

U.C.L.A. Law Review

Everything Is Obvious

Ryan Abbott

ABSTRACT

For more than sixty years, “obviousness” has set the bar for patentability. Under this standard, if a hypothetical “person having ordinary skill in the art” would find an invention obvious in light of existing relevant information, then the invention cannot be patented. This skilled person is defined as a non-innovative worker with a limited knowledge-base. The more creative and informed the skilled person, the more likely an invention will be considered obvious. The standard has evolved since its introduction, and it is now on the verge of an evolutionary leap: Inventive machines are increasingly being used in research, and once the use of such machines becomes standard, the person skilled in the art should be a person using an inventive machine, or just an inventive machine. Unlike the skilled person, the inventive machine is capable of innovation and considering the entire universe of prior art. As inventive machines continue to improve, this will increasingly raise the bar to patentability, eventually rendering innovative activities obvious. The end of obviousness means the end of patents, at least as they are now.

AUTHOR

Professor of Law and Health Sciences, University of Surrey School of Law and Adjunct Assistant Professor, David Geffen School of Medicine at University of California, Los Angeles. Thanks to Ryan Calo, Ian Kerr, Mark Lemley, Lisa Larrimore-Ouellette, and Jake Sherkow, as well as participants in workshops at the University of Surrey, WeRobot Conference, Oxford Business Law Workshop, and the Sixth Annual Fall Conference hosted by the Center for the Protection of Intellectual Property (CPIP) at Antonin Scalia Law School for their insightful comments.

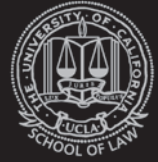


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INTRODUCTION

For at least two decades, machines have been autonomously generating patentable inventions.¹ “Autonomously” here refers to the machine, rather than to a person, meeting traditional inventorship criteria. In other words, if the “inventive machine” were a natural person, it would qualify as a patent inventor. In fact, the U.S. Patent and Trademark Office (USPTO or Patent Office) may have granted patents for inventions autonomously generated by computers as early as 1998.² In earlier articles, I examined instances of autonomous machine invention in detail and argued that such machines ought to be legally recognized as patent inventors to incentivize innovation and promote fairness.³ The owners of such machines would be the owners of their inventions.⁴ In those works, as here, terms such as “computers” and “machines” are used interchangeably to refer to computer programs or software rather than to physical devices or hardware.⁵

This Article focuses on a related phenomenon: What happens when inventive machines become a standard part of the inventive process? This is not a thought experiment.⁶ For instance, while the timeline is controversial, surveys of experts suggest that artificial general intelligence, which is a computer able to perform any intellectual task a person could, will develop in the next twenty-five years.⁷ Some thought leaders, such as Ray Kurzweil, one of Google’s Directors of

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1. See Ryan Abbott, *I Think, Therefore I Invent: Creative Computers and the Future of Patent Law*, 57 B.C. L. REV. 1079, 1083–91 (2016) [hereinafter *I Think*] (describing instances of “computational invention” or “computer-generated works”); see also *infra* Subpart II.B (discussing some such instances in greater detail).
 2. Abbott, *supra* note 1, at 1085.
 3. *Id.* at 1083–91; Ryan Abbott, *Hal the Inventor: Big Data and Its Use by Artificial Intelligence*, in *BIG DATA IS NOT A MONOLITH* (Cassidy R. Sugimoto, Hamid R. Ekbia & Michael Mattioli eds., 2016) [hereinafter *Hal the Inventor*] (discussing computational invention in a book chapter first posted online February 19, 2015).
 4. Except where no owner exists, in possible cases of some open-source or distributed software, in which case ownership could vest in a user.
 5. Except perhaps in exceptional cases where software does not function on a general-purpose machine, and where specialized hardware is required for the software’s function.
 6. The growing prevalence and sophistication of artificial intelligence is accelerating the use of inventive machines in research and development. See Ryan Abbott & Bret Bogenschneider, *Should Robots Pay Taxes? Tax Policy in the Age of Automation*, 12 HARV. L. & POL’Y REV. 145 (2018) [hereinafter *Should Robots Pay Taxes?*] (discussing the trend toward automation).
 7. See generally Vincent C. Müller & Nick Bostrom, *Future Progress in Artificial Intelligence: A Survey of Expert Opinion*, in *FUNDAMENTAL ISSUES OF ARTIFICIAL INTELLIGENCE* 553 (Vincent C. Müller ed., 2016).

Engineering, predict computers will have human levels of intelligence in about a decade.⁸

The impact of the widespread use of inventive machines will be tremendous, not just on innovation, but also on patent law.⁹ Right now, patentability is determined based on what a hypothetical, non-inventive, skilled person would find obvious.¹⁰ The skilled person represents the average worker in the scientific field of an invention.¹¹ Once the average worker uses inventive machines, or inventive machines replace the average worker, then inventive activity will be normal instead of exceptional.

If the skilled person standard fails to evolve accordingly, this will result in too lenient a standard for patentability. Patents have significant anticompetitive costs, and allowing the average worker to routinely patent their outputs would cause social harm. As the U.S. Supreme Court has articulated, “[g]ranting patent protection to advances that would occur in the ordinary course without real innovation retards progress and may . . . deprive prior inventions of their value or utility.”¹²

The skilled standard must keep pace with real world conditions. In fact, the standard needs updating even before inventive machines are commonplace. Already, computers are widely facilitating research and assisting with invention. For instance, computers may perform literature searches, data analysis, and pattern recognition.¹³ This makes current workers more knowledgeable and creative than they would be without the use of such technologies. The Federal Circuit has provided a list of nonexhaustive factors to consider in determining the level of ordinary skill: (1) “type[s] of problems encountered in the art,” (2) “prior art solutions to those problems,” (3) “rapidity with which innovations are made,” (4) “sophistication of the technology,” and (5) “educational level of active

8. Peter Rejcek, *Can Futurists Predict the Year of the Singularity?*, SINGULARITY HUB (Mar. 31, 2017), <https://singularityhub.com/2017/03/31/can-futurists-predict-the-year-of-the-singularity> [https://perma.cc/4TDE-QQTW] (predicting artificial general intelligence in 2029).

9. See, e.g., ROBERT PLOTKIN, *THE GENIE IN THE MACHINE: HOW COMPUTER-AUTOMATED INVENTING IS REVOLUTIONIZING LAW & BUSINESS* 60 (2009) (arguing that “[a]rtificial invention technology . . . enables [users] to produce inventions that they could not have created at all without such technology”); Ben Hattenbach & Joshua Glucoft, *Patents in an Era of Infinite Monkeys and Artificial Intelligence*, 19 STAN. TECH. L. REV. 32, 44 n.70 (2015); Brenda M. Simon, *The Implications of Technological Advancement for Obviousness*, 19 MICH. TELECOMM. & TECH. L. REV. 331 (2013).

10. 35 U.S.C. § 103(a) (2006). The “person having ordinary skill in the art” may be abbreviated as “PHOSITA” or simply the skilled person.

11. See *infra* Subpart I.D.

12. *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 402 (2007).

13. Such contributions when made by other persons do not generally rise to the level of inventorship, but they assist with reduction to practice.

workers in the field.”¹⁴ This test should be modified to include a sixth factor: (6) “technologies used by active workers.”

This change will more explicitly take into account the fact that machines are already augmenting the capabilities of workers, in essence making more obvious and expanding the scope of prior art. Once inventive machines become the standard means of research in a field, the test would also encompass the routine use of inventive machines by skilled persons. Taken a step further, once inventive machines become the standard means of research in a field, the skilled person should be an inventive machine. Specifically, the skilled person should be an inventive machine when the standard approach to research in a field or with respect to a particular problem is to use an inventive machine (the “Inventive Machine Standard”).

To obtain the necessary information to implement this test, the Patent Office should establish a new requirement for applicants to disclose when a machine contributes to the conception of an invention, which is the standard for qualifying as an inventor. Applicants are already required to disclose all human inventors, and failure to do so can render a patent invalid or unenforceable. Similarly, applicants should need to disclose whether a machine has done the work of a human inventor. This information could be aggregated to determine whether most invention in a field is performed by people or machines. This information would also be useful for determining appropriate inventorship, and more broadly for formulating innovation policies.

Whether the Inventive Machine Standard is that of a skilled person using an inventive machine or just an inventive machine, the result will be the same: The average worker will be capable of inventive activity. Conceptualizing the skilled person as using an inventive machine might be administratively simpler, but replacing the skilled person with the inventive machine would be preferable because it emphasizes that the *machine* is engaging in inventive activity, rather than the human worker.

Yet simply substituting an inventive machine for a skilled person might exacerbate existing problems with the nonobviousness inquiry. With the current skilled person standard, decisionmakers, in hindsight, need to reason about what another person would have found obvious.¹⁵ This results in

14. *In re GPAC Inc.*, 57 F.3d 1573, 1579 (Fed. Cir. 1995).

15. See generally Gregory N. Mandel, *Patently Non-Obvious: Empirical Demonstration that the Hindsight Bias Renders Patent Decisions Irrational*, 67 OHIO ST. L.J. 1391 (2006) (discussing problems with hindsight in non-obviousness inquiries).

inconsistent and unpredictable nonobviousness determinations.¹⁶ In practice, the skilled person standard bears unfortunate similarities to the “Elephant Test,”¹⁷ or Justice Stewart’s famously unworkable definition of obscene material: “I know it when I see it.”¹⁸ This may be even more problematic in the case of inventive machines, as it is likely to be difficult for human decisionmakers to theoretically reason about what a machine would find obvious.

An existing vein of critical scholarship has already advocated for nonobviousness inquiries to focus more on economic factors or objective “secondary” criteria, such as long-felt but unsolved needs, the failure of others, and real-world evidence of how an invention was received in the marketplace.¹⁹ Inventive machines may provide the impetus for such a shift.

Nonobvious inquiries utilizing the Inventive Machine Standard might also focus on *reproducibility*, specifically whether standard machines could reproduce the subject matter of a patent application with sufficient ease. This could be a more objective and determinate test that would allow the Patent Office to apply a single standard consistently, and it would result in fewer judicially invalidated patents.²⁰ A nonobviousness inquiry focused on either secondary

16. See FED. TRADE COMM’N, TO PROMOTE INNOVATION: THE PROPER BALANCE OF COMPETITION AND PATENT LAW AND POLICY 6–15 (2003) (critiquing Section 103 decisions).

17. *Cadogan Estates Ltd. v. Morris* [1998] EWCA Civ. 1671 at 17 (Eng.) (referring to “the well known elephant test. It is difficult to describe, but you know it when you see it”).

18. 378 U.S. 184, 197 (1964).

19. See, e.g., Michael Abramowicz & John F. Duffy, *The Inducement Standard of Patentability*, 120 YALE L.J. 1590, 1596 (2011) (arguing for an inducement standard); Tun-Jen Chiang, *A Cost-Benefit Approach to Patent Obviousness*, 82 ST. JOHN’S L. REV. 39, 42 (2008) (arguing that, “[a]n invention should receive a patent if the accrued benefits before independent invention outweigh the costs after independent invention”); Alan Devlin & Neel Sukhatme, *Self-Realizing Inventions and the Utilitarian Foundation of Patent Law*, 51 WM. & MARY L. REV. 897 (2009); John F. Duffy, *A Timing Approach to Patentability*, 12 LEWIS & CLARK L. REV. 343 (2008) (arguing for a timing approach to determining obviousness); Daralyn J. Durie & Mark A. Lemley, *A Realistic Approach to the Obviousness of Inventions*, 50 WM. & MARY L. REV. 989, 1004–07 (2008) (arguing for a greater reliance on secondary considerations); Gregory Mandel, *The Non-Obvious Problem: How the Indeterminate Nonobviousness Standard Produces Excessive Patent Grants*, 42 U.C. DAVIS L. REV. 57, 62 (2008) [hereinafter Mandel, *The Non-Obvious Problem*] (arguing for nonobviousness to be based on “how probable the invention would have been for a person having ordinary skill in the art working on the problem that the invention solves”); Robert P. Merges, *Uncertainty and the Standard of Patentability*, 7 HIGH TECH. L.J. 1, 19 (1992) (arguing that patents should be issued for inventions which appeared unlikely to succeed in advance).

20. For decades, obviousness has been the most common issue in litigation to invalidate a patent, and the most common grounds for a finding of patent invalidity. See John R. Allison & Mark A. Lemley, *Empirical Evidence on the Validity of Litigated Patents*, 26 AIPLA Q.J. 185, 208–09 (1998); John R. Allison et al., *Understanding the Realities of Modern Patent Litigation*, 92 TEX. L. REV. 1769, 1782, 1785 (2014). As other commentators have noted, the bar here is low, and the new standard, “can be an administrative success if it is even just a bit

factors or reproducibility may avoid some of the difficulties inherent in applying a “cognitive” inventive machine standard.

However the test is applied, the Inventive Machine Standard will dynamically raise the current benchmark for patentability. Inventive machines will be significantly more intelligent than skilled persons and also capable of considering more prior art. An Inventive Machine Standard would not prohibit patents, but it would make obtaining them substantially more difficult: A person or computer might need to have an unusual insight that other inventive machines could not easily recreate, developers might need to create increasingly intelligent computers that could outperform standard machines, or, most likely, invention will be dependent on specialized, non-public sources of data. The nonobviousness bar will continue to rise as machines inevitably become increasingly sophisticated. Taken to its logical extreme, and given there may be no limit to how intelligent computers will become, it may be that every invention will one day be obvious to commonly used computers. That would mean no more patents should be issued without some radical change to current patentability criteria.

This Article is structured in three parts. Part I considers the current test for obviousness and its historical evolution. It finds that obviousness is evaluated through the lens of the skilled person, who reflects the characteristics of the average worker in a field.²¹ The level of creativity and knowledge imputed to the skilled person is critical for the obviousness analysis.²² The more capable the skilled person, the more they will find obvious, and this will result in fewer issued patents.

Part II considers the use of artificial intelligence in research and development (R&D) and proposes a novel framework for conceptualizing the transition from human to machine inventors. Already, inventive machines are competing with human inventors, and human inventors are augmenting their

better than current doctrine as a helpful theoretical and pragmatic guide for applying the obviousness doctrine.” Abramowicz & Duffy, *supra* note 19, at 1601.

21. See *Ruiz v. A.B. Chance Co.*, 234 F.3d 654, 666 (Fed. Cir. 2000); see also *Ryko Mfg. Co. v. Nu-Star, Inc.*, 950 F.2d 714, 718 (Fed. Cir. 1991) (“The importance of resolving the level of ordinary skill in the art lies in the necessity of maintaining objectivity in the obviousness inquiry.”). The Manual of Patent Examining Procedure (MPEP) provides guidance on the level of ordinary skill in the art. MPEP § 2141.03.
22. *DyStar Textilfarben GmbH & Co. Deutschland KG v. C.H. Patrick Co.*, 464 F.3d 1356, 1370 (Fed. Cir. 2006) (“If the level of skill is low, for example that of a mere dyer, as Dystar has suggested, then it may be rational to assume that such an artisan would not think to combine references absent explicit direction in a prior art reference.”). Though, in practice, few cases involve explicit factual determinations of the PHOSITA’s skill. Rebecca S. Eisenberg, *Obvious to Whom? Evaluating Inventions From the Perspective of PHOSITA*, 19 BERKELEY TECH. L.J. 885, 888 (2004). See *infra* Subpart I.D for a discussion of the PHOSITA standard.

abilities with inventive machines. In time, inventive machines or people using inventive machines will become the standard in a field, and eventually, machines will be responsible for most or all innovation. As this occurs, the skilled person standard must evolve if it is to continue to reflect real-world conditions. Failure to do this would “stifle, rather than promote, the progress of the useful arts.”²³

Part II then proposes a framework for implementing a proposed Inventive Machine Standard. A decisionmaker would need to (1) determine the extent to which inventive machines are used in a field, (2) if inventive machines are the standard, characterize the inventive machine(s) that best represents the average worker, and (3) determine whether the machine(s) would find an invention obvious. The decisionmaker is a patent examiner in the first instance,²⁴ and potentially a judge or jury if the validity of a patent is at issue in trial.²⁵ In both instances, this new test would involve new challenges.

Finally, Part III provides examples of how the Inventive Machine Standard could work in practice, such as by focusing on reproducibility or secondary factors. It then goes on to consider some of the implications of the new standard. Once the average worker is inventive, there may no longer be a need for patents to function as innovation incentives. To the extent patents accomplish other goals such as promoting commercialization and disclosure of information or validating moral rights, other mechanisms may be found to accomplish these goals with fewer costs.

