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ESSAYS

Albert Einstein, Esq.

STEVEN GOLDBERG*

Discussed in this Essay: EINSTEIN'S CLOCKS, POINCARÉ'S MAPS: EMPIRES OF TIME.
By Peter Galison, W.W. Norton & Co., 2003. 256 pages.

INTRODUCTION

If, for instance, I say, "That train arrives here at 7 o'clock," I mean something like this: "The pointing of the small hand of my watch to 7 and the arrival of the train are simultaneous events."¹

This sounds like a lawyer's effort to remove all ambiguity before establishing when a train reached the station. In reality, however, it is a key sentence in one of the most famous scientific papers ever written, Albert Einstein's 1905 exposition of the theory of special relativity.² The radical insights in that paper about space and time have had an impact far beyond science. On the hundredth anniversary of the appearance of Einstein's seminal paper it is therefore appropriate to reflect on the light that new scholarship casts on the relationship between Einstein's breakthrough and his formative years as a patent examiner.

In a recent pathbreaking book, Peter Galison demonstrates that Einstein's paper was fundamentally shaped by his work as a patent examiner.³ Galison shows that arguments previously seen as abstract thought experiments were derived instead from Einstein's immersion in patent applications for devices that coordinate clocks, a pressing economic and social need at the time.⁴

I believe Galison also opens the way for seeing portions of Einstein's paper as reflecting the quasi-judicial role of a patent examiner. For while Einstein, like most patent examiners today, was not a lawyer, his job required him to do what patent examiners still do: apply legal principles, such as the idea of novelty, to the facts presented in a patent application. Like trial judges, patent examiners are not free to change the law. They must instead apply principles to new situations and write opinions explaining their result. When we focus carefully

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1. Albert Einstein, *On the Electrodynamics of Moving Bodies*, in ARTHUR I. MILLER, ALBERT EINSTEIN'S SPECIAL THEORY OF RELATIVITY: EMERGENCE (1905) AND EARLY INTERPRETATION (1905-1911) 392, 393 (1981) (Professor Miller's translation of Einstein's 1905 special relativity paper).

2. Einstein, *supra* note 1.

3. PETER GALISON, EINSTEIN'S CLOCKS, POINCARÉ'S MAPS: EMPIRES OF TIME 221-93 (2003).

4. *See id.*

on the structure of Einstein's 1905 special relativity paper we see a similar effort to apply settled principles in a reasoned way to an open problem. Unlike the Supreme Court, which has broad freedom to reinterpret or overrule precedents, Einstein, in his 1905 paper, proceeds like a patent examiner or trial judge to work out the implications of certain postulates in a particular setting.

In this Essay, I begin with a brief summary of Einstein's career in order to show where the 1905 paper fits into his work. I then describe the reasoning in that paper, and Galison's contribution to our understanding of that reasoning, before turning to my own analysis of how Einstein's paper can be compared to the legal reasoning in a patent examiner's or trial judge's opinion.

I.

In 1901, Albert Einstein was twenty-two years old and a recent graduate of Zurich Polytechnic, where he had studied mathematics and physics.⁵ Unable to find a university position, he supported himself by tutoring and other temporary work.⁶ His financial situation was precarious.⁷ Fortunately, the father of a friend from the Polytechnic recommended Einstein for an opening in the Patent Office in Bern.⁸ In late May 1902, the Director of the Patent Office, Friedrich Haller, offered Einstein an interview,⁹ and on June 23, 1902, Einstein started work at the Patent Office as a Technical Expert, Third Class.¹⁰

In 1905, while working as a patent examiner, Einstein produced an unprecedented series of physics publications in his spare time.¹¹ One of them was an important explanation of Brownian motion,¹² while another explicated the photoelectric effect.¹³ The latter paper was the basis on which the Nobel Prize was awarded to him sixteen years later.¹⁴ But Einstein's most important publication in 1905 was *On the Electrodynamics of Moving Bodies*, which set forth the special theory of relativity.¹⁵ That paper, which is the focus of this Essay, solved a series of problems that numerous physicists had worked on for years.¹⁶ It did so by shattering the Newtonian concepts of absolute space and time.¹⁷ In a supplemental paper published later, Einstein showed that the special theory leads to the conclusion that energy and mass are related by the equation $E =$

