain the full breadth of rights she was entitled to during patent prosecution, such as limitations of language, prosecutorial mistakes, and later developed technology. The friction theory fails us because it is implausible on empirical grounds; it fails to explain why other doctrinal avenues, such as reissue, are inadequate; and, like the fairness theory, it pays insufficient attention to patent law’s notice requirement. In short, both the fairness and friction theories fail to provide a persuasive normative justification for applying the DOE.

On the other hand, our refinement theory offers a compelling description of

amendment . . . bear[s] no more than a tangential relation to the equivalent in question; or . . . [if there is] some other reason suggesting that the patentee could not reasonably be expected to have described the insubstantial substitute in question.” *Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co.*, 535 U.S. 722, 740–41 (2002). These alternative grounds for rebutting estoppel are clearly motivated by concern about refinement cost.

291. *Id.* at 741.

292. *Id.*

293. Greater certainty about patent scope comes at a price—diminished incentive to invent. Obviously, any constraint on the DOE reduces the expected scope and value of patent claims. Less obviously, PHE creates noise that diminishes the value of a patent to risk averse inventors. Lichtman produced empirical evidence making this point. He shows the probability of claim amendment correlates with the identity of the examiner, and thus the risk of PHE correlates with examiner identity. Douglas Lichtman, *Rethinking Prosecution History Estoppel*, 71 U. CHI. L. REV. 151, 165–67 (2004).

patent claiming and a social welfare justification of the DOE. We posit that inventors fail to obtain the full claim breadth they are entitled to when they have not sufficiently refined their claims during patent prosecution to capture equivalent technology. According to the refinement theory, the DOE creates a social benefit by allowing patent applicants to avoid certain refinement costs during patent prosecution. The theory also reveals the limits that should be imposed on the doctrine. A socially optimal patent policy should balance refinement cost savings and innovative incentives created by the DOE against the harm to competition and rent-seeking costs created by the doctrine.

APPENDIX

This appendix explains the derivation of the equilibrium outcomes depicted in Figure 1, and then justifies Propositions 1 through 6. In the first stage the potential inventor, called firm 1, decides whether to invest w to obtain E , a patentable embodiment of the invention.²⁹⁴ Firm 1 also decides in the first stage whether to make an additional investment of x to refine the invention and obtain the embodiment F . To keep the model as simple as possible, we suppose that F can only be obtained after E . If firm 1 obtains E but not F , then the game moves to stage two. The game ends after stage one if firm 1 makes no investment, or if firm 1 obtains both E and F . In the second stage the potential competitor, called firm 2, decides whether to invest y to develop F .²⁹⁵

Patent law is incorporated into the model by comparing the outcomes of the game with and without our stylized version of the DOE. Under the DOE firm 1 can exclude firm 2 from making E or F after firm 1 claims E in a patent. The DOE expands the scope of firm 1's claim to cover F . In contrast, in the game without the DOE firm 1 must claim F before it gets patent protection over it.

Equilibrium behavior under the DOE is easy to derive. If firm 1 does not make the initial investment w , then there is no invention, no technology to exploit, and firm 1 makes a profit of zero.

$$\pi_1(\emptyset) = 0. \quad (1)$$

If firm 1 invests w to obtain E and neither firm has access to F , then firm 1 gets the profit from a single product monopoly (denoted M_1). Profit for firm 1 is:

$$\pi_1(E) = M_1 - w. \quad (2)$$

If firm 1 invests w and x , then it obtains both embodiments E and F , and gets the profit from a two product monopoly (denoted M_2). Thus, profit for firm 1 is:

294. For ease of exposition, we will treat E and F as single embodiments instead of sets of embodiments. This choice of language does not affect the validity of our analysis for the case when E and F are sets of embodiments.

295. We assume that firm 2 cannot "invent," i.e., obtain embodiment E before firm 1.

$$\pi_1(\text{EF}) = M_2 - w - x. \quad (3)$$

Under the DOE firm 1 simply chooses the strategy that maximizes the profit given by the expressions in (1) through (3). Invention and refinement yields the highest profit if $x \leq M_2 - M_1$ and $x \leq M_2 - w$. These inequalities bound the efficient refinement region in Figure 1. Invention and no refinement yields the highest profit if $x \geq M_2 - M_1$ and $w \leq M_1$. These inequalities bound the rectangle in Figure 1 made up of imitation, preemptive refinement and pioneer inventions. The remaining case matches the no invention region in Figure 1.