Although this Article focuses on U.S. patent law, a similar framework exists in nearly every country. Member States of the World Trade Organization (WTO) are required to grant patents for inventions that “are new, involve an

23. *KSR Int’l Co.*, 550 U.S. at 427.

24. At the Patent Office, applications are initially considered by a patent examiner, and examiner decisions can be appealed to the Patent Trial and Appeal Board (PTAB). U.S. PATENT & TRADEMARK OFFICE, *Patent Trial and Appeal Board*, <https://www.uspto.gov/patents-application-process/patent-trial-and-appeal-board-0> [<https://perma.cc/3W42-FHH2>]. Also, the PTAB can adjudicate issues of patentability in certain proceedings such as inter partes review. *Id.*

25. Determinations of patent validity can involve mixed questions of law and fact. Generally, in civil litigation, legal questions are determined by judges, while factual questions are for a jury. *See, e.g.,* *Structural Rubber Prods. Co. v. Park Rubber Co.*, 749 F.2d 707, 713 (Fed. Cir. 1984) (“Litigants have the right to have a case tried in a manner which ensures that factual questions are determined by the jury and the decisions on legal issues are made by the court . . .”). There are some exceptions to this rule. *See, e.g.,* *Gen. Electro Music Corp. v. Samick Music Corp.*, 19 F.3d 1405, 1408 (Fed. Cir. 1994) (“[I]ssues of fact underlying the issue of inequitable conduct are not jury questions, the issue being entirely equitable in nature.”). *See also* Mark A. Lemley, *Why Do Juries Decide If Patents Are Valid?* (Stanford Pub. Law, Working Paper No. 2306152, 2013), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2306152.

inventive step and are capable of industrial application.”²⁶ Although U.S. law uses the term “nonobvious” rather than “inventive step,” the criteria are substantively similar.²⁷ For instance, the European Patent Office’s criteria for inventive step is similar to the U.S. criteria for obviousness, and also uses the theoretical device of the skilled person.²⁸

I. OBVIOUSNESS

Part I investigates the current obviousness standard, its historical origins, and how the standard has changed over time. It finds that obviousness depends on the creativity of the skilled person, as well as the prior art they consider. These factors, in turn, vary according to the complexity of an invention and its field of art.

A. Public Policy

Patents are not intended to be granted for incremental inventions.²⁹ Only inventions which represent a significant advance over existing technology should receive protection.³⁰ That is because patents have significant costs: They limit competition, and they can inhibit future innovation by restricting the use

26. Agreement on Trade-Related Aspects of Intellectual Property Rights, art. 27, Apr. 15, 1994, 33 I.L.M. 1197, 1208 [hereinafter TRIPS]. See Ryan B. Abbott, et al., *The Price of Medicines in Jordan: The Cost of Trade-Based Intellectual Property*, 9 J. GENERIC MEDS. 75, 76 (2012).

27. TRIPS, *supra* note 26, at 1208 n.5. Although, there are some substantive differences in the way these criteria are implemented, and TRIPS provides nations with various flexibilities for compliance. See generally Ryan Abbott, *Balancing Access and Innovation in India’s Shifting IP Regime*, Remarks, 35 WHITTIER L. REV. 341 (2014) [hereinafter *Balancing Access*].

28. “An invention shall be considered as involving an inventive step if, having regard to the state of the art, it is not obvious to a person skilled in the art.” Convention on the Grant of European Patents art. 56, Oct. 5, 1973, 13 I.L.M. 268. For guidance on the “skilled person” in European patent law, see *Guidelines for Examinations*, EUR. PAT. OFF., http://www.epo.org/law-practice/legal-texts/html/guidelines/e/g_vii_3.htm [<https://perma.cc/XFY3-JD8J>] (last visited Sept. 24, 2018).

29. The nonobviousness requirement is contained in Section 103 of the Patent Act:
A patent for a claimed invention may not be obtained, notwithstanding that the claimed invention is not identically disclosed as set forth in section 102, if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains.

35 U.S.C. § 103 (2018).

30. *Atlantic Works v. Brady*, 107 U.S. 192, 200 (1883) (noting that “[t]o grant to a single party monopoly of every slight advance made, except where the exercise of invention, somewhat above ordinary mechanical or engineering skill, is distinctly shown, is unjust in principle and injurious in its consequences”).

of patented technologies in research and development.³¹ To the extent that patents are justified, it is because they are thought to have more benefits than costs. Patents can function as innovation incentives, promote the dissemination of information, encourage commercialization of technology, and validate moral rights.³²

Patents are granted for inventions that are new, nonobvious, and useful.³³ Of these three criteria, obviousness is the primary hurdle for most patent applications.³⁴ Although other patentability criteria contribute to this function, the nonobviousness requirement is the primary test for distinguishing between significant innovations and trivial advances.³⁵ Of course, it is one thing to express a desire to only protect meaningful scientific advances, and another to come up with a workable rule that applies across every area of technology.

B. Early Attempts

The modern obviousness standard has been the culmination of hundreds of years of struggle by the Patent Office, courts, and Congress to separate the wheat from the chaff.³⁶ As Thomas Jefferson, the first administrator of the U.S.

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31. See *I Think*, *supra* note 1, at 1105–06 (discussing the costs and benefits of the patent system).
 32. *Id.* at 1105–08. Congress’s power to grant patents is constitutional, and based on incentive theory: “To promote the progress of science . . . by securing for limited times to . . . inventors the exclusive right to their respective . . . discoveries.” U.S. CONST. art. I, § 8, cl. 8. See Mark A. Lemley, *Ex Ante Versus Ex Post Justifications for Intellectual Property*, 71 U. CHI. L. REV. 129, 129 (2004) (“The standard justification for intellectual property is *ex ante* It is the prospect of the intellectual property right that spurs creative incentives.”); see also *United States v. Line Material Co.*, 333 U.S. 287, 316 (1948) (Douglas, J., concurring) (noting “the reward to inventors is wholly secondary” to the reward to society); THE FEDERALIST NO. 43 (James Madison) (stating that social benefit arises from patents to inventors). The U.S. Supreme Court has endorsed an economic inducement rationale in which patents should only be granted for inventions which would “not be disclosed or devised but for the inducement of a patent.” This is the inducement theory articulated in *Graham v. John Deere Co.*, 383 U.S. 1, 10 (1966). See also Abramowicz & Duffy, *supra* note 20.
 33. 35 U.S.C. §§ 101–103, 112 (2018). In the European system, these criteria are referred to as novelty, inventive step, and industrial applicability. Art. 52 EPC. Inventions must also comprise patentable subject matter and be adequately disclosed. 35 U.S.C. §§ 101–103, 112 (2018).
 34. DONALD CHISUM, CHISUM ON PATENTS § 5.02[6] (2007); NONOBVIOUSNESS—THE ULTIMATE CONDITION OF PATENTABILITY 2:101 (J. Witherspoon ed., 1980). Obviousness is the most commonly litigated issue of patent validity. Allison & Lemley, *supra* note 20, at 208–09 (1998).
 35. 35 U.S.C. §§ 101–102, 112 (2018).
 36. For that matter, the struggle dates back to the very first patent law, the Venetian Act of 1474, which stated that only “new and ingenious” inventions would be protected. See Giulio Mandich, *Venetian Patents (1450–1550)*, 30 J. PAT. OFF. SOC’Y 166, 176–77 (1948); A. Samuel Oddi, *Beyond Obviousness: Invention Protection in the Twenty-First Century*, 38 AM.

patent system and one of its chief architects, wrote, “I know well the difficulty of drawing a line between the things which are worth to the public the embarrassment of an exclusive patent, and those which are not . . . I saw with what slow progress a system of general rules could be matured.”³⁷

The earliest patent laws focused on novelty and utility, although Jefferson did at one point suggest an “obviousness” requirement.³⁸ The Patent Act of 1790 was the first patent statute, and it required patentable inventions to be “sufficiently useful and important.”³⁹ Three years later, a more comprehensive patent law was passed—the Patent Act of 1793.⁴⁰ The new act did not require an invention to be “important,” but required it to be “new and useful.”⁴¹ The 1836 Patent Act reinstated the requirement that an invention be “sufficiently used and important.”⁴²

In 1851, the Supreme Court adopted the progenitor of the skilled person and the obviousness test—an “invention” standard.⁴³ *Hotchkiss v. Greenwood*

U. L. REV. 1097, 1102–03 (1989); Frank D. Prager, *A History of Intellectual Property From 1545 to 1787*, 26 J. PAT. OFF. SOC’Y 711, 715 (1944).

37. Letter to Isaac McPherson (Aug. 13, 1813), in 5 THE WRITINGS OF THOMAS JEFFERSON, 1790–1826, 175, 181 (Riker, Thorne & Co. 1854) [hereinafter Letter to Isaac McPherson].

38. In 1791, Jefferson proposed amending the 1790 Patent Act to prohibit patents on an invention if it “is so unimportant and obvious that it ought not be the subject of an exclusive right.” 5 THE WRITINGS OF THOMAS JEFFERSON 278, 1788–1792, (Paul Leicester Ford ed., G.P. Putnam & Sons 1895).

39. Patent Act of 1790, ch. 7, 1 Stat. 109 (repealed 1793).

40. Patent Act of 1793, ch. 11, 1 Stat. 318 (repealed 1836).

41. Patent Act of 1793, ch. 11, 1 Stat. at 318–23. It also prohibited patents on certain minor improvements: “[S]imply changing the form or the proportions of any machine, or compositions of matter, in any degree, shall not be deemed a discovery.” *Id.* at 321. On this basis, Jefferson, who was credited with drafting most of this statute, argued that “[a] change of material should not give title to a patent. As the making a ploughshare of cast rather than of wrought iron; a comb of iron, instead of horn or of ivory . . .” Letter to Isaac McPherson, *supra* note 37, at 181.

42. Patent Act of 1836, ch. 357, § 18, 5 Stat. 117, 124 (repealed 1861).

43. *See, e.g.,* *Graham v. John Deere Co.*, 383 U.S. 1, 17 (1966) (“We conclude that [§ 103] was intended merely as a codification of judicial precedents embracing the *Hotchkiss* condition, with congressional directions that inquiries into the obviousness of the subject matter sought to be patented are a prerequisite to patentability.”); *see also* S. REP. NO. 82-1979, at 6 (1952); H.R. REP. NO. 82-1923, at 7 (1952) (“Section 103 . . . provides a condition which exists in the law and has existed for more than 100 years.”). Obviousness had been at issue in earlier cases, although not necessarily in such terms. For instance, in *Earle v. Sawyer*, Justice Story rejected an argument by the defendant that the invention at issue was obvious, and that something more than novelty and utility was required for a patent. 8 F. Cas. 254, 255 (Cir. Ct. D. Mass. 1825). He argued a court was not required to engage in a “mode of reasoning upon the metaphysical nature, or the abstract definition of an invention.” *Id.* Justice Story further noted that English law permits the introducer of a foreign technology to receive a patent, and such an act could not require intellectual labor. *Id.* at 256. In *Evans v. Eaton*, the Supreme Court held that, a patent invention must involve a change in the “principle” of the machine rather than a change “merely in form and proportion.” 20 U.S.

concerned a patent for substituting clay or porcelain for a known door knob material such as metal or wood.⁴⁴ The Court invalidated the patent, holding that “the improvement is the work of a skillful mechanic, not that of the inventor.”⁴⁵ The Court also articulated a new legal standard for patentability: “Unless more ingenuity and skill . . . were required . . . 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.”⁴⁶

However, the Court did not give specific guidance on what makes something inventive or the required level of inventiveness. In subsequent years, the Court made several efforts to address these deficiencies, but with limited success. As the Court stated in 1891, “[t]he truth is the word [invention] cannot be defined in such manner as to afford any substantial aid in determining whether any particular device involves an exercise of inventive faculty or not.”⁴⁷ Or as one commentator noted, “it was almost impossible for one to say with any degree of certainty that a particular patent was indeed valid.”⁴⁸

Around 1930, the Supreme Court, possibly influenced by a national antimonopoly sentiment, began implementing stricter criteria for determining the level of invention.⁴⁹ This culminated in the widely disparaged “Flash of Genius” test articulated in *Cuno Engineering v. Automatic Devices Corp.*⁵⁰ Namely, that in order to receive a patent, “the new device must reveal the flash of creative genius, not merely the skill of the calling.”⁵¹ This test was interpreted to mean that an invention must come into the mind of an inventor as a result of

(7 Wheat) 356, 361–62 (1822). Writing for the Court, Justice Story noted the patent was invalid because it was “substantially the same in principle” as a prior invention. *Id.* at 362.

44. 52 U.S. 248, 265 (1850).

45. *Id.* at 267.

46. *Id.*

47. *McClain v. Ortmayer*, 141 U.S. 419, 427 (1891). Another court noted that “invention” is “as fugitive, impalpable, wayward, and vague a phantom as exists in the paraphernalia of legal concepts.” *Harries v. Air King Prods. Co.*, 183 F.2d 158, 162 (2d Cir. 1950).

48. Gay Chin, *The Statutory Standard of Invention: Section 103 of the 1952 Patent Act*, 3 PAT. TRADEMARK & COPY. J. RES. & EDUC. 317, 318 (1959).

49. See, e.g., Edward B. Gregg, *Tracing the Concept of Patentable Invention*, 13 VILL. L. REV. 98 (1967).

50. *Cuno Eng’g Corp. v. Automatic Devices Corp.*, 314 U.S. 84, 91 (1941) (formalizing the test). See, e.g., *Hamilton Standard Propeller Co. v. Fay-Egan Mfg. Co.*, 101 F.2d 614, 617 (6th Cir. 1939) (“The patentee did not display any flash of genius, inspiration or imagination . . .”). The Flash of Genius test was reaffirmed by the Court in 1950 in *Great Atlantic & Pacific Tea Co. v. Supermarket Equip. Corp.*, 340 U.S. 147, 154 (1950) (Douglas, J., concurring).

51. *Cuno Eng’g Corp.*, 314 U.S. at 91.

“inventive genius”⁵² rather than as a “result of long toil and experimentation.”⁵³ The Court reasoned that “strict application of the test is necessary lest in the constant demand for new appliances the heavy hand of tribute be laid on each slight technological advance in the art.”⁵⁴

The Flash of Genius test was criticized for being vague and difficult to implement, and for involving subjective decisions about an inventor’s state of mind.⁵⁵ It certainly made it substantially more difficult to obtain a patent.⁵⁶ Extensive criticism of perceived judicial hostility toward patents resulted in President Franklin D. Roosevelt’s creation of a National Patent Planning Commission to make recommendations for improving the patent system.⁵⁷ The

52. *Reckendorfer v. Faber*, 92 U.S. 347, 357 (1875).

53. The Supreme Court later claimed the “Flash of Creative Genius” language was just a rhetorical embellishment, and that requirement concerned only the device itself, not the manner of invention. *Graham v. John Deere Co.*, 383 U.S. 1, 15 n.7, 16 n.8 (1966). That was not, however, how the test was interpreted. See P.J. Federico, *Origins of Section 103*, 5 APLA Q.J. 87, 97 n.5 (1977) (noting the test led to a higher standard of invention in the lower courts). In *Atlantic & Pacific Tea Co. v. Supermarket Equipment Corp.*, 340 U.S. 147 (1950), another case cited for the proposition that the Court had adopted stricter patentability criteria, the majority did not consider the question of inventiveness, but in his concurring opinion Justice Douglas reiterated the concept of “inventive genius”: “It is not enough that an article is new and useful. The Constitution never sanctioned the patenting of gadgets. Patents serve a higher end—the advancement of science. An invention need not be as startling as an atomic bomb to be patentable. But it has to be of such quality and distinction that that masters of the scientific field in which it falls will recognize it as an advance.” *Id.*

54. *Cuno Eng’g Corp.*, 314 U.S. at 92.

55. As a commentator at the time noted, “the standard of patentable invention represented by [the Flash of Genius doctrine] is apparently based upon the nature of the mental processes of the patentee-inventor by which he achieved the advancement in the art claimed in his patent, rather than solely upon the objective nature of the advancement itself.” Comment, *The “Flash of Genius” Standard of Patentable Invention*, 13 FORDHAM L. REV. 84, 87 (1944). See Note, *Patent Law—“Flash of Genius” Test for Invention Rejected*, 5 DEPAUL L. REV. 144, 146 (1955); Stephen G. Kalinchak, *Obviousness and the Doctrine of Equivalents in Patent Law: Striving for Objective Criteria*, 43 CATH. U. L. REV. 577, 586 (1994); see also, Note, *The Standard of Patentability—Judicial Interpretation of Section 103 of the Patent Act Source*, 63 COLUM. L. REV. 306, 306 (1963) [hereinafter *The Standard of Patentability*] (criticizing the standard).