5. BANESH HOFFMANN, ALBERT EINSTEIN: CREATOR AND REBEL 28–36 (1972).

6. *Id.*

7. *Id.*

8. *Id.*

9. ALBRECHT FOLSING, ALBERT EINSTEIN: A BIOGRAPHY 101 (Ewald Osers trans., 1997).

10. *Id.*

11. See DENIS BRIAN, EINSTEIN: A LIFE 52 (1996).

12. See FOLSING, *supra* note 9, at 128.

13. See HOFFMANN, *supra* note 5, at 51–54.

14. See *id.* at 54.

15. See *id.* at 60–79.

16. See *id.* Indeed, by 1905, other scientists were very close to developing the special theory of relativity. *Id.* at 68.

17. See *id.* at 60–79.

mc^2 , the formula that lies behind nuclear energy.¹⁸

In 1909, Einstein, who had risen to Technical Expert, Second Class, gave notice that he was leaving the Patent Office to take the first in a series of academic appointments.¹⁹ Director Haller wrote that Einstein had “performed highly valued services. His departure is a loss to the Office. However, Herr Einstein feels that teaching and scientific research are his real profession”²⁰ Over the next decade, Einstein developed his greatest contribution to physics, the general theory of relativity, which set forth a revolutionary theory of gravity.²¹ In 1919, when astronomical observations provided preliminary confirmation that light was deflected in the gravitational field of the sun, as the general theory predicted, Einstein became world famous.²² He died in 1955.²³

II.

On the Electrodynamics of Moving Bodies, Einstein’s 1905 paper on special relativity, is venerated by scientists. It has been described as “the best-known physics paper of the twentieth century,”²⁴ and as “unparalleled in the history of science in its depth, breadth and sheer intellectual virtuosity.”²⁵ Newton had posited a universe in which absolute space and absolute time provided a reference frame from which we could measure distance, motion, and the laws of physics.²⁶ Einstein’s paper shattered that universe.²⁷

What most people know about the special theory of relativity is captured in an image from popular culture: a spaceship, traveling near the speed of light relative to the earth, is viewed from earth.²⁸ From that perspective, the ship shrinks in size and its clocks slow down, although to the people on the ship there is no such change.²⁹ Neither the people on the earth nor those on the ship can claim that their measurements are better than the others’.³⁰ There is no absolute length or time; both are relative.³¹ These effects have been confirmed in modern experiments. Indeed, readings from the global positioning satellites that drivers use every day to find their location are adjusted slightly because the satellites are orbiting the earth at 12,500 miles per hour and thus their clocks run

18. *See id.* at 80–81.

19. FOLSING, *supra* note 9, at 253, 852–53.

20. *See id.* at 253.

21. *See id.* at 301–21, 369–93.

22. *See id.* at 433–52. The astronomical evidence that appeared to confirm general relativity in 1919 has been subjected to criticism, but later tests demonstrate that Einstein’s theory of gravity produces better results than Newton’s. *See* BRIAN GREENE, *THE ELEGANT UNIVERSE* 77–78 (1999).

23. FOLSING, *supra* note 9, at 739–41.

24. GALISON, *supra* note 3, at 14.

25. MILLER, *supra* note 1, at xiii.

26. *See* HOFFMANN, *supra* note 5, at 61.

27. *See* GREENE, *supra* note 22, at 23.

28. *See, e.g.*, HOFFMANN, *supra* note 5, at 74–78.