In the regime with no DOE, profit expressions (1) and (3) still apply if firm 1 chooses not to invent, or to invent and refine. The other possibility is that firm 1 invents and allows firm 2 to imitate. In this case profit to firm 1 is:

$$\pi_1(\text{imitation}) = D - w. \quad (4)$$

Recall that imitation is not profitable to firm 2 and will not occur unless $D \geq y$. Assuming this condition holds, then firm 1 chooses the strategy that maximizes the profit given by expressions (1), (3), and (4). Invention and refinement yields the highest profit if $x \leq M_2 - D$ and $x \leq M_2 - w$. These inequalities bound the preemptive and efficient refinement regions in Figure 1. Invention and imitation yields the highest profit if $x \geq M_2 - D$ and $w \leq D$. These inequalities bound the imitation region in Figure 1. The remaining case corresponds to the pioneer invention and no invention regions in Figure 1. Notice that $M_1 \geq D$, thus $M_2 - D \geq M_2 - M_1$, and the DOE and no DOE regions in Figure 1 are located correctly relative to each other.

After characterizing the equilibrium outcomes, proof of the propositions follows rather easily. Proposition 1 observes that the DOE and no DOE are equivalent when $y < D$ because firm 2 does not pose a credible threat of entry. If $D \geq y$ and (3) is larger than (1) or (2), then invention and refinement occurs regardless of whether the DOE is available. Recall refinement is efficient under the DOE when refinement costs are sufficiently small, i.e., $x \leq M_2 - M_1$ and $x \leq M_2 - w$.

Proposition 2 indicates that the DOE boosts the incentive to invent. In the region labeled pioneer invention in Figure 1, invention is profitable under the DOE because (2) is greater than zero. But invention is not profitable under no DOE because (3) and (4) are both less than zero. Therefore, DOE leads to invention when the sum of invention and refinement costs is relatively high (in the pioneer region) and no DOE leads to no invention.

Proposition 3 reflects the outcomes in the region labeled preemptive refinement in Figure 1. Under the DOE, firm 1 avoids refinement because the benefit in terms of access to a greater range of technology is not worth the cost, i.e., $x \geq M_2 - M_1$. Under no DOE, firm 1 refines to preempt entry which is profitable because $x \leq M_2 - D$.

Proposition 4 reflects the outcomes in the region labeled imitation in Figure

1. The model is designed with a strong DOE such that imitation never occurs under the doctrine. In contrast, imitation occurs under no DOE in the imitation region where refinement costs are especially high.

Propositions 5 and 6 emerge from a three-stage model. The third stage offers firms 1 and 2 a chance to develop F at a later date, perhaps when development is easier because of technological advances. There are a variety of plausible ways to set up the three-stage model. Here we simply sketch an approach and suggest how to prove Propositions 5 and 6.

Proposition 5 can be demonstrated by assuming the parameter values fall into the preemptive refinement region in Figure 1. Thus, in the two-stage model, firm 1 does not refine under the DOE. Shifting to the three-stage model, suppose that firm 1 expects refinement costs to fall significantly over time, and firm 1 invents E and waits until the third stage to develop F . Firm 1 would enjoy the single-product monopoly profit for a period of time and then later enjoy the two-product monopoly profit. Let firm 1's profit from use of the technology equal M' where $M_2 \geq M' \geq M_1$, and let $x' < x$ be the expected cost of delayed refinement. The profit under the DOE from delayed refinement is:

$$\pi_1(\text{delay}) = M' - w - x'. \quad (5)$$

Firm 1 would not delay refinement in the absence of the DOE because firm 2 could enter the market either during stage two or stage three. Therefore, we have firm 1 profiting from delayed refinement under the DOE, assuming (5) is greater than (2), and firm 1 choosing early refinement and getting a profit of (3) under no DOE. The profit expression in (5) is greater than (2) if the refinement cost falls enough over time.

Proposition 6 can be demonstrated by assuming refinement and development costs are high so that firm 2 cannot profitably enter, and firm 1 has no interest in refinement. Unforeseeable later-developed technology can be modeled such that refinement cost will probably remain constant but could fall substantially with a small probability. Given the assumption of high initial refinement cost, firm 1 expects to make the profit given in (2). Making an adjustment for unforeseeable later-developed technology would raise the expected profit of firm 1 by a small amount under the DOE, and reduce it by a small amount if there is no DOE. Application of the DOE in this case is not warranted because the impact on the incentive to invent is small, and the ex post social gain from imitation could be large.