56. Supreme Court Justice Robert Jackson noted in a dissent that “the only patent that is valid is one which this Court has not been able to get its hands on.” *Jungersen v. Ostby & Barton Co.*, 335 U.S. 560, 572 (1949) (Jackson, J., dissenting).

57. See William Jarratt, *U.S. National Patent Planning Commission*, 153 NATURE 12 (1944); see also REPORT OF THE NATIONAL PATENT PLANNING COMMISSION, NATIONAL PATENT PLANNING COMMISSION, at 6, 10 (1943).

Commission's report recommended that Congress adopt a more objective and certain standard of obviousness.⁵⁸ A decade later, Congress did.⁵⁹

C. The Nonobviousness Inquiry

The Patent Act of 1952 established the modern patentability framework.⁶⁰ Among other changes to substantive patent law,⁶¹ “the central thrust of the 1952 Act removed ‘unmeasurable’ inquiries into ‘inventiveness’ and instead supplied the nonobviousness requirement of Section 103.”⁶² Section 103 states:

A patent may not be obtained . . . if the difference between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.⁶³

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58. REPORT OF THE NATIONAL PATENT PLANNING COMMISSION, *supra* note 57, at 5–6. “One of the greatest technical weaknesses of the patent system is the lack of a definitive yardstick as to what is invention.” *Id.* at 26. “The most serious weakness of the present patent system is the lack of a uniform test or standard for determining whether the particular contribution of an inventor merits the award of the patent grant.” *Id.* at 14. “It is proposed that Congress shall declare a national standard whereby patentability of an invention shall be determined by the objective test as to its advancement of the arts and sciences.” *Id.* at 26.
 59. Though, Congress may not have realized what it was doing. See George M. Sirilla, 35 *U.S.C. § 103: From Hotchkiss to Hand to Rich, the Obvious Patent Law Hall-of-Famers*, 32 *J. MARSHALL L. REV.* 437, 509–14 (1999) (discussing the legislative history of the Patent Act of 1952 and the lack of congressional awareness of, and intent for, Section 103).
 60. See *The Standard of Patentability*, *supra* note 55, at 309. “[P]robably no other title incorporates the thinking of so many qualified technical men throughout the country as does this revision.” L. James Harris, *Some Aspects of the Underlying Legislative Intent of the Patent Act of 1952*, 23 *GEO. WASH. L. REV.* 658, 661 (1955).
 61. “The major changes or innovations in the title consist of incorporating a requirement for invention in § 103 and the judicial doctrine of contributory infringement in § 271.” H.R. REP. NO. 1923, 82d Cong., 2d Sess. 5 (1952); S. REP. NO. 1979, 82d Cong., 2d Sess. 4 (1952).
 62. *CLS Bank Int’l v. Alice Corp. Pty. Ltd.*, 717 F.3d 1269, 1296 (Fed. Cir. 2013) (Rader, J., dissenting in part, concurring in part) (citing P.J. Federidco’s Commentary on the New Patent Act, *reprinted in* 75 *J. PAT. & TRADEMARK OFFICE SOC’Y* 161, 177 (1993)). See also *Dann v. Johnston*, 425 U.S. 219, 225–26 (1976) (describing the shift from “an exercise of the inventive faculty” established in case law to a statutory test and stating that “it was only in 1952 that Congress, in the interest of uniformity and definiteness, articulated the requirement in a statute, framing it as a requirement of ‘nonobviousness’” (internal quotation marks and footnote omitted)). The official “Revision Notes” state § 103 is meant to be the basis for “holding . . . patents invalid by the courts[] on the ground of lack of invention.” S. REP. NO. 82-1979, at 18.
 63. 35 U.S.C. § 103, as amended by the America Invents Act. Leahy-Smith America Invents Act, Pub. L. No. 112-29, 125 Stat. 284, 286 (2011) (codified at 35 U.S.C. § 103 (2018)). The America Invents Act did not fundamentally change the nonobviousness inquiry but did

Section 103 legislatively disavowed the Flash of Genius test, codified the sprawling judicial doctrine on “invention” into a single statutory test, and restructured the standard of obviousness in relation to a person having ordinary skill in the art.⁶⁴ However, while Section 103 may be more objective and definite than the Flash of Genius test, the meanings of “obvious” and “a person having ordinary skill” were not defined, and in practice also proved “often difficult to apply.”⁶⁵

The Supreme Court first interpreted the statutory nonobviousness requirement in a trilogy of cases: *Graham v. John Deere* (1966) and its companion cases, *Calmar v. Cook Chemical* (1965) and *United States v. Adams* (1966).⁶⁶ In these cases, the Court articulated a framework for evaluating obviousness as a question of law based on the following underlying factual inquiries: (1) the scope and content of the prior art, (2) the level of ordinary skill in the prior art, (3) the differences between the claimed invention and the prior art, and (4) objective evidence of nonobviousness.⁶⁷ This framework remains applicable today. Of note, the *Graham* analysis does not explain how to evaluate the ultimate legal question of nonobviousness, beyond identifying underlying factual considerations.⁶⁸

In 1984, the newly established United States Court of Appeals for the Federal Circuit, the only appellate-level court with jurisdiction to hear patent case appeals, devised the “teaching, suggestion, and motivation” (TSM) test for obviousness.⁶⁹ Strictly applied, this test only permits an obviousness rejection when prior art explicitly teaches, suggests or motivates a combination of existing

result in some modest changes. <https://www.uspto.gov/web/offices/pac/mpep/s2158.html> [<https://perma.cc/TAQ7-KMCC>].

64. See Giles S. Rich, *Principles of Patentability*, 28 GEO. WASH. U. L. REV. 393, 393–407 (1960); see also Chin, *supra* note 48, at 318. In *Graham*, the Supreme Court noted that “[i]t . . . seems apparent that Congress intended by the last sentence of § 103 to abolish the test it believed this Court announced in the controversial phrase ‘flash of creative genius,’ used in *Cuno Engineering*.” *Graham*, 383 U.S. at 15.
65. *Uniroyal, Inc. v. Rudkin-Wiley Corp.*, 837 F.2d 1044, 1050 (Fed. Cir. 1988) (noting the obviousness standard is easy to expound and “often difficult to apply”).
66. *Graham v. John Deere Co.*, 383 U.S. 1 (1966); *United States v. Adams*, 383 U.S. 39, 51–52 (1966); *Calmar v. Cook Chem.*, 380 U.S. 949 (1965).
67. *Graham*, 383 U.S. at 17. With regards to the fourth category, considerations such as *commercial success* and *long felt but unsolved needs* can serve as evidence of nonobviousness in certain circumstances. *Id.*
68. See Joseph Miller, *Nonobviousness: Looking Back and Looking Ahead*, in 2 INTELLECTUAL PROPERTY AND INFORMATION WEALTH: ISSUES AND PRACTICES IN THE DIGITAL AGE: PATENTS AND TRADE SECRETS 9 (Peter K. Yu ed., 2007) (“[T]he Court did *not* indicate . . . *how* one was to go about determining obviousness (or not).”).
69. *Court Jurisdiction*, U.S. CT. APPEALS FOR FED. CIR., <http://www.cafc.uscourts.gov/the-court/court-jurisdiction> [<https://perma.cc/TE4D-GRF2>].

elements into a new invention.⁷⁰ The TSM test protects against hindsight bias because it requires an objective finding in the prior art. In retrospect, it is easy for an invention to appear obvious by piecing together bits of prior art using the invention as a blueprint.⁷¹

In *KSR v. Teleflex* (2006), the Supreme Court upheld the *Graham* analysis but rejected the Federal Circuit's exclusive reliance on the TSM test. The Court instead endorsed a flexible approach to obviousness in light of "[t]he diversity of inventive pursuits and of modern technology."⁷² Rather than approving a single definitive test, the Court identified a nonexhaustive list of rationales to support a finding of obviousness.⁷³ This remains the approach to obviousness today.

D. Finding PHOSITA

Determining the level of ordinary skill is critical to assessing obviousness.⁷⁴ The more sophisticated the person having ordinary skill in the art (PHOSITA, or the skilled person), the more likely a new invention is to appear obvious.

70. *ACS Hosp. Sys., Inc. v. Montefiore Hosp.*, 732 F.2d 1572 (Fed. Cir. 1984).

71. *See In re Fritch*, 972 F.2d 1260, 1266 (Fed. Cir. 1992).

72. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 402 (2007). "[An obviousness] analysis need not seek out precise teachings directed to the specific subject matter of the challenged claim, for a court can take account of the inferences and creative steps that a [PHOSITA] would employ." *Id.* at 418.

73. These post-*KSR* rationales include:

(A) Combining prior art elements according to known methods to yield predictable results; (B) Simple substitution of one known element for another to obtain predictable results; (C) Use of known technique to improve similar devices (methods, or products) in the same way; (D) Applying a known technique to a known device (method, or product) ready for improvement to yield predictable results; (E) 'Obvious to try'—choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success; (F) Known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations are predictable to one of ordinary skill in the art; (G) Some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

2141 Examination Guidelines for Determining Obviousness Under 35 U.S.C. 103 [R-08.2017], U.S. PAT. & TRADEMARK OFF., <https://www.uspto.gov/web/offices/pac/mpep/s2141.html> [http://perma.cc/EE7P-4CQ9] [hereinafter *2141 Examination Guidelines*].

74. *Ruiz v. A.B. Chance Co.*, 234 F.3d 654, 666 (Fed. Cir. 2000); *see also* *Ryko Mfg. Co., v. Nu-Star, Inc.*, 950 F.2d 714 718 (Fed. Cir. 1991) ("The importance of resolving the level of ordinary skill in the art lies in the necessity of maintaining objectivity in the obviousness inquiry."). The skilled person is relevant to many areas of patent law, including claim construction, best mode, definiteness, enablement, and the doctrine of equivalents. *See* Dan L. Burk & Mark A. Lemley, *Is Patent Law Technology-Specific?*, 17 *BERKELEY TECH. L.J.* 1155, 1186–87 (2002).

Thus, it matters a great deal whether the skilled person is a “moron in a hurry”⁷⁵ or the combined “masters of the scientific field in which an [invention] falls.”⁷⁶

The skilled person has never been precisely defined, although judicial guidance exists.⁷⁷ In *KSR*, the Supreme Court described the skilled person as “a person of ordinary creativity, not an automaton.”⁷⁸ The Federal Circuit has explained the skilled person is a hypothetical person, like the reasonable person in tort law,⁷⁹ who is presumed to have known the relevant art at the time of the invention.⁸⁰ The skilled person is not a judge, amateur, person skilled in remote arts, or a set of “geniuses in the art at hand.”⁸¹ The skilled person is “one who thinks along the line of conventional wisdom in the art and is not one who undertakes to innovate.”⁸²

The Federal Circuit has provided a nonexhaustive list of factors to consider in determining the level of ordinary skill: (1) “type[s] of problems encountered in the art,” (2) “prior art solutions to those problems,” (3) “rapidity with which innovations are made,” (4) “sophistication of the technology,” and (5) “educational level of active workers in the field.”⁸³ In any particular case, one or more factors may predominate, and not every factor may be relevant.⁸⁴ The

75. *Morning Star Coop. Soc’y v. Express Newspapers Ltd.* [1979] FSR 113 (marking the first use of the term “moron in a hurry” as a standard for trademark confusion).

76. *Great Atl. & Pac. Tea Co. v. Supermarket Equip. Corp.*, 340 U.S. 147, 155 (1950).

77. See James B. Gambrell & John H. Dodge, II, *Ordinary Skill in the Art—An Enemy of the Inventor or a Friend of the People?*, in *NONOBVIOUSNESS—THE ULTIMATE CONDITION OF PATENTABILITY* 5:302 (John F. Witherspoon ed., 1980) (“[T]he Supreme Court in particular, but other courts as well, has done precious little to define the person of ordinary skill in the art.”).

78. *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 421 (2007). The MPEP provides guidance on the level of ordinary skill in the art. MPEP § 2141.03. See John F. Duffy & Robert P. Merges, *The Story of Graham v. John Deere Company: Patent Law’s Evolving Standard of Creativity*, in *INTELLECTUAL PROPERTY STORIES* 110 (Jane C. Ginsburg & Rochelle Cooper Dreyfuss eds., 2006) (noting that determining the appropriate level of ordinary skill for the nonobviousness standard “is one of the most important policy issues in all of patent law”).

79. See, e.g., *Panduit Corp. v. Dennison Mfg. Co.*, 810 F.2d 1561, 1566 (Fed. Cir. 1987) (“[T]he decision maker confronts a ghost, i.e., ‘a person having ordinary skill in the art,’ not unlike the ‘reasonable man’ and other ghosts in the law.”).

80. *2141 Examination Guidelines*, *supra* note 73.

81. *Env’tl. Designs Ltd. v. Union Oil Co. of Cal.*, 713 F.2d 693, 697 (Fed. Cir. 1983).

82. *Standard Oil Co. v. Am. Cyanamid Co.*, 774 F.2d 448, 454 (Fed. Cir. 1985).

83. *In re GPAC Inc.*, 57 F.3d 1573, 1579 (Fed. Cir. 1995).

84. *Id.*; *Custom Accessories, Inc. v. Jeffrey-Allan Indus., Inc.*, 807 F.2d 955, 962–63 (Fed. Cir. 1986). Previously, this list of factors included the “educational level of the inventor.” *Env’tl. Designs, Ltd.*, 713 F.2d at 696. That was until the Federal Circuit announced that, “courts never have judged patentability by what the real inventor/applicant/patentee could or would do.” *Kimberly-Clark Corp. v. Johnson & Johnson*, 745 F.2d 1437, 1454 (Fed. Cir. 1984). Instead, “[r]eal inventors, as a class, vary in the capacities from ignorant geniuses to Nobel

skilled person standard thus varies according to the invention in question, its field of art, and researchers in the field.⁸⁵ In the case of a simple invention in a field where most innovation is created by laypersons, such as, for instance, a device to keep flies away from horses, the skilled person may be someone with little education or practical experience.⁸⁶ By contrast, where an invention is in a complex field with highly educated workers such as chemical engineering or pharmaceutical research, the skilled person may be quite sophisticated.⁸⁷ At least in Europe, the skilled person may even be a team of individuals where collaborative approaches to research are the norm.⁸⁸

laureates; the courts have always applied a standard based on an imaginary work of their own devising whom they have equated with the inventor.” *Id.*

85. See, e.g., *DyStar Textilfarben GmbH & Co. Deutschland KG*, 464 F.3d 1356, 1370 (Fed. Cir. 2006). The court writes:

If the level of skill is low, for example that of a mere dyer, as Dystar has suggested, then it may be rational to assume that such an artisan would not think to combine references absent explicit direction in a prior art reference. . . . [If] the level of skill is that of a dyeing process designer, then one can assume comfortably that such an artisan will draw ideas from chemistry and systems engineering—without being told to do so.

Daiichi Sankyo Co. v. Apotex, Inc. concerned a patent for treating ear infections by applying an antibiotic to the ear. 501 F.3d 1254, 1257 (Fed. Cir. 2007). The district court found that the skilled person “would have a medical degree, experience treating patients with ear infections, and knowledge of the pharmacology and use of antibiotics.” *Id.* “This person would be . . . a pediatrician or general practitioner—those doctors who are often the ‘first line of defense’ in treating ear infections and who, by virtue of their medical training, possess basic pharmacological knowledge.” *Id.* The Federal Circuit overturned this finding, holding that rather, a person of ordinary skill in the art was “a person engaged in developing new pharmaceuticals, formulations and treatment methods, or a specialist in ear treatments such as an otologist, otolaryngologist, or otorhinolaryngologist who also has training in pharmaceutical formulations.” *Id.* Courts have employed a flexible approach to considering informal education. See, e.g., *Penda Corp. v. United States*, 29 Fed. Cl. 533, 565 (1993). For instance, in *Bose Corp. v. JBL, Inc.*, the District Court found that keeping “up with current literature and trade magazines to keep abreast of new developments” could be the equivalent of “a bachelor of science degree in electrical engineering, physics, mechanical engineering, or possibly acoustics.” 112 F. Supp. 2d 138, 155 (D. Mass. 2000).