29. *Id.*

30. *Id.*

31. *Id.*

slow from the drivers' point of view.³²

Einstein's insight reaches beyond length and time to physical effects generally. Even simultaneity is relative. Suppose two people at opposite ends of the spaceship clap their hands at the same time. They are convinced that the claps are simultaneous. But from the point of view of someone on earth, one clap precedes the other. Again, neither viewpoint is more true than the other.³³

Although some of Einstein's reasoning in his 1905 paper is mathematical, there are many fine descriptions for the layman of his thirty-page masterpiece.³⁴ My goal here is not to recapitulate those descriptions. I simply want to outline the structure of Einstein's argument.³⁵

Einstein's first sentence states a problem which he describes as "well known."³⁶ In the mid-nineteenth century, the Scottish physicist James Clerk Maxwell had developed a set of equations that successfully predicted how electromagnetic forces behave.³⁷ But Einstein points out that "when applied to moving bodies" Maxwell's equations lead "to asymmetries which do not appear to be inherent in the phenomena."³⁸ In particular, Einstein notes, Maxwell's theory makes an arbitrary distinction between rest and motion.³⁹ When you move a magnet and a conductor (such as a loop of wire) near one another, an electric current appears in the conductor.⁴⁰ Maxwell's equations correctly predict the magnitude and direction of the induced current.⁴¹ The oddity is that Maxwell's equations give different physical explanations for this current depending upon whether the magnet is moving and the conductor is at rest, or the conductor is moving and the magnet is at rest.⁴²

After explaining this and a related problem with the concept of rest and motion,⁴³ Einstein begins the first section, titled *Definition of Simultaneity*, with extremely precise definitions of motion and time.⁴⁴ Einstein asserts that if we

32. GALISON, *supra* note 3, at 288–89. Adjustments also have to be made because of general relativity. *Id.*

33. HOFFMANN, *supra* note 5, at 75–76.

34. *See, e.g.*, FOLSING, *supra* note 9, at 178–95; GALISON, *supra* note 3, at 14–23; HOFFMANN, *supra* note 5, at 60–79.

35. In developing this outline, I relied heavily on Galison, Hoffmann, and Fölsing, as well as on my own reading of Einstein. I left out several matters discussed by Einstein which were not central to my point. For example, one famous step Einstein took, which I do not discuss here, was to set aside as superfluous the then-current notion that light waves moved in an all-pervasive ether. *See, e.g.*, HOFFMANN, *supra* note 5, at 72.

36. Einstein, *supra* note 1, at 392.

37. *See* HOFFMANN, *supra* note 5, at 45–47.

38. Einstein, *supra* note 1, at 392.

39. *Id.*; *see also* HOFFMAN, *supra* note 5, at 69.

40. Einstein, *supra* note 1, at 392; *see also* HOFFMANN, *supra* note 5, at 69.

41. *See* FOLSING, *supra* note 9, at 179.

42. Einstein, *supra* note 1, at 392; *see also* HOFFMANN, *supra* note 5, at 69.

43. The related problem—"the unsuccessful attempts to discover any motion of the earth relatively to the 'light medium,'" Einstein, *supra* note 1, at 392—concerns the ether which Einstein's contemporaries believed was all-pervasive, but which he regarded as superfluous. *See supra* note 35.

44. Einstein, *supra* note 1, at 393.

want to describe mathematically the motion of an object, we imagine it moving through Cartesian coordinates and “give the values of its coordinates as functions of the time.”⁴⁵ In more informal terms, if we want to describe the motion of a train going thirty miles an hour, we would note that at seven o’clock the train is at Washington, DC, at eight o’clock it is at Baltimore, and that the two cities are thirty miles apart.