86. See *Graham v. Gun-Munro*, No. C-99-04064 CRB, 2001 U.S. Dist. LEXIS 7110, at *19 (N.D. Cal. May 22, 2001) (holding that the skilled person had some formal education but no special training in the field of art in a case regarding fly wraps for the legs of horses).
87. See *Imperial Chem. Indus., PLC v. Danbury Pharmacal, Inc.*, 777 F. Supp. 330, 371–72 (D. Del. 1991) (holding that the skilled person in the chemical industry is an organic chemist with a PhD); see also *Envtl. Designs, Ltd. v. Union Oil Co. of Cal.*, 713 F.2d 693, 697 (Fed. Cir. 1983) (noting the respective chemical expert witnesses of the parties with extensive backgrounds in sulfur chemistry were skilled persons).
88. *Guidelines for Examination*, EUR. PAT. OFF., http://www.epo.org/law-practice/legal-texts/html/guidelines/e/g_vii_3.htm [<https://perma.cc/XFY3-JD8J>] (“There may be instances where it is more appropriate to think in terms of a group of persons, e.g. a research or production team, rather than a single person.”). See, e.g., *MedImmune v. Novartis Pharm. U.K., Ltd.*, [2012] EWCA Civ. 1234 (evaluating obviousness from the perspective of

E. Analogous Prior Art

Determining what constitutes prior art is also central to the obviousness inquiry.⁸⁹ On some level, virtually all inventions involve a combination of known elements.⁹⁰ The more prior art can be considered, the more likely an invention is to appear obvious. To be considered for the purposes of obviousness, prior art must fall within the definition for anticipatory references under Section 102 and must additionally qualify as “analogous art.”⁹¹

Section 102 contains the requirement for novelty in an invention, and it explicitly defines prior art.⁹² An extraordinarily broad amount of information qualifies as prior art, including any printed publication made available to the public prior to filing a patent application.⁹³ Courts have long held that inventors are charged with constructive knowledge of all prior art.⁹⁴ While no real inventor could have such knowledge,⁹⁵ the social benefits of this rule are thought to outweigh its costs.⁹⁶ Granting patents on existing inventions could prevent the

a “skilled team”). The “[P]atent is addressed to a team of scientists with differing backgrounds in areas such as immunology, in particular antibody structural biology, molecular biology and protein chemistry, but with a common interest in antibody engineering.” *Id.* In the United States, the idea that the skilled person could be a group of individuals has been discussed in academic literature, but may not have been explicitly adopted by the courts. See, e.g., Jonathan J. Darrow, *The Neglected Dimension of Patent Law’s PHOSITA Standard*, 23 HARV. J.L. & TECH. 227, 244, 257 (2009). A “skilled persons” standard would seem to be appropriate given that most patents are now filed with more than one inventor. Dennis Crouch, *PHOSITA: Not a Person—People Having Ordinary Skill in the Art*, PATENTLY-O (June 7, 2018), <https://patentlyo.com/patent/2018/06/phosita-not-a-person-people-having-ordinary-skill-in-the-art.html> [<https://perma.cc/UAK2-5NT8>] (noting that most patents have multiple inventors).

89. This is the second inquiry of the *Graham* analysis described earlier.

90. See, e.g., *Ryko Mfg. Co. v. Nu-Star, Inc.*, 950 F.2d 714, 718 (Fed. Cir. 1991).

91. *In re Bigio*, 381 F.3d 1320, 1325 (Fed. Cir. 2004).

92. 35 U.S.C. § 102 (2018).

93. *Id.* § 102(a)(1); see MPEP § 2152 for a detailed discussion of what constitutes prior art. Almost anything in writing is prior art. “A U.S. patent on the lost wax casting technique was invalidated on the basis of Benvenuto Cellini’s 16th century autobiography which makes mention of a similar technique.” See Michael Ebert, *Superperson and the Prior Art*, 67 J. PAT. & TRADEMARK OFF. SOC’Y 657, 658 (1985).

94. In *Mast, Foos, & Co. v. Stover Manufacturing Co.*, the Supreme Court applied a presumption that the skilled person is charged with constructive knowledge of all prior art: “Having all these various devices before him, and whatever the facts may have been, he is chargeable with a knowledge of all preexisting devices.” 177 U.S. 485, 493 (1900) (emphasis added) (further, “we must presume the patentee was fully informed of everything which preceded him, whether such were the actual fact or not”).

95. See, e.g., *In re Wood*, 599 F.2d 1032, 1036 (C.C.P.A. 1979) (“[A]n inventor could not possibly be aware of every teaching in every art.”).

96. See *Bonito Boats, Inc. v. Thunder Craft Boats, Inc.*, 489 U.S. 141, 147–48 (1989) (reciting that Thomas Jefferson, the “driving force behind early federal patent policy,” believed that

public from using something it already had access to, and remove knowledge from the public domain.⁹⁷

For the purposes of obviousness, prior art under Section 102 must also qualify as analogous. That is to say, the prior art must be in the field of an applicant's endeavor, or reasonably pertinent to the problem with which the applicant was concerned.⁹⁸ A real inventor would be expected to focus on this type of information. The "analogous art" rule better reflects practical conditions, and it ameliorates the harshness of the definition of prior art for novelty given that prior art references may be combined for purposes of obviousness but not novelty.⁹⁹ Consequently, for the purposes of obviousness, the skilled person is presumed to have knowledge of all prior art within the field of an invention, as well as prior art reasonably pertinent to the problem the invention solves. Restricting the universe of prior art to analogous art lowers the bar to patentability.¹⁰⁰

"a grant of patent rights in an idea already disclosed to the public [i]s akin to an *ex post facto* law, 'obstruct[ing] others in the use of what they possessed before'" (quoting Letter to Isaac McPherson, *supra* note 37, at 176)); *Graham v. John Deere Co.*, 383 U.S. 1, 5–6 (1966) (stating that granting patents on non-novel inventions would remove knowledge from the public domain).

97. *Graham*, 383 U.S. at 5–6.

98. See, e.g., *Wyers v. Master Lock Co.*, 616 F.3d 1231, 1237 (Fed. Cir. 2010) ("Two criteria are relevant in determining whether prior art is analogous: '(1) whether the art is from the same field of endeavor, regardless of the problem addressed, and (2) if the reference is not within the field of the inventor's endeavor, whether the reference still is reasonably pertinent to the particular problem with which the inventor is involved.'" (quoting *Comaper Corp. v. Antec, Inc.*, 596 F.3d 1343, 1351 (Fed. Cir. 2010)). "Under the correct analysis, any need or problem known in the field of endeavor at the time of the invention and addressed by the patent [or application at issue] can provide a reason for combining the elements in the manner claimed." *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 420 (2007). Prior art in other fields may sometimes be considered as well. *Id.* at 417. The general question is whether it would have been "reasonable" for the skilled person to consider a piece of prior art to solve their problem. *In re Clay*, 966 F.2d 656 (Fed. Cir. 1992). To be "reasonably pertinent," prior art must "logically [] have commended itself to an inventor's attention in considering his problem." *Id.*

99. See *In re Wood*, 599 F.2d 1032, 1036 (C.C.P.A. 1979) ("The rationale behind this rule precluding rejections based on combination of teachings of references from nonanalogous arts is the realization that an inventor could not possibly be aware of every teaching in every art."). The rule "attempt[s] to more closely approximate the reality of the circumstances surrounding the making of an invention by only presuming knowledge by the inventor of prior art in the field of his endeavor and in analogous arts." *Id.*

100. See Margo A. Bagley, *Internet Business Model Patents: Obvious by Analogy*, 7 MICH. TELECOMM. & TECH. L. REV. 253, 270 (2001) (arguing that prior to the analogous arts test references were rarely excluded as prior art); see also Jacob S. Sherkow, *Negating Invention*, 2011 BYU L. REV. 1091, 1094–95 (2011) (noting that once a relevant piece of prior art is classified as analogous, an obviousness finding is often inevitable).

The analogous art requirement was most famously conceptualized in the case of *In re Winslow*, in which the court explained a decisionmaker was to “picture the inventor as working in his shop with the prior art references—which he is presumed to know—hanging on the walls around him.”¹⁰¹ Or, as Judge Learned Hand presciently remarked, “the inventor must accept the position of a mythically omniscient worker in his chosen field. As the arts proliferate with prodigious fecundity, his lot is an increasingly hard one.”¹⁰²

II. MACHINE INTELLIGENCE IN THE INVENTIVE PROCESS

A. Automating and Augmenting Research

Artificial intelligence (AI), which is to say a computer able to perform tasks normally requiring human intelligence, is playing an increasingly important role in innovation.¹⁰³ For instance, IBM’s flagship AI system “Watson” is being used exploratively to conduct research in drug discovery, as well as clinically to analyze the genes of cancer patients and develop treatment plans.¹⁰⁴ In drug discovery, Watson has already identified novel drug targets and new indications for existing drugs.¹⁰⁵ In doing so, Watson may be generating patentable inventions either autonomously or collaboratively with human researchers.¹⁰⁶ In clinical practice, Watson is also automating a once human function.¹⁰⁷ In fact, according to IBM, Watson can interpret a patient’s entire genome and prepare a clinically actionable report in ten minutes, a task which otherwise requires

101. *In re Winslow*, 365 F.2d 1017, 1020 (C.C.P.A. 1966).

102. *Merit Mfg. Co. v. Hero Mfg. Co.*, 185 F.2d 350, 352 (2d Cir. 1950).

103. See, e.g., DATA SCI. ASS’N, OUTLOOK ON ARTIFICIAL INTELLIGENCE IN THE ENTERPRISE 3, 6 (2016), <http://www.datascienceassn.org/sites/default/files/Outlook%20on%20Artificial%20Intelligence%20in%20the%20Enterprise%202016.pdf> [hereinafter Outlook on AI] (a survey of 235 business executives conducted by the National Business Research Institute (NBRI) which found that 38 percent of enterprises were using AI technologies in 2016, and 62 percent will likely use AI technologies by 2018).

104. *IBM Watson for Drug Discovery*, IBM, <https://www.ibm.com/watson/health/life-sciences/drug-discovery> [<https://perma.cc/DQ4D-ZKJF>]; *IBM Watson for Genomics*, IBM, <https://www.ibm.com/watson/health/oncology-and-genomics/genomics> [<https://perma.cc/8XK7-S8DN>].

105. Ying Chen et al., *IBM Watson: How Cognitive Computing Can Be Applied to Big Data Challenges in Life Sciences Research*, 38 CLINICAL THERAPEUTICS 688 (2016), https://www.medicalaffairs.org/app/uploads/2018/02/Chen_2016_IBM_Watson.pdf.

106. See generally *Hal the Inventor*, *supra* note 3 (discussing the “hypothetical” example of an AI system being used in drug discovery to identify new drug targets and indications for existing drugs).

107. Kazimierz O. Wrzeszczynski et al., *Comparing Sequencing Assays and Human-Machine Analyses in Actionable Genomics for Glioblastoma*, 3 NEUROLOGY GENETICS e164 (2017), <http://ng.neurology.org/content/3/4/e164> [<https://perma.cc/3LGH-TKPW>].

around 160 hours of work by a team of experts.¹⁰⁸ A recent study by IBM found that Watson's report outperformed the standard practice.¹⁰⁹

Watson is largely structured as an "expert system," although Watson is not a single program or computer—the brand incorporates a variety of technologies.¹¹⁰ Here, Watson will be considered a single software program in the interests of simplicity. Expert systems are one way of designing AI that solve problems in a specific domain of knowledge using logical rules derived from the knowledge of experts. These were a major focus of AI research in the 1980s.¹¹¹ Expert system-based chess-playing programs HiTech and Deep Thought defeated chess masters in 1989, paving the way for another famous IBM computer, Deep Blue, to defeat world chess champion Garry Kasparov in 1997.¹¹² But Deep Blue had limited utility—it was solely designed to play chess. The machine was permanently retired after defeating Kasparov.¹¹³

Google's leading AI system DeepMind is an example of another sort of inventive machine. DeepMind uses an artificial neural network, which essentially consists of many highly interconnected processing elements working together to solve specific problems.¹¹⁴ The design of neural networks is inspired by the way the human brain processes information.¹¹⁵ Like the human brain, neural networks can learn by example and from practice.¹¹⁶ Examples for neural networks come in the form of data, so more data means improved performance.¹¹⁷ This has led to data being described as the new oil of the twenty-first century, and the fuel for machine learning.¹¹⁸ Developers may not be able to

108. *Id.*

109. *Id.*

110. See Richard Waters, *Artificial Intelligence: Can Watson Save IBM?*, FINANCIAL TIMES (Jan. 5, 2016), <https://www.ft.com/content/dced8150-b300-11e5-8358-9a82b43f6b2f> [<https://perma.cc/J3N6-QMP3>]; see also Will Knight, *IBM's Watson Is Everywhere—But What Is It?*, MIT TECH. REV. (Oct. 27, 2016), <https://www.technologyreview.com/s/602744/ibms-watson-is-everywhere-but-what-is-it> [<http://perma.cc/YK3Q-HRQB>].

111. STUART J. RUSSELL & PETER NORVIG, *ARTIFICIAL INTELLIGENCE: A MODERN APPROACH* 22–23 (2d ed. 2002) (1995).

112. *IBM's 100 Icons of Progress: Deep Blue*, IBM <http://www-03.ibm.com/ibm/history/ibm100/us/en/icons/deepblue/words> [<https://perma.cc/7SG3-UYST>].

113. *Id.*

114. KEVIN GURNEY, *AN INTRODUCTION TO NEURAL NETWORKS* 1–4 (1997). The first neural network was built in 1951. See, e.g., RUSSELL & NORVIG, *supra* note 111.

115. See, e.g., Volodymyr Mnih et al., *Human-Level Control Through Deep Reinforcement Learning*, 518 NATURE 529, 529–33 (2015).

116. See GURNEY, *supra* note 114, at 1–4.

117. PEDRO DOMINGOS, *THE MASTER ALGORITHM: HOW THE QUEST FOR THE ULTIMATE LEARNING MACHINE WILL REMAKE OUR WORLD* xi (2015).

118. See, e.g., Michael Palmer, *Data Is the New Oil*, ANA MARKETING MAESTROS (Nov. 3, 2006).

understand exactly how a neural network processes data or generates a particular output.

In 2016, DeepMind developed an algorithm known as AlphaGo which beat a world champion of the traditional Chinese board game Go, and then the world's leading player in 2017.¹¹⁹ Go was the last traditional board game at which people had been able to outperform machines.¹²⁰ AlphaGo's feat was widely lauded in the artificial intelligence community because Go is exponentially more complicated than chess.¹²¹ Current computers cannot "solve" Go solely by using "brute force" computation to determine the optimal move to any potential configuration in advance.¹²² There are more possible board configurations in Go than there are atoms in the universe.¹²³ Rather than being preprogrammed with a number of optimal Go moves, DeepMind used a general-purpose algorithm to interpret the game's patterns.¹²⁴ DeepMind is now working to beat human players at the popular video game *StarCraft II*.¹²⁵

AI like DeepMind is proving itself and training by playing games, but similar techniques can be applied to other challenges requiring recognition of complex patterns, long-term planning, and decisionmaking.¹²⁶ DeepMind is already being applied to solve practical problems. For instance, it has helped decrease cooling costs at company datacenters.¹²⁷ DeepMind is working to

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119. David Silver et al., *Mastering the Game of Go With Deep Neural Networks and Tree Search*, 529 NATURE 484, 484–89 (2016). In 2015, DeepMind attained "human-level performance in video games" playing a series of class Atari 2600 games. Mnih et al., *supra* note 115, at 529. See also, Cade Metz, <https://www.wired.com/2017/05/googles-alphago-continues-dominance-second-win-china> [<https://perma.cc/WA9G-JUGK>].
 120. See Richard Haridy, 2017: *The Year AI Beat Us at All Our Own Games*, NEW ATLAS (Dec. 26, 2017), <https://newatlas.com/ai-2017-beating-humans-games/52741> [<https://perma.cc/AH2Y-6FFD>].
 121. Silver et al, *supra* note 119.
 122. *Id.*; cf. Cade Metz, *One Genius' Lonely Crusade to Teach a Computer Common Sense*, WIRED (Mar. 24, 2016), [hereinafter *Lonely Crusade*] <https://www.wired.com/2016/03/doug-lenat-artificial-intelligence-common-sense-engine> [<https://perma.cc/WN2G-5CU9>] (arguing that brute force computation was part of AlphaGo's functionality).
 123. 10¹⁷⁰, or thereabouts. Silver et al, *supra* note 119.
 124. Silver et al, *supra* note 119.
 125. Tom Simonite, *Google's AI Declares Galactic War on StarCraft*, WIRED (Aug. 9, 2017), <https://www.wired.com/story/googles-ai-declares-galactic-war-on-starcraft> [<http://perma.cc/3VZJ-XXJV>]. Compared with Go, *StarCraft* is vastly more complex. It involves high levels of strategic thinking and acting with imperfect information. *Id.*
 126. Game playing has long been a proving ground for AI, as far back as what may have been the very first AI program in 1951. See Jack Copeland, *A Brief History of Computing*, ALANTURING.NET (June 2000) http://www.alanturing.net/turing_archive/pages/Reference%20Articles/BriefHistofComp.html [<https://perma.cc/82JN-UC93>]. That program played checkers and was competitive with amateurs. *Id.*
 127. See Simonite, *supra* note 125.

develop an algorithm to distinguish between healthy and cancerous tissues, and to evaluate eye scans to identify early signs of diseases leading to blindness.¹²⁸ The results of this research may well be patentable.

Ultimately, the developers of DeepMind hope to create Artificial General Intelligence (AGI).¹²⁹ Existing, “narrow” or specific AI (SAI) systems focus on discrete problems or work in specific domains. For instance, “Watson for Genomics” can analyze a genome and provide a treatment plan, and “Chef Watson” can develop new food recipes by combining existing ingredients. However, Watson for Genomics cannot respond to open-ended patient queries about their symptoms. Nor can Chef Watson run a kitchen. New capabilities could be added to Watson to do these things, but Watson can only solve problems it has been programmed to solve.¹³⁰ By contrast, AGI would be able to successfully perform any intellectual task a person could.

AGI could even be set to the task of self-improvement, resulting in a continuously improving system that surpasses human intelligence—what philosopher Nick Bostrom has termed Artificial SuperIntelligence (ASI).¹³¹ Such an outcome has been referred to as the intelligence explosion or the technological singularity.¹³² ASI could then innovate in all areas of technology, resulting in progress at an incomprehensible rate. As the mathematician Irving John Good wrote in 1965, “the first ultraintelligent machine is the last invention that man need ever make.”¹³³

128. Chris Baraniuk, *Google’s DeepMind to Peek at NHS Eye Scans for Disease Analysis*, BBC (July 5, 2016), <https://www.bbc.com/news/technology-36713308> [<https://perma.cc/WA6R-RUX3>]; Chris Baraniuk, *Google DeepMind Targets NHS Head and Neck Cancer Treatment*, BBC (Aug. 31, 2016), <https://www.bbc.com/news/technology-37230806> [<http://perma.cc/6GAN-7EAZ>].

129. *Solving Intelligence Through Research*, DEEPMIND, <https://deepmind.com/research> [<https://perma.cc/7TC2-49B8>].

130. See, e.g., *Lonely Crusade*, *supra* note 122.

131. See generally NICK BOSTROM, *SUPERINTELLIGENCE: PATHS, DANGERS, STRATEGIES* (2014).

132. See generally RAY KURZWEIL, *THE SINGULARITY IS NEAR: WHEN HUMANS TRANSCEND BIOLOGY* (2005).

133. Irving John Good, *Speculations Concerning the First Ultraintelligent Machine*, 6 *ADVANCES IN COMPUTERS* 31, 33 (1965)

Let an ultraintelligent machine be defined as a machine that can far surpass all the intellectual activities of any man however clever. Since the design of machines is one of these intellectual activities, an ultraintelligent machine could design even better machines; there would then unquestionably be an ‘intelligence explosion,’ and the intelligence of man would be left far behind. . . . Thus the first ultraintelligent machine is the last invention that man need ever make

Id. at 32–33.

Experts are divided on when, and if, AGI will be developed. Many industry leaders predict based on historical trends that AGI will occur within the next couple of decades.¹³⁴ Others believe the magnitude of the challenge has been underestimated, and that AGI may not be developed in this century.¹³⁵ In 2013, hundreds of AI experts were surveyed on their predictions for AGI development.¹³⁶ On average, participants predicted a 10 percent likelihood that AGI would exist by 2022, a 50 percent likelihood it would exist by 2040, and a 90 percent likelihood it would exist by 2075.¹³⁷ In a similar survey, 42 percent of participants predicted AGI would exist by 2030, and an additional 25 percent predicted AGI by 2050.¹³⁸ In addition, 10 percent of participants reported they believed ASI would develop within two years of AGI, and 75 percent predicted this would occur within 30 years.¹³⁹ The weight of expert opinion thus holds artificial general intelligence and superintelligence will exist this century. In the meantime, specific artificial intelligence is getting ever better at outcompeting people at specific tasks—including invention.

B. Timeline to the Creative Singularity

We are amid a transition from human to machine inventors. The following five-phase framework illustrates this transition and divides the history and future of inventive AI into several stages.

134. Pawel Sysiak, *When Will the First Machine Become Superintelligent?*, AI REVOLUTION, (Apr. 11, 2016), <https://medium.com/ai-revolution/when-will-the-first-machine-become-superintelligent-ae5a6f128503> [<https://perma.cc/7YUP-DEYM>].

135. *Id.* In fairness, history also reflects some overly optimistic predictions. In 1970, Marvin Minsky, one of the most famous AI thought leaders, was quoted in *Life Magazine* as stating, “In from three to eight years we will have a machine with the general intelligence of an average human being.” Brad Darrach, *Meet Shaky, the First Electronic Person*, LIFE, Nov. 20 1970, at 58B, 66, 68.

136. See Muller & Bostrom, *supra* note 7.

137. *Id.* Participants were asked to provide an optimistic year for AGI’s development (10 percent likelihood), a realistic year (50 percent likelihood), and a pessimistic year (90 percent likelihood). The median responses were 2022 as an optimistic year, 2040 as a realistic year, and 2075 as a pessimistic year. *Id.*

138. A survey conducted at an annual AGI Conference reported that 42 percent believed AGI would exist by 2030, 25 percent by 2050, 20 percent by 2100, 10 percent after 2100, and 2 percent never. See JAMES BARRAT, OUR FINAL INVENTION: ARTIFICIAL INTELLIGENCE AND THE END OF THE HUMAN ERA 152 (2013). For instance, Demis Hassabis, the founder of DeepMind, believes AGI is still decades away. David Rowan, *DeepMind: Inside Google’s Super-Brain*, WIRED (June 22, 2015), <https://www.wired.co.uk/article/deepmind> [<https://perma.cc/MM6P-EU43>].

139. See Muller & Bostrom, *supra* note 7.

Phase	Inventors	Skilled Standard	Timeframe
I	Human	Person	Past
II	Human > SAI	Augmented Person	Present
III	Human ~ SAI	Augmented Person ~ SAI	Short Term
IV	SAI ~ AGI > Human	Augmented AGI	Medium Term
V	ASI	ASI	Long Term
SAI = Specific Artificial Intelligence; AGI = Artificial General Intelligence; ASI = Artificial Superintelligence; ~ = competing; > = outcompeting			

Table 1: Evolution of Machine Invention

Previously, in Phase I, all invention was created by people. If a company wanted to solve an industrial problem, it asked a research scientist, or a team of research scientists, to solve the problem. Phase I ended when the first patent was granted for an invention created by an autonomous machine—likely 1998 or earlier.¹⁴⁰ It may be difficult to determine precisely when the first patent was issued for an autonomous machine invention, as there is no obligation to report the role of machines in patent applications. Still, any number of patents have likely been issued to inventions autonomously generated by machines.¹⁴¹ In 1998, a patent was issued for an invention autonomously developed by a neural network-based system known as the Creativity Machine.¹⁴²

140. Phase I might also be distinguished by the first time a machine invented anything independently of receiving a patent. However, using the first granted patent application is a better benchmark. It is an external measure of a certain threshold of creativity, and it represents the first time a computer automated the role of a patent inventor. Of course, there is a degree of subjectivity in a patent examiner determining whether an invention is new, nonobvious, and useful. What is nonobvious to one examiner may be obvious to another. See, e.g., Iain M. Cockburn et al., *Are All Patent Examiners Equal? The Impact of Characteristics on Patent Statistics and Litigation Outcomes*, in *PATENTS IN THE KNOWLEDGE-BASED ECONOMY*, (Wesley M. Cohen & Steven A. Merrill eds., 2003) (describing significant interexaminer variation).

141. See generally, *I Think*, *supra* note 1, at 1083–91 (describing patents issued for “computational invention”).

142. *Id.* at 1083–86.

Patents may have been granted on earlier machine inventions. For instance, an article published in 1983 describes experiments with an AI program known as Eurisko, in which the program “invent[ed] new kinds of three-dimensional microelectronic devices . . . novel designs and design rules have emerged.”¹⁴³ Eurisko was an early, expert AI system for autonomously discovering new information.¹⁴⁴ It was programmed to operate according to a series of rules known as heuristics, but it was able to discover new heuristics and use these to modify its own programming.¹⁴⁵ To design new microchips, Eurisko was programmed with knowledge of basic microchips along with simple rules and evaluation criteria.¹⁴⁶ It would then combine existing chip structures together to create new designs, or mutate existing entities.¹⁴⁷ The new structure would then be evaluated for interest and either retained or discarded.¹⁴⁸ Several references suggest a patent was granted for one of Eurisko’s chip designs in the mid-1980s.¹⁴⁹

Although, after investigating those references for this article, the references appear to refer to a patent application filed for the chip design by Stanford University in 1980 which the University abandoned for unknown reasons in 1984.¹⁵⁰ Thus, a patent was never issued. Also, as with other publicly described

143. Douglas B. Lenat et al., *Heuristic Search for New Microcircuit Structures: An Application of Artificial Intelligence*, 3 AI MAG., 17, 17 (1982).

144. Eurisko was created by Douglas Lenat as the successor to the Automated Mathematician (AM). See generally Douglas B. Lenat & John Seely Brown, *Why AM and EURISKO Appear to Work*, 23 AI MAG., 269, 269–94 (1983). AM was an “automatic programming system” that could modify its own computer code, relying on heuristics. *Id.* Eurisko was a subsequent iteration of the machine designed to additionally develop new heuristics and incorporate those into its function. *Id.*

145. See Douglas B. Lenat et al., *supra* note 143.

146. *Id.*

147. *Id.*

148. *Id.*

149. See, e.g., RICHARD FORSYTH & CHRIS NAYLOR, *THE HITCHHIKER’S GUIDE TO ARTIFICIAL INTELLIGENCE* IBM PC BASIC VERSION 2167 (1986); see also MARGARET A. BODEN, *THE CREATIVE MIND: MYTHS AND MECHANISMS* 228 (2004).

150. U.S. provisional patent application SN 144,960, April 29, 1980. Email From Katherine Ku, Dir. of Stanford Office of Tech. Licensing, to author (Jan. 17, 2018) (on file with author). Douglas Lenat, CEO of Cycorp, Inc., who wrote Eurisko and performed the above-mentioned research, reported that this work was done “before the modern rage about patenting things . . .” and that in his opinion Eurisko had independently created a number of patentable inventions. See Telephone Interview With Douglas Lenat, CEO, Cycorp, Inc. (Jan. 12, 2018). He further reported that after Eurisko came up with the chip design, Professor James Gibbons at Stanford successfully built a chip based on the machine’s design. *Id.* This chip was the subject of a patent application by Stanford, but the application was abandoned in 1984. U.S. provisional patent application SN 144,960, *supra*. Prior to the present investigation, Stanford had purged its paper file for the application and so no longer had records reflecting the reason for the abandonment. Email From Katherine Ku, *supra*.

instances of patent applications claiming the output of inventive machines, the patent application was filed on behalf of natural persons.¹⁵¹ In this case, they were the individuals who had built a physical chip based on Eurisko's design.¹⁵²

In the present, Phase II, machines and people are competing and cooperating at inventive activity. However, in all technological fields, human researchers are the norm and thus best represent the skilled person standard. While AI systems are inventing, it is unclear to what extent this is occurring: Inventive machine owners may not be disclosing the extent of such machines in the inventive process, due to concerns about patent eligibility or because companies generally restrict information about their organizational methods to maintain a competitive advantage. This phase will reward early adopters of inventive machines which are able to outperform human inventors at solving specific problems, and whose output can exceed the skilled person standard. In 2006, for instance, NASA recruited an autonomously inventive machine to design an antenna that flew on NASA's Space Technology 5 (ST5) mission.¹⁵³

While there may now only be a modest amount of autonomous¹⁵⁴ machine invention, human inventors are being widely augmented by creative computers. For example, a person may design a new battery using a computer to perform calculations, search for information, or run simulations on new designs. The computer does not meet inventorship criteria, but it does augment the capabilities of a researcher in the same way that human assistants can help reduce an invention to practice. Depending on the industry researchers work in and the

Incidentally, Dr. Lenat is now continuing to develop an expert system-based AI that can use logical deduction and inference reasoning based on "common sense knowledge," as opposed to a system like Watson that recognizes patterns in very large datasets. *Id.* He also states that his current company has developed numerous patentable inventions, but that it has not filed for patent protection, because he believes that, at least with regards to software, the downside of patents providing competitors with a roadmap to copying patented technology exceeds the value of a limited term patent. *Id.*

151. See *I Think*, *supra* note 1, at 1083–91 (describing instances of "computational invention").
152. Email From Katherine Ku, *supra* note 150. Whether the individual(s) designing a chip or building a chip would qualify as inventor(s) would depend on the specific facts of the case and who "conceived" of the invention. See generally *Hal the Inventor*, *supra* note 3 (discussing standards for inventorship).
153. Gregory S. Hornby et al., *Automated Antenna Design With Evolutionary Algorithms*, AM. INST. AERONAUTICS & ASTRONAUTICS (2006), <http://alglabus.net/NASAwork/papers/Space2006Antenna.pdf>.
154. As the term is used here, autonomous machines are given goals to complete by users, but determine for themselves the means of completing those goals. See Ryan Abbott, *The Reasonable Computer: Disrupting the Paradigm of Tort Liability*, 86 GEO. WASH. L. REV. 1 (2018). For example, a user could ask a computer to design a new battery with certain characteristics, and the computer could produce such a design without further human input. In this case, the machine would be autonomously inventive and competing with human inventors.

problems they are trying to solve, researchers may rarely be unaided by computers. The more sophisticated the computer, the more it may be able to augment the worker's skills.

Phase III, in the near future, will involve increased competition and cooperation between people and machines. In certain industries, and for certain problems, inventive machines will become the norm. For example, in the pharmaceutical industry, Watson is now identifying novel drug targets and new indications for existing drugs. Soon, it may be the case that inventive machines are the primary means by which new uses for existing drugs are researched. That is a predictable outcome, given the advantage machines have over people at recognizing patterns in very large datasets. However, it may be that people still perform the majority of research related to new drug targets. Where the standard varies within a broad field like drug discovery, this can be addressed by defining fields and problems narrowly, for instance according to the subclasses currently used by the Patent Office.¹⁵⁵

Perhaps twenty-five years from now—based on expert opinion—the introduction of AGI will usher in Phase IV. Recall that AGI refers to artificial intelligence that can be applied generally, as opposed to narrowly in specific fields of art, and that it has intelligence comparable to a person. AGI will compete with human inventors in every field, which makes AGI a natural substitute for the skilled person. Even with this new standard, human inventors may continue to invent—just not as much. An inventor may be a creative genius whose abilities exceed the human average, or a person of ordinary intelligence who has a groundbreaking insight.

Just as SAI outperforms people in certain fields, it will likely be the case that SAI outperforms AGI in certain circumstances. An example of this could be when screening a million compounds for pesticide function lends itself to a “brute force” computational approach. For this reason, SAI could continue to represent the level of ordinary skill in fields in which SAI is the standard, while AGI could replace the skilled person in all other fields. However, the two systems will likely be compatible. A general AI system wanting to play Go could incorporate AlphaGo into its own programming, design its own algorithm like AlphaGo, or even instruct a second computer operating AlphaGo.

AGI will change the human-machine dynamic in another way. If the machine is genuinely capable of performing any intellectual task a person could,

155. See generally, *Overview of the U.S. Patent Classification System (U.S.P.C.)*, U.S. PAT & TRADEMARK OFF. (2012), <https://www.uspto.gov/sites/default/files/patents/resources/classification/overview.pdf>.

the machine would be capable of setting goals collaboratively with a person, or even by itself. Instead of a person instructing a computer to screen a million compounds for pesticide function, a person could merely ask a computer to develop a new pesticide. For that matter, an agrochemical company like Bayer could instruct DeepMind to develop any new technology for its business, or just to improve its profitability. Such machines should not only be able to solve known problems, but also solve unknown problems.