But to say that this train’s location is a function of time is insufficiently precise for Einstein. He says that a description of this kind “has no physical meaning unless we are quite clear as to what we will understand by ‘time.’”⁴⁶ Here he makes a crucial observation:

We have to take into account that all our judgments in which time plays a role are always judgments of *simultaneous events*. If, for instance, I say, “That train arrives here at 7 o’clock,” I mean something like this: “The pointing of the small hand of my watch to 7 and the arrival of the train are simultaneous events.”⁴⁷

Einstein then notes that defining time in terms of “the position of the small hand of my watch” is only satisfactory if we are “defining time exclusively for the place where the watch is located.”⁴⁸ But things become more complicated if we are concerned with the time at a place remote from the watch’s location. For this situation, where we have clocks at two locations that are at rest relative to each other, Einstein says we can synchronize our clocks by sending a beam of light from the first clock to the second and back again.⁴⁹ We can then set the second clock to the first clock’s time plus half the round-trip time.⁵⁰

Having carefully defined his terms, Einstein begins Section 2 of the article, *On the Relativity of Lengths and Times*,⁵¹ by announcing that his analysis is based on “two principles.”⁵² The first is that no experiment can detect the difference between absolute rest and uniform motion.⁵³ This idea goes back to Galileo, who had pictured a ship moving smoothly across the ocean. If you are in a closed cabin on that ship, Galileo argued, there is no experiment you could perform that would tell you whether the ship was moving at a uniform velocity as opposed to standing still. In either case, for example, a ball dropped to the floor will appear to you to fall in exactly the same way. Newton had made a similar point, and Einstein drew on these ideas for his first postulate.

45. *Id.*

46. *Id.*

47. *Id.*

48. *Id.*

49. *Id.* at 394.

50. *Id.* This point is well explained by GALISON, *supra* note 3, at 21–22.

51. Einstein, *supra* note 1, at 394.

52. *Id.*

53. *Id.* at 395. This point, and the observations in the remainder of this paragraph, are found in GALISON, *supra* note 3, at 16, and HOFFMANN, *supra* note 5, at 63–64, 69–70.

Einstein's second principle was that light travels through empty space with a set speed that does not depend on the motion of its source. As Einstein put it, "light moves . . . with the definite velocity c , which is independent of whether the ray was emitted by a resting or by a moving body."⁵⁴ For these purposes, it is helpful to think of light as a wave.⁵⁵ Once the wave starts, it moves at a fixed speed, so if you measure the speed of light as it reaches you from a lamp on a train, you will record 186,000 miles per second whether the train is moving or still.⁵⁶

Both of Einstein's principles comported with the empirical evidence available to him.⁵⁷ He was not concerned with establishing their validity; he was assuming they were valid.

Once the two physical principles and the definitions of time and simultaneity are in place, Einstein is off and running to the heart of his argument.⁵⁸ He has the reader imagine a rod with a clock at each end. He puts the rod in uniform motion in relation to a person. He then imagines a second person moving alongside the rod, measuring its length and synchronizing its clocks. This second person will get certain answers which are perfectly sensible from his point of view. But when the first person measures the length of the moving rod and synchronizes its clocks, he gets completely different answers. Length, time, and simultaneity are all relative.

Demonstrating this result in detail is beyond our scope here, and it is well done in many sources.⁵⁹ Fundamentally, Einstein shows that any effort to determine a "true" length or time, or to determine which observer is "really" at rest, runs afoul of one of his postulates. According to the first postulate, no experiment done on the rod can reveal whether it is moving or still. And, although you use a light beam to synchronize clocks, any effort to tell by the speed of the light arriving from the rod whether the rod is moving or still runs afoul of the second postulate, which holds that the speed of light is independent of the motion of its source.

There is vastly more to Einstein's 1905 article. But this description gives some sense of how he attacked the problem before him.

III.

It is surely incongruous that the special theory of relativity was developed by a patent examiner in his spare time. Many commentators have assumed that the patent job had nothing to do with the science. Banesh Hoffmann, a physicist

54. Einstein, *supra* note 1, at 395.

55. GALISON, *supra* note 3, at 17.

56. *Id.* at 16–17.

57. *See id.*

58. The remainder of this paragraph is based on Einstein, *supra* note 1, at 395–96, and FOLSING, *supra* note 9, at 186.