AGI will continually improve, transforming into ASI. Ultimately, in Phase V, when AGI succeeds in developing artificial superintelligence, it will mean the end of obviousness. Everything will be obvious to a sufficiently intelligent machine.

C. Inventive and Skilled Machines

For purposes of patent law, an inventive machine should be one which generates patentable output while meeting traditional inventorship criteria.¹⁵⁶ Because obviousness focuses on the quality of a patent application's inventive content, it should be irrelevant whether the content comes from a person or machine, or a particular type of machine. A machine which autonomously generates patentable output, or which does so collaboratively with human inventors where the machine meets joint inventorship criteria, is inventive.

Under the present framework, inventive machines would not be the equivalent of hypothetical skilled machines, just as human inventors are not skilled persons. In fact, it should not be possible to extrapolate about the characteristics of a skilled entity from information about inventive entities. Granted, the Federal Circuit once included the "educational level of the inventor" in its early factor-based test for the skilled person.¹⁵⁷ However, that was only until it occurred to the Federal Circuit that:

[C]ourts never have judged patentability by what the real inventor/applicant/patentee could or would do. Real inventors, as a class, vary in the capacities from ignorant geniuses to Nobel laureates; the courts have always applied a standard based on an

156. See *I Think*, *supra* note 1 (arguing computers which independently meet human inventorship criteria should be recognized as inventors).

157. See *e.g.*, *Environmental*, *supra* note 84.

imaginary work of their own devising whom they have equated with the inventor.¹⁵⁸

What then conceptually is a skilled machine? A machine that anthropomorphizes to the various descriptions courts have given for the skilled person? Such a test might focus on the way a machine is designed or how it functions. For instance, a skilled machine might be a conventional computer that operates according to fixed, logical rules, as opposed to a machine like DeepMind which can function unpredictably. However, basing a rule on how a computer functions might not work for the same reason the Flash of Genius test failed: Even leaving aside the significant logistical problem of attempting to figure out how a computer is structured or how it generates particular output, patent law should be concerned with whether a machine is generating inventive output, not what is going on inside the machine.¹⁵⁹ If a conventional computer and a neural network were both able to generate the same inventive output, there should be no reason to favor one over the other.

Alternately, the test could focus on a machine's capacity for creativity. For example, Microsoft Excel plays a role in a significant amount of inventive activity, but it is not innovative. It applies a known body of knowledge to solve problems with known solutions in a predictable fashion (for example, multiplying values together). However, while Excel may sometimes solve problems that a person could not easily solve without the use of technology, it lacks the ability to engage in almost any inventive activity.¹⁶⁰ Excel is not the equivalent of a skilled machine—it is an automaton incapable of ordinary creativity.

Watson in clinical practice may be a better analogy for a skilled worker. Watson analyzes patients' genomes and provides treatment recommendations.¹⁶¹ Yet as with Excel, this activity is not innovative. The problem Watson is solving may be more complex than multiplying a series of numbers, but it has a known solution. Watson is identifying known genetic mutations from a patient's genome. Watson is then suggesting known treatments based on existing medical literature. Watson is not innovating

158. *Kimberly-Clark Corp. v. Johnson & Johnson*, 745 F.2d 1437, 1454 (Fed. Cir. 1984) (“[The] hypothetical person is not the inventor, but an imaginary being possessing ‘ordinary skill in the art’ created by Congress to provide a standard of patentability.”).

159. See *I Think*, *supra* note 1 (arguing against a subjective standard for computational invention).

160. Some behaviors like correcting a rogue formula may have a functionally creative aspect, but this is a minimal amount that would not rise to the level of patent conception if performed by a person.

161. See Wrzeszczynski et al., *supra* note 107.

because it is being applied to solve problems with known solutions, adhering to conventional wisdom.

Unlike Excel, however, Watson could be inventive. For instance, Watson could be given unpublished clinical data on patient genetics and actual drug responses and tasked with determining whether a drug works for a genetic mutation in a way that has not yet been recognized. Traditionally, such findings have been patentable. Watson may be situationally inventive depending on the problem it is solving.

It may be difficult to identify an actual computer program now which has a “skilled” level of creativity. To the extent a computer is creative, in the right circumstances, any degree of creativity might result in inventive output. To be sure, this is similar to the skilled person. A person of ordinary skill, or almost anyone, may have an inventive insight. Characteristics can be imputed to a skilled person, but it is not possible the way the test is applied to identify an actual skilled person or to definitively say what she would have found obvious. The skilled person test is simply a theoretical device for a decisionmaker.

Assuming a useful characterization of a skilled machine, to determine that a skilled machine now represents the average worker in a field, decisionmakers would need information about the extent to which such machines are used. Obtaining this information may not be practical. Patent applicants could be asked generally about the use and prevalence of computer software in their fields, but it would be unreasonable to expect applicants to already have, or to obtain, accurate information about general industry conditions. The Patent Office, or another government agency, could attempt to proactively research the use of computers in different fields, but this would not be a workable solution. Such efforts would be costly, the Patent Office lacks expertise in this activity, and its findings would inevitably lag behind rapidly changing conditions. Ultimately, there may not be a reliable and low-cost source of information about skilled machines right now.

D. Inventive Is the New Skilled

Having inventive machines replace the skilled person may better correspond with real world conditions. Right now, there are inherent limits to the number and capabilities of human workers. The cost to train and recruit new researchers is significant, and there are a limited number of people with the ability to perform this work. By contrast, inventive machines are software

programs which may be copied without additional cost.¹⁶² Once Watson outperforms the average industry researcher, IBM may be able to simply copy Watson and have it replace most of an existing workforce. Copies of Watson could replace individual workers, or a single Watson could do the work of a large team of researchers.

Indeed, as mentioned earlier, in a non-inventive setting, Watson can interpret a patient's entire genome and prepare a clinically actionable report in ten minutes, as opposed to a team of human experts, which takes around one-hundred and sixty hours.¹⁶³ Once Watson is proven to produce better patient outcomes than the human team, it may be unethical to have people underperform a task which Watson can automate. When that occurs, Watson should not only replace the human team at its current facility—it should replace every comparable human team. Watson could similarly automate in an inventive capacity.

Thus, inventive machines change the skilled paradigm because once they become the average worker, the average worker becomes inventive. As the outputs of these inventive machines become routinized, however, they should no longer be inventive by definition. The widespread use of these machines should raise the bar for obviousness, so that these machines no longer qualify as inventive but shift to become skilled machines—machines which now represent the average worker and are no longer capable of routine invention.¹⁶⁴

Regardless of the terminology, as machines continue to improve, the bar for nonobviousness should rise. To generate patentable output, it may be necessary to use an advanced machine that can outperform standard machines, or a person or machine will need to have an unusual insight that standard machines cannot easily recreate. Inventiveness might also depend on the data supplied to a machine, such that only certain data would result in inventive output. Taken to its logical extreme, and given there is no limit to how sophisticated computers can become, it may be that everything will one day be obvious to commonly used computers.

It is possible to generate reasonably low-cost and accurate information about the use of inventive machines. The Patent Office should institute a requirement for patent applicants to disclose the role of computers in the

162. ANDREAS KEMPER, VALUATION OF NETWORK EFFECTS IN SOFTWARE MARKETS: A COMPLEX NETWORKS APPROACH 37 (2010).

163. See Wrzeszczynski et al., *supra* note 107.

164. See *Enzo Biochem, Inc. v. Calgene, Inc.*, 188 F.3d 1362, 1374 n.10 (Fed. Cir. 1999) (“In view of the rapid advances in science, we recognize that what may be unpredictable at one point in time may become predictable at a later time.”).

inventive process.¹⁶⁵ This disclosure could be structured along the lines of current inventorship disclosure. Right now, applicants must disclose all patent inventors.¹⁶⁶ Failure to do so can invalidate a patent or render it unenforceable.¹⁶⁷ Similarly, applicants should have to disclose when a machine autonomously meets inventorship criteria.

These disclosures would only apply to an individual invention. However, the Patent Office could aggregate responses to see whether most inventors in a field (for example, a class or subclass) are human or machine. These disclosures would have a minimal burden on applicants compared to existing disclosure requirements and the numerous procedural requirements of a patent application. In addition to helping the Patent Office with determinations of nonobviousness, these disclosures would provide valuable information for purposes of attributing inventorship.¹⁶⁸ It might also be used to develop appropriate innovation policies in other areas.¹⁶⁹

E. Skilled People Use Machines

The current standard neglects to appropriately take into account the modern importance of machines in innovation. Instead of now replacing the skilled person with the skilled machine, it would be less of a conceptual change, and administratively easier, to characterize the skilled person as an average worker facilitated by technology. Recall the factor test for the skilled person includes: (1) “type[s] of problems encountered in the art,” (2) “prior art solutions to those problems,” (3) “rapidity with which innovations are made,” (4) “sophistication of the technology,” and (5) “educational level of active workers in the field.”¹⁷⁰ This test could be amended to include, (6) “technologies used by

165. It may also be beneficial for applicants to disclose the use of computers when they have been part of the inventive process but where their contributions have not risen to the level of inventorship. Ideally, a detailed disclosure should be provided: Applicants should need to disclose the specific software used and the task it performed. In most cases, this would be as simple as noting a program like Excel was used to perform calculations. However, while this information would have value for policy making, it might involve a significant burden to patent applicants.

166. Duty to Disclose Information Material to Patentability, 37 C.F.R. § 1.56 (2018), <https://www.uspto.gov/web/offices/pac/mpep/s2001.html> [<https://perma.cc/4DE9-ZRWE>].

167. See, e.g., *Advanced Magnetic Closures, Inc. v. Rome Fastener Corp.*, 607 F.3d 817, 829–30 (Fed. Cir. 2010) (upholding a district court decision to render a patent unenforceable on the grounds of inequitable conduct for misrepresenting inventorship).

168. See *I Think*, *supra* note 1 (advocating for acknowledging machines as inventors).

169. See *Should Robots Pay Taxes?*, *supra* note 6 (arguing the need to monitor automation for adjusting tax incentives).

170. *In re GPAC Inc.*, 57 F.3d 1573, 1579 (Fed. Cir. 1995).

active workers.” This would more explicitly take into account the fact that human researchers’ capabilities are augmented with computers.

Moving forward in time, once the use of inventive machines is standard, instead of a skilled person being an inventive machine, the skilled person standard could incorporate the fact that technologies used by active workers includes inventive machines. In future research, the standard practice may be for a worker to ask an inventive machine to solve a problem. This could be conceptualized as the inventive machine doing the work, or the person doing the work using an inventive machine.

Granted, in some instances, using an inventive machine may require significant skill, for instance, if the machine is only able to generate a certain output by virtue of being supplied with certain data. Determining which data to provide a machine, and obtaining that data, may be a technical challenge. Also, it may be the case that significant skill is required to formulate the precise problem to put to a machine. In such instances, a person might have a claim to inventorship independent of the machine, or a claim to joint inventorship. This is analogous to collaborative human invention where one person directs another to solve a problem. Depending on details of their interaction, and who “conceived” of the invention, one person or the other may qualify as an inventor, or they may qualify as joint inventors.¹⁷¹ Generally, however, directing another party to solve a problem does not qualify for inventorship.¹⁷² Moreover, after the development of AGI, there may not be a person instructing a computer to solve a specific problem.

Whether the future standard becomes an inventive machine or a skilled person using an inventive machine, the result will be the same: The average worker will be capable of inventive activity. Replacing the skilled person with the inventive machine may be preferable doctrinally, because it emphasizes that it is the machine which is engaging in inventive activity, rather than the human worker.

The changing use of machines also suggests a change to the scope of prior art. The analogous art test was implemented because it is unrealistic to expect inventors to be familiar with anything more than the prior art in their field, and

171. “[C]onception is established when the invention is made sufficiently clear to enable one skilled in the art to reduce it to practice without the exercise of extensive experimentation or the exercise of inventive skill.” *Hiatt v. Ziegler & Kilgour*, 179 U.S.P.Q. 757, 763 (Bd. Pat. Interferences 1973); *see also* *Gunter v. Stream*, 573 F.2d 77, 79 (C.C.P.A. 1978).

172. *Ex parte Smernoff*, 215 U.S.P.Q. at 547 (“[O]ne who suggests an idea of a result to be accomplished, rather than the means of accomplishing it, is not a coinventor.”).

the prior art relevant to the problem they are trying to solve.¹⁷³ However, a machine is capable of accessing a virtually unlimited amount of prior art. Advances in medicine, physics, or even culinary science may be relevant to solving a problem in electrical engineering. Machine augmentation suggests that the analogous arts test should be modified or abolished once inventive machines are common, and that there should be no difference in prior art for purposes of novelty and obviousness.¹⁷⁴ The scope of analogous prior art has consistently expanded in patent law jurisprudence, and this would complete that expansion.¹⁷⁵

F. The Evolving Standard

The skilled person standard should be amended as follows:

- 1) The test should now incorporate the fact that skilled persons are already augmented by machines. This could be done by adding “technologies used by active workers” as a sixth factor to the Federal Circuit’s factor test for the skilled person.
- 2) Once inventive machines become the standard means of research in a field, the skilled person should be an inventive machine when the standard approach to research in a field or with respect to a particular problem is to use an inventive machine.
- 3) When and if artificial general intelligence is developed, inventive machines should become the skilled person in all areas, taking into account that artificial general intelligence may also be augmented by specific artificial intelligence.

III. A POST-SKILLED WORLD

This Part provides examples of how the Inventive Machine Standard could work in practice, such as by focusing on reproducibility or secondary factors. It then goes on to consider some of the implications of the new standard. Once the average worker is inventive, there may no longer be a need for patents to function

173. In 1966, in *Graham*, the Court recognized that “the ambit of applicable art in given fields of science has widened by disciplines unheard of a half century ago [T]hose persons granted the benefit of a patent monopoly [must] be charged with an awareness of these changed conditions.” *Graham v. John Deere Co.*, 383 U.S. 1, 19 (1966).

174. See *supra* Subpart I.E.

175. *Innovative Scuba Concepts, Inc., v. Feder Indus., Inc.*, 819 F. Supp. 1487, 1503 (D. Colo. 1993) (discussing the expansion of analogous art); see also, e.g., *George. J. Meyer Mfg. Co. v. San Marino Elec. Corp.*, 422 F.2d 1285, 1288 (9th Cir. 1970) (discussing the expansion of analogous art).

as innovation incentives. To the extent patents accomplish other goals such as promoting commercialization and disclosure of information or validating moral rights, other mechanisms may be found to accomplish these goals with fewer costs.

A. Application

Mobil Oil Corp. v. Amoco Chemicals Corp. concerned complex technology involving compounds known as Zeolites used in various industrial applications.¹⁷⁶ Mobil had developed new compositions known as ZSM-5 zeolites and a process for using these zeolites as catalysts in petroleum refining to help produce certain valuable compounds. The company received patent protection for these zeolites and for the catalytic process.¹⁷⁷ Mobil subsequently sued Amoco, which was using zeolites as catalysts in its own refining operations, alleging patent infringement. Amoco counterclaimed seeking a declaration of noninfringement, invalidity, and unenforceability with respect to the two patents at issue. The case involved complex scientific issues. The three-week trial transcript exceeds 3300 pages, and more than 800 exhibits were admitted into evidence.

One of the issues in the case was the level of ordinary skill. An expert for Mobil testified that the skilled person would have “a bachelor’s degree in chemistry or engineering and two to three years of experience.”¹⁷⁸ An expert for Amoco argued the skilled person would have a doctorate in chemistry and several years of experience.¹⁷⁹ The District Court for the District of Delaware ultimately decided that the skilled person “should be someone with at least a Masters degree in chemistry or chemical engineering or its equivalent, [and] two or three years of experience working in the field.”¹⁸⁰

If a similar invention and subsequent fact pattern happened today, to apply the obviousness standard proposed in this Article a decisionmaker would need to: (1) determine the extent to which inventive technologies are used in the field, (2) characterize the inventive machine(s) that best represents the average worker if inventive machines are the standard, and (3) determine whether the machine(s) would find an invention obvious. The decisionmaker is a patent

176. *Mobil Oil Corp. v. Amoco Chems. Corp.*, 779 F. Supp. 1429, 1442–43 (D. Del. 1991).

177. *Id.*

178. *Id.* at 1443.

179. *Id.*

180. *Id.*

examiner in the first instance,¹⁸¹ and potentially a judge or jury in the event the validity of a patent is at issue in trial.¹⁸² For the first step, determining the extent to which inventive technologies are used in a field, evidence from disclosures to the Patent Office could be used. That may be the best source of information for patent examiners, but evidence may also be available in the litigation context.

Assume that today most petroleum researchers are human, and that if machines are autonomously inventive in this field, it is happening on a small scale. Thus, the court would apply the skilled person standard. However, the court would now also consider “technologies used by active workers.” For instance, experts might testify that the average industry researcher has access to a computer like Watson. They further testify that while Watson cannot autonomously develop a new catalyst, it can significantly assist an inventor. The computer provides a researcher with a database containing detailed information about every catalyst used not only in petroleum research, but in all fields of scientific inquiry. Once a human researcher creates a catalyst design, Watson can also test it for fitness together with a predetermined series of variations on any proposed design.

The question for the court will thus be whether the hypothetical person who holds at least a Master’s degree in chemistry or chemical engineering or its equivalent, has two or three years of experience working in the field, *and is using Watson*, would find the invention obvious. It may be obvious, for instance, if experts convincingly testify that the particular catalyst at issue were very closely related to an existing catalyst used outside of the petroleum industry in ammonia synthesis, that any variation was minor, and that a computer could do all the work of determining if it were fit for purpose.¹⁸³ It might thus have been an obvious design to investigate, and it did not require undue experimentation in order to prove its effectiveness.

Now imagine the same invention and fact pattern occurring approximately ten years into the future, at which point DeepMind, together with Watson and a competing host of AI systems, have been set to the task of developing new

181. See U.S. PAT. & TRADEMARK OFF., *supra* note 24 (at the Patent Office, applications are initially considered by a patent examiner, and examiner decisions can be appealed to the Patent Trial and Appeal Board (PTAB)).

182. Mark A. Lemley, *Why Do Juries Decide if Patents Are Valid?* (Stanford Law Sch., Pub. Law & Legal Theory Research Paper Series, Working Paper No. 2306152, 2013), <https://ssrn.com/abstract=2306152>.

183. See *Daiichi Sankyo Co. v. Matrix Labs., Ltd.*, 619 F.3d 1346, 1352 (Fed. Cir. 2010) (finding that a “chemist of ordinary skill would have been motivated to select and then to modify a prior art compound (e.g., a lead compound) to arrive at a claimed compound with a reasonable expectation that the new compound would have similar or improved properties compared with the old”).

compounds to be used as catalysts in petroleum refining. Experts testify that the standard practice is for a person to provide data to a computer like DeepMind, specify desired criteria (for example, activity, stability, perhaps even designing around existing patents), and ask the computer to develop a new catalyst. From this interaction, the computer will produce a new design. As most research in this field is now performed by inventive machines, a machine would be the standard for judging obviousness.

The decisionmaker would then need to characterize the inventive machine(s). It could be a hypothetical machine based on general capabilities of inventive machines, or a specific computer. Using the standard of a hypothetical machine would be similar to using the skilled person test, but this test could be difficult to implement. A decisionmaker would need to reason what the machine would have found obvious, perhaps with expert guidance. It is already challenging for a person to predict what a hypothetical person would find obvious; it would be even more difficult to do so with a machine. Computers may excel at tasks people find difficult (like multiplying a thousand different numbers together), but even supercomputers struggle with visual intuition, which is mastered by most toddlers.

In contrast, using a specific computer should result in a more objective test. This computer might be the most commonly used computer in a field. For instance, if DeepMind and Watson are the two most commonly used AI systems for research on petroleum catalysts, and DeepMind accounts for 35 percent of the market while Watson accounts for 20 percent, then DeepMind could represent the standard. However, this potentially creates a problem—if DeepMind is the standard, then it would be more likely that DeepMind's own inventions would appear obvious as opposed to the inventions of another machine. This might give an unfair advantage to non-market leaders, simply because of their size.

To avoid unfairness, the test could be based on more than one specific computer. For instance, both DeepMind and Watson could be selected to represent the standard. This test could be implemented in two different ways. In the first case, if a patent application would be obvious to DeepMind or Watson, then the application would fail. In the second case, the application would have to be obvious to both DeepMind and Watson to fail. The first option would result in fewer patents being granted, with those patents presumably going mainly to disruptive inventive machines with limited market penetration, or to inventions made using specialized non-public data. The second option would permit patents where a machine is able to outperform its competitors in some

material respect. The second option could continue to reward advances in inventive machines, and therefore seems preferable.

It may be that relatively few AI systems, such as DeepMind and Watson, end up dominating the research market in a field. Alternately, many different machines may each occupy a small share of the market. There is no need to limit the test to two computers. To avoid discriminating on the basis of size, all inventive machines being routinely used in a field or to solve a particular problem might be considered. However, allowing any machine to be considered could allow an underperforming machine to lower the standard, and too many machines might result in an unmanageable standard. An arbitrary cutoff may be applied based on some percentage of market share. That might still give some advantage to very small entities, but it should be a minor disparity.

After characterizing the inventive machine(s), a decisionmaker would need to determine whether the inventive machine(s) would find an invention obvious. This could broadly be accomplished in one of two ways: either with abstract knowledge of what the machines would find obvious, perhaps through expert testimony, or through querying the machines. The former would be the more practical option.¹⁸⁴ For example, a petroleum researcher experienced with DeepMind might be an expert, or a computer science expert in DeepMind and neural networks. This inquiry could focus on reproducibility.

Finally, a decisionmaker will have to go through a similar process if the same invention and fact pattern occurs twenty-five years from now, at which point artificial general intelligence has theoretically taken over in all fields of research. AGI should have the ability to respond directly to queries about whether it finds an invention obvious. Once AGI has taken over from the average researcher in all inventive fields, it may be widely enough available that the Patent Office could arrange to use it for obviousness queries. In the litigation context, it may be available from opposing parties. If courts cannot somehow access AGI, they may still have to rely on expert evidence.

184. Alternatively, the machine could be asked to solve the problem at question and given the relevant prior art. If the machine generates the substance of the patent, the invention would be considered obvious. However, this would require a decisionmaker to have access to the inventive machine. At the application stage, the Patent Office would need to contract with, say, Google to use DeepMind in such a fashion. For that matter, the Patent Office might use DeepMind not only to decide whether inventions are obvious, but to automate the entire patent examination process. At trial, if Google is party to a lawsuit, an opposing party might subpoena use of the computer. However, if Google is not a party, it might be unreasonable to impose on Google for access to DeepMind.

B. Reproducibility

Even if an inventive machine standard is the appropriate theoretical tool for nonobviousness, it still requires certain somewhat subjective limitations, and decisionmakers may still have difficulty with administration. Still, the new standard only needs to be slightly better than the existing standard to be an administrative success.

A test focused on reproducibility, based on the ability of the machine selected to represent the standard being able to independently reproduce the invention, offers some clear advantages over the current skilled person standard, which results in inconsistent and unpredictable outcomes.¹⁸⁵ Courts have “provided almost no guidance concerning either what degree of ingenuity is necessary to meet the standard or how a decisionmaker is supposed to evaluate whether the differences between the invention and prior art meet this degree.”¹⁸⁶ This leaves decisionmakers in the unenviable position of trying to subjectively establish what another person would have found obvious. Worse, this determination is to be made in hindsight with the benefit of a patent application. On top of that, judges and juries lack scientific expertise.¹⁸⁷ In practice, decisionmakers may read a patent application, decide that they know

185. See FED. TRADE COMM’N, *supra* note 16 (discussing objections to the skilled person standard).

186. Mandel, *The Non-Obvious Problem*, *supra* note 19, at 64.

187. As Judge Learned Hand wrote:

I cannot stop without calling attention to the extraordinary condition of the law which makes it possible for a man without any knowledge of even the rudiments of chemistry to pass upon such questions as these. The inordinate expense of time is the least of the resulting evils, for only a trained chemist is really capable of passing upon such facts How long we shall continue to blunder along without the aid of unpartisan and authoritative scientific assistance in the administration of justice, no one knows; but all fair persons not conventionalized by provincial legal habits of mind ought, I should think, unite to effect some such advance.

Parke-Davis & Co. v. H.K. Mulford Co., 189 F. 95, 115 (S.D.N.Y. 1911). See also *Safety Car Heating & Lighting Co. v. Gen. Elec. Co.*, 155 F.2d 937, 939 (1946) (“Courts, made up of laymen as they must be, are likely either to underrate, or to overrate, the difficulties in making new and profitable discoveries in fields with which they cannot be familiar”); see also Doug Lichtman & Mark A. Lemley, *Rethinking Patent Law’s Presumption of Validity*, 60 STAN. L. REV. 45, 67 (2007) (“District Court judges are poorly equipped to read patent documents and construe technical patent claims. Lay juries have no skill when it comes to evaluating competing testimony about the originality of a technical accomplishment.”).

obviousness when they see it, and then reason backward to justify their findings.¹⁸⁸

This is problematic because patents play a critical role in the development and commercialization of products, and patent holders and potential infringers should have a reasonable degree of certainty about whether patents are valid. A more determinate standard would make it more likely the Patent Office would apply a single standard consistently and result in fewer judicially invalidated patents. To the extent machine reproducibility is a more objective standard, this would seem to address many of the problems inherent in the current standard.

On the other hand, reproducibility comes with its own baggage. Decisionmakers have difficulty imagining what another person would find obvious, and it would probably be even more difficult to imagine in the abstract what a machine could reproduce. More evidence might need to be supplied in patent prosecution and during litigation, perhaps in the format of analyses performed by inventive machines, to demonstrate whether particular output was reproducible. This might also result in a greater administrative burden.

In some instances, reproducibility may be dependent on access to data. A large health insurer might be able to use Watson to find new uses for existing drugs by giving Watson access to proprietary information on its millions of members. Or, the insurer might license its data to drug discovery companies using Watson for this purpose. Without that information, another inventive computer might not be able to recreate Watson's analysis.

This too is analogous to the way data is used now in patent applications: Obviousness is viewed in light of the prior art, which does not include non-public data relied upon in a patent application. The rationale here is that this rule incentivizes research to produce and analyze new data. Yet as machines become highly advanced, it is likely that the importance of proprietary data will decrease. More advanced machines may be able to do more with less.

Finally, reproducibility would require limits. For instance, a computer which generates semi-random output might eventually recreate the inventive concept of a patent application if it were given unlimited resources. However, it would be unreasonable to base a test on what a computer would reproduce given, say, 7.5 million years.¹⁸⁹ The precise limits that should be placed on

188. *Jacobellis v. Ohio*, 378 U.S. 184, 197 (1964) (Stewart, J., dissenting). This was later recognized as a failed standard. *Miller v. California*, 413 U.S. 15, 47–48 (1973) (Brennan, J., dissenting) (obscenity cases similarly relying on the Elephant Test).

189. This brings to mind a super intelligent artificial intelligence system, “Deep Thought,” which famously, and fictionally, took 7.5 million years to arrive at the “Answer to the Ultimate Question of Life, the Universe, and Everything.” DOUGLAS ADAMS, *THE HITCHHIKER’S GUIDE TO THE GALAXY* 180 (rev. ed. 2001) (1979). The answer was 42. *Id.* at 188.

reproducibility might depend on the field in question, and what best reflected the actual use of inventive machines in research. For instance, when asked to design a new catalyst in the petroleum industry, Watson might be given access to all prior art and publicly available data, and then given a day to generate output.

C. An Economic vs. Cognitive Standard

The skilled person standard received its share of criticism even before the arrival of inventive machines.¹⁹⁰ The inquiry focuses on the degree of cognitive difficulty in conceiving an invention but fails to explain what it actually means for differences to be obvious to an average worker. The approach lacks both a normative foundation and a clear application.¹⁹¹

In *Graham*, the Supreme Court's seminal opinion on nonobviousness, the Court attempted to supplement the test with more "objective" measures by looking to real-world evidence about how an invention was received in the marketplace.¹⁹² Rather than technological features, these "secondary" considerations focus on "economic and motivational" features, such as commercial success, unexpected results, long-felt but unsolved needs, and the failure of others.¹⁹³ Since *Graham*, courts have also considered, among other

190. See, e.g., Chiang, *supra* note 19, at 49 (as one commentator noted about the test as articulated by the Supreme Court in *Graham*, it gives "all the appearance of expecting a solution to appear out of thin air once the formula was followed. The lack of an articulable rule meant that determinations of obviousness took the appearance—and arguably the reality—of resting on judicial whim" (footnote omitted)); Abramowicz & Duffy, *supra* note 16, at 1598; Gregory N. Mandel, *Patently Non-Obvious: Empirical Demonstration That the Hindsight Bias Renders Patent Decisions Irrational*, 67 OHIO ST. L.J. 1391 (2006) (discussing problems with hindsight in nonobviousness inquiries); Gregory N. Mandel, *Another Missed Opportunity: The Supreme Court's Failure to Define Nonobviousness or Combat Hindsight Bias in KSR v. Teleflex*, 12 LEWIS & CLARK L. REV. 323 (2008).

191. See Abramowicz & Duffy, *supra* note 16, at 1603 ("[N]either *Graham* nor in subsequent cases has the Supreme Court attempted either to reconcile the inducement standard with the statutory text or to provide a general theoretical or doctrinal foundation for the inducement standard.").

192. See *Graham v. John Deere Co.*, 383 U.S. 1, 17; MPEP § 2144.

193. *Graham*, 383 U.S. at 17; MPEP § 2144. Additional secondary considerations have since been proposed. See, e.g., Andrew Blair-Stanek, *Increased Market Power as a New Secondary Consideration in Patent Law*, 58 AM. U.L. REV. 707 (2009) (arguing for whether an invention provides an inventor with market power); Abramowicz & Duffy, *supra* note 16, at 1656 (proposing changing commercial success to "unexpected commercial success," adding as a consideration of the "cost of the experimentation leading to the invention," and a few additional considerations).

things, patent licensing,¹⁹⁴ professional approval,¹⁹⁵ initial skepticism,¹⁹⁶ near-simultaneous invention,¹⁹⁷ and copying.¹⁹⁸ Today, while decisionmakers are required to consider secondary evidence when available, the importance of these factors varies significantly.¹⁹⁹ *Graham* endorsed the use of secondary considerations, but their precise use and relative importance have never been made clear.²⁰⁰

An existing vein of critical scholarship has advocated for adopting a more economic than cognitive nonobviousness inquiry, for example through greater reliance on secondary considerations.²⁰¹ This would reduce the need for decisionmakers to try and make sense of complex technologies, and it could reduce hindsight bias.²⁰²

Theoretically, in *Graham*, the Court articulated an inducement standard, which dictates that patents should only be granted to “those inventions which would not be disclosed or devised but for the inducement of a patent.”²⁰³ But in practice, the inducement standard has been largely ignored due to concerns over application.²⁰⁴ For instance, few, if any, inventions would never be disclosed or devised given an unlimited time frame. Patent incentives may not increase, so

194. See, e.g., *SIBIA Neurosciences, Inc. v. Cadus Pharm. Corp.*, 225 F.3d 1349, 1358 (Fed. Cir. 2000).

195. See, e.g., *Vulcan Eng'g Co. v. Fata Aluminum, Inc.*, 278 F.3d 1366, 1373 (Fed. Cir. 2002).

196. See, e.g., *Metabolite Labs., Inc. v. Lab. Corp. of Am. Holdings*, 370 F.3d 1354, 1368 (Fed. Cir. 2004).

197. See, e.g., *Ecolochem, Inc. v. S. Cal. Edison Co.*, 227 F.3d 1361, 1379 (Fed. Cir. 2000).

198. See, e.g., *id.* at 1377. See also Mark A. Lemley, *Should Patent Infringement Require Proof of Copying?*, 105 MICH. L. REV. 1525, 1534–35 (2007).

199. See MPEP § 2144; Durie & Lemley, *supra* note 19, at 996–97.

200. See, e.g., Dorothy Whelan, *A Critique of the Use of Secondary Considerations in Applying the Section 103 Nonobviousness Test for Patentability*, 28 B.C. L. REV. 357 (1987).

201. See, e.g., *Merges*, *supra* note 19, at 19 (arguing for patentability to be based on an a priori degree of uncertainty, that “rewards one who successfully invents when the uncertainty facing her prior to the invention makes it more likely than not that the invention won’t succeed” (emphasis omitted)); Chiang, *supra* note 19, at 42 (arguing for a utilitarian standard, such that “[a]n invention should receive a patent if the accrued benefits before independent invention outweigh the costs after independent invention”); Mandel, *The Non-Obvious Problem*, *supra* note 19, at 62 (arguing for nonobviousness to be based on “how probable the invention would have been for a person having ordinary skill in the art working on the problem that the invention solves”); Durie & Lemley, *supra* note 19, at 1004–07 (arguing for a greater reliance on secondary considerations); Duffy, *supra* note 19, at 343 (arguing a timing approach to determining obviousness); Devlin & Sukhatme, *supra* note 19; Abramowicz & Duffy, *supra* note 16, at 1598 (arguing for an inducement standard).