59. An excellent account of the points made in the remainder of this paragraph can be found in HOFFMANN, *supra* note 5, at 72–77.

who worked with Einstein later in his life, saw the patent office as the “unlikely conservatory” in which Einstein’s “genius matured.”⁶⁰ The physicist and historian of science Arthur I. Miller described patent examiner Einstein as “working dutifully at his job” while reserving “his iconoclasm for evenings and weekends which he devoted to physics.”⁶¹ Several biographers have described the patent job as sufficiently undemanding that Einstein had time to think about more theoretical matters.⁶² Contemporary scientists also found Einstein’s day job incongruous. When the physicist Johann Jakob Laub learned that the “Esteemed Herr Doktor” who had revolutionized physics worked at the patent office, he wrote to Einstein, “I must confess to you that I was amazed to read that you have to sit in an office for eight hours a day! But history is full of bad jokes.”⁶³

It is not just the incongruity of a great physicist in a lowly job. Einstein is typically seen as an abstract thinker. He was known for creating thought experiments that could not be performed in practice, but which clarified physical issues.⁶⁴ In a famous example that shaped special relativity, Einstein had wondered since boyhood how a beam of light would appear if we could run alongside it at light speed.⁶⁵ In the years after he developed special relativity, he credited his insights to philosophers such as Ernst Mach and David Hume,⁶⁶ to the beauty of pure mathematics,⁶⁷ and to a search for God’s order in the universe.⁶⁸ Einstein emphasized the separation between his intellectual life and his day-to-day work when he looked back on the Patent Office as his “temporal monastery.”⁶⁹

No one doubts Einstein’s capacity for abstract thought, but other observers have postulated that working as a patent examiner may have sharpened his thinking.⁷⁰ With the publication in 2003 of Peter Galison’s brilliant book, *Einstein’s Clocks, Poincaré’s Maps*, this line of analysis moves light years forward.

Galison is a leading historian of science known for his emphasis on how the tools that scientists use shape their thinking.⁷¹ His work is often contrasted with that of Thomas Kuhn, who emphasized the role of conceptual ideas in scientific

60. *Id.* at 35.

61. MILLER, *supra* note 1, at 7.

62. *See, e.g.*, BRIAN, *supra* note 11, at 52; FOLSING, *supra* note 9, at 222.

63. *See* FOLSING, *supra* note 9, at 235.

64. LEOPOLD INFELD, ALBERT EINSTEIN: HIS WORK AND ITS INFLUENCE ON OUR WORLD 41 (1950).

65. *See id.* at 41.

66. *See* BRIAN, *supra* note 11, at 61.

67. *See* FOLSING, *supra* note 9, at 559–61.

68. *See id.* at 196. In 1929, when Einstein was asked, “Do you believe in God,” he replied: “I believe in Spinoza’s God who reveals Himself in the orderly harmony of what exists, not in a God who concerns Himself with fates and actions of human beings.” *Einstein Believes in “Spinoza’s God”*, N.Y. TIMES, Apr. 25, 1929, at 60.

69. *See* FOLSING, *supra* note 9, at 102.

70. *E.g., id.* at 103–05.

71. *See* Freeman Dyson, *Clockwork Science*, N.Y. REV. BOOKS, Nov. 6, 2003, at 42; M. Norton Wise, *Seeking Simultaneity*, 302 SCIENCE 2072 (2003).

progress, although both Kuhn and Galison recognize that neither tools nor ideas can be overlooked in the history of science.⁷²

Galison's book treats a variety of important topics.⁷³ I will focus on just one: his demonstration that the specific technological problems Einstein worked on in the patent office played a role in shaping the reasoning in Einstein's momentous 1905 paper on special relativity.⁷⁴ In the words of one reviewer, this is "an eye-opening surprise given the all-pervasive image of Einstein as an otherworldly thinker oblivious to his surroundings."⁷⁵

Galison takes us back to long-forgotten efforts to coordinate clocks. He reminds us that as late as 1880, a famous tower in Geneva had three large clock faces.⁷⁶ When the face giving Geneva time showed 10:13, the face showing Paris time read 9:58 and the face showing Bern time read 10:18.⁷⁷ Local times reflected the preferences of