202. *Graham*, 383 U.S. at 36 (“[Secondary considerations] may also serve to ‘guard against slipping into use of hindsight.’” (citation omitted)). See also HERBERT F. SCHWARTZ & ROBERT J. GOLDMAN, *PATENT LAW AND PRACTICE* 90–91 (6th ed. 2008).

203. *Graham*, 383 U.S. at 11.

204. See Abramowicz & Duffy, *supra* note 16, at 1594–95.

much as accelerate, invention.²⁰⁵ This suggests that an inducement standard would at least need to be modified to include some threshold for the quantum of acceleration needed for patentability. Too high a threshold would fail to provide adequate innovation incentives, but too low a threshold would be similarly problematic. Just as inventions will be eventually disclosed without patents given enough time, patents on all inventions could marginally speed the disclosure of just about everything, but a trivial acceleration would not justify the costs of patents. An inducement standard would thus require a somewhat arbitrary threshold in relation to how much patents should accelerate the disclosure of information, as well as a workable test to measure acceleration.²⁰⁶ To be sure, an economic test based on the inducement standard would have challenges, but it might be an improvement over the current cognitive standard.²⁰⁷

The widespread use of inventive machines may provide the impetus for an economic focus. After inventive machines become the standard way that R&D is conducted in a field, courts could increase reliance on secondary factors. For instance, patentability may depend on how costly it was to develop an invention, and the ex ante probability of success.²⁰⁸ There is no reason an inventive machine cannot be thought of, functionally, as an economically motivated rational actor. The test would raise the bar to patentability in fields where the cost of invention decreases over time due to inventive machines.

D. Other Alternatives

Courts may maintain the current skilled person standard and decline to consider the use of machines in obviousness determinations. However, this means that as research is augmented and then automated by machines, the average worker will routinely generate patentable output. The dangers of such a

205. See, e.g., Yoram Barzel, *Optimal Timing of Innovations*, 50 REV. ECON. & STATS. 348, 348 (1968); John F. Duffy, *Rethinking the Prospect Theory of Patents*, 71 U. CHI. L. REV. 439, 444 (2004).

206. Abramowicz & Duffy, *supra* note 16, at 1599 (proposing a “substantial period of time”).

207. See Abramowicz & Duffy, *supra* note 16, at 1663.

208. *Id.*

standard for patentability are well-recognized.²⁰⁹ A low obviousness requirement can “stifle, rather than promote, the progress of the useful arts.”²¹⁰

Concerns already exist that the current bar to patentability is too low, and that a patent “anticommons” with excessive private property is resulting in “potential economic value . . . disappear[ing] into the ‘black hole’ of resource underutilization.”²¹¹ It is expensive for firms interested in making new products to determine whether patents cover a particular innovation, evaluate those patents, contact patent owners, and negotiate licenses.²¹² In many cases, patent owners may not wish to license their patents, even if they are non-practicing entities that do not manufacture products themselves.²¹³ Firms that want to make a product may thus be unable to find and license all the rights they need to avoid infringing. Adding to this morass, most patents turn out to be invalid or not infringed in litigation.²¹⁴ Excessive patenting can thus slow innovation, destroy markets, and, in the case of patents on some essential medicines, even cost lives.²¹⁵ Failing to raise the bar to patentability once the use of inventive machines is widespread would significantly exacerbate this anticommons effect.

Instead of updating the skilled person standard, courts might determine that inventive machines are incapable of inventive activity, much as the U.S. Copyright Office has determined that nonhuman authors cannot generate copyrightable output.²¹⁶ In this case, otherwise patentable inventions might not

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209. See, e.g., ADAM B. JAFFE & JOSH LERNER, *INNOVATION AND ITS DISCONTENTS: HOW OUR BROKEN PATENT SYSTEM IS ENDANGERING INNOVATION AND PROGRESS, AND WHAT TO DO ABOUT IT* 32–35, 75, 119–23, 145–49 (2004) (criticizing the Patent Office for granting patents on obvious inventions); NATIONAL RESEARCH COUNCIL, *A PATENT SYSTEM FOR THE 21ST CENTURY* 87–95 (2004) (criticizing lenient nonobviousness standards); Matthew Sag & Kurt Rohde, *Patent Reform and Differential Impact*, 8 MINN. J.L. SCI. & TECH. 1, 2 (2007) (“Academics, business leaders, and government officials have all expressed concern that too many patents are issued for [obvious] inventions.”).
 210. *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 427 (2007).
 211. James M. Buchanan & Yong J. Yoon, *Symmetric Tragedies: Commons and Anticommons*, 43 J.L. & ECON. 1, 2; accord DAN L. BURK & MARK A. LEMLEY, *THE PATENT CRISIS AND HOW THE COURTS CAN SOLVE IT* (2009) (arguing for a heightened bar to patentability).
 212. See generally Mark A. Lemley, *Ignoring Patents*, 2008 MICH. ST. L. REV. 19, 25–26 (2008) (describing various costs associated with innovation in patent heavy industries).
 213. See David L. Schwartz & Jay P. Kesan, *Analyzing the Role of Non-Practicing Entities in the Patent System*, 99 CORNELL L. REV. 425 (2014).
 214. See Mark A. Lemley & Carl Shapiro, *Probabilistic Patents*, 19 J. ECON. PERSP. 75, 80 (2005).
 215. See Michael A. Heller, *The Tragedy of the Anticommons: Property in the Transition From Marx to Markets*, 111 HARV. L. REV. 621 (1998); see also MICHAEL HELLER, *THE GRIDLOCK ECONOMY: HOW TOO MUCH OWNERSHIP WRECKS MARKETS, STOPS INNOVATION AND COSTS LIVES* (2008); see also Michael A. Heller & Rebecca S. Eisenberg, *Can Patents Deter Innovation? The Anticommons in Biomedical Research*, 280 SCIENCE 698 (1998).
 216. This has been a policy of the Copyright Office since at least 1984. See U.S. COPYRIGHT OFFICE, *COMPENDIUM OF U.S. COPYRIGHT OFFICE PRACTICES* § 306 (3d ed. 2014). The

be eligible for patent protection, unless provisions were made for the inventor to be the first person to recognize the machine output as patentable. However, this would not be a desirable outcome. As I have argued elsewhere, providing intellectual property protection for computer-generated inventions would incentivize the development of inventive machines, which would ultimately result in additional invention.²¹⁷ This is most consistent with the constitutional rationale for patent protection “[t]o promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries.”²¹⁸

E. Incentives Without Patents?

Today, there are strong incentives to develop inventive machines. Inventions by these machines have value independent of intellectual property protection, but they should also be eligible for patent protection. People may apply as inventors for recognizing the inventive nature of a machine’s output,²¹⁹ or more ambitiously, inventive machines may be recognized as inventors, resulting in stronger and fairer incentives.

Once inventive machines set the baseline for patentability, standard inventive machines, as well as people, should have difficulty obtaining patents. It is widely thought that setting a nonobviousness standard too high would reduce the incentives for innovators to invent and disclose. Yet once inventive machines are normal, there should be less need for patent incentives.²²⁰ Once the

Compendium of U.S. Copyright Office Practices elaborates on the “human authorship” requirement by stating: “The term ‘authorship’ implies that, for a work to be copyrightable, it must owe its origin to a human being.” *Id.* It further elaborates on the phrase “[w]orks not originated by a human author” by stating: “In order to be entitled to copyright registration, a work must be the product of human authorship. Works produced by mechanical processes or random selection without any contribution by a human author are not registrable.” *Id.* § 503.03(a).

217. See generally *I Think*, *supra* note 1.

218. U.S. CONST. art. I, § 8, cl. 8.

219. Conception requires contemporaneous recognition and appreciation of the invention. See *Invitrogen Corp. v. Clontech Labs., Inc.*, 429 F.3d 1052, 1064 (Fed. Cir. 2005) (noting that the inventor must have actually made the invention and understood the invention to have the features that comprise the inventive subject matter at issue); see also, e.g., *Silvestri v. Grant*, 496 F.2d 593, 597 (C.C.P.A. 1974) (“[A]n accidental and unappreciated duplication of an invention does not defeat the patent right of one who, though later in time, was the first to recognize that which constitutes the inventive subject matter.”).

220. See generally, Mark A. Lemley, *IP in a World Without Scarcity* (Stanford Public Law, Working Paper No. 2413974, 2014), <http://dx.doi.org/10.2139/ssrn.2413974> (arguing new technologies that reduce costs will weaken the case for IP).

average worker is inventive, inventions will “occur in the ordinary course.”²²¹ Machine inventions will be self-sustaining. In addition, the heightened bar might result in a technological arms race to create ever more intelligent computers capable of outdoing the standard. That would be a desirable outcome in terms of incentivizing innovation.

Even after the widespread use of inventive machines, patents may still be desirable. For instance, patents may be needed in the biotechnology and pharmaceutical industries to commercialize new technologies. The biopharma industry claims that new drug approvals cost around 2.2 billion dollars and take an average of eight years.²²² This cost is largely due to resource intensive clinical trials required to prove safety and efficacy. Once a drug is approved, it is often relatively easy for another company to recreate the approved drug. Patents thus incentivize the necessary levels of investment to commercialize a product given that patent holders can charge monopoly prices for their approved products during the term of a patent.

Yet patents are not the only means of promoting product commercialization. Newly approved drugs and biologics, for example, receive a period of market exclusivity during which time no other party can sell a generic or biosimilar version of the product. Newly approved biologics, for instance, receive a twelve-year exclusivity period in the United States. Because of the length of time it takes to get a new biologic approved, the market exclusivity period may exceed the term of any patent an originator company has on its product. A heightened bar to patentability may lead to greater reliance on alternative forms of intellectual property protection such as market exclusivity, prizes, grants, or tax incentives.²²³

With regards to disclosure, without the ability to receive patent protection, owners of inventive machines may choose not to disclose their discoveries and rely on trade secret protection. However, with an accelerated rate of technological progress, intellectual property holders would run a significant risk that their inventions would be independently recreated by inventive machines.

Depending on the type of innovation, industry, and competitive landscape, business ventures may be successful without patents, and patent protection is

221. KSR Int’l Co. v. Teleflex Inc., 550 U.S. 398, 402 (2007).

222. Joseph A. DiMasi, Henry G. Grabowski, & Ronald W. Hansen, *Innovation in the Pharmaceutical Industry: New Estimates of R&D Costs*, 47 J. OF HEALTH ECON. 20–33 (2016).

223. See generally Daniel J. Hemel & Lisa Larrimore Ouellette, *Beyond the Patents-Prizes Debate*, 92 TEX. L. REV. 303 (2013) (describing various nontraditional intellectual property incentives).

not sought for all potentially patentable inventions.²²⁴ In fact, “few industries consider patents essential.”²²⁵ For instance, patents are often considered a critical part of biotechnology corporate strategy, but often ignored in the software industry.²²⁶ On the whole, a relatively small percentage of firms patent, even among firms conducting R&D.²²⁷ Most companies do not consider patents crucial to business success.²²⁸ Other types of intellectual property such as trademark, copyright, and trade secret protection, combined with “alternative” mechanisms such as first mover advantage and design complexity may protect innovation even in the absence of patents.²²⁹

F. A Changing Innovation Landscape

Inventive machines may result in further consolidation of wealth and intellectual property in the hands of large corporations like Google and IBM. Large enterprises may be the most likely developers of inventive machines due to their high development costs.²³⁰ A counterbalance to additional wealth disparity could be broad societal gains. The public would stand to gain access to a tremendous amount of innovation—innovation which might be significantly delayed or never come about without inventive machines. In fact, concerns about industry consolidation are another basis for revising the obviousness inquiry. The widespread use of inventive machines may be inevitable, but raising the bar to patentability would make it so that inventions which would

224. BRONWYN HALL ET AL., INTELLECTUAL PROPERTY OFFICE, THE USE OF ALTERNATIVES TO PATENTS AND LIMITS TO INCENTIVES, 2 (2012), <http://webarchive.nationalarchives.gov.uk/20140603121456/http://www.ipo.gov.uk/ipresearch-patalternative.pdf>; see also, Rochelle Cooper Dreyfuss, *Does IP Need IP? Accommodating Intellectual Production Outside the Intellectual Property Paradigm*, 31 CARDOZO L. REV. 1437, 1439 (2010); see also David Fagundes, *Talk Derby to Me: Intellectual Property Norms Governing Roller Derby Pseudonyms*, 90 TEX. L. REV. 1094, 1146 (2012) (describing norm-based protections that function effectively in the absence of traditional IP). Patent holders are only successful in about a quarter of cases that are litigated to a final disposition and appealed. Paul M. Janicke & LiLan Ren, *Who Wins Patent Infringement Cases?*, 34 AIPLA Q.J. 1, 8 (2006). Fewer than two percent of patents are ever litigated, and only about 0.1 percent go to trial. Lemley & Shapiro, *supra* note 214, at 79. In cases where the validity of a patent is challenged, about half of the time the patent is invalidated. Allison & Lemley, *supra* note 20, at 205 (1998).

225. Merges, *supra* note 19, at 19.

226. See generally, Lemley & Shapiro, *supra* note 214.

227. *Id.*

228. *Id.*

229. *Id.*

230. See Jamie Carter, *The Most Powerful Supercomputers in the World—and What They Do*, TECHRADAR (Dec. 13, 2014), <http://www.techradar.com/us/news/computing/the-most-powerfulsupercomputers-in-the-world-and-what-they-do-1276865> (noting that most advanced computer systems are owned by governments and large businesses).

naturally occur would be less likely to receive protection. To the extent market abuses such as price gouging and supply shortages are a concern, protections are, at least theoretically, built into patent law to protect consumers against such problems.²³¹ For example, the government could exercise its march in rights or issue compulsory licenses.²³²

Inventive machines may ultimately automate knowledge work and render human researchers redundant. While past technological advances have resulted in increased rather than decreased employment, the technological advances of the near future may be different.²³³ There will be fewer limits to what machines will be able to do, and greater access to machines. Automation should generate innovation with net societal gains, but it may also contribute to unemployment, financial disparities, and decreased social mobility.²³⁴ It is important that policymakers act to ensure that automation benefits everyone, for instance by investing in retraining and social benefits for workers rendered technologically unemployed.²³⁵ Ultimately, patent law alone will not determine whether automation occurs. Even without the ability to receive patent protection, once inventive machines are significantly more efficient than human researchers, they will replace people.

CONCLUSION

Prediction is very difficult, especially about the future.²³⁶

In the past, patent law has reacted slowly to technological change. For instance, it was not until 2013 that the Supreme Court decided human genes should be unpatentable.²³⁷ By then, the Patent Office had been granting patents on human genes for decades,²³⁸ and more than 50,000 gene-related patents had been issued.²³⁹

231. See *Balancing Access*, *supra* note 27 (discussing patent law protections against practices including “evergreening”).

232. See *id.* at 345 (explaining India’s issuance of a compulsory license).

233. See *Should Robots Pay Taxes?*, *supra* note 6; see *supra* Part I.

234. *Id.*

235. *Id.*

236. ARTHUR K. ELLIS, TEACHING AND LEARNING ELEMENTARY SOCIAL STUDIES 56, (1970) (quoting physicist Niels Bohr).

237. *Ass’n for Molecular Pathology v. Myriad Genetics, Inc.*, 133 S. Ct. 2107 (2013).

238. See, e.g., U.S. Patent No. 4,447,538 (filed Feb. 5, 1982) (a patent issued in 1984 which claims the human *Chorionic Somatomammotropin* gene).

239. Robert Cook-Deegan & Christopher Heaney, *Patents in Genomics and Human Genetics*, 11 ANN. REV. OF GENOMICS & HUM. GENETICS 383, 384 (2010) (“In April 2009, the U.S. Patent

Eminent technologists now predict that artificial intelligence is going to revolutionize the way innovation occurs in the near to medium term. Much of what we know about intellectual property law, while it might not be wrong, has not been adapted to where we are headed. The principles that guide patent law need to be, if not rethought, then at least retooled in respect of inventive machines. We should be asking what our goals are for these new technologies, what we want our world to look like, and how the law can help make it so.

and Trademark Office (USPTO) granted the 50,000th U.S. patent that entered the DNA Patent Database at Georgetown University. That database includes patents that make claims mentioning terms specific to nucleic acids (e.g., DNA, RNA, nucleotide, plasmid, etc.).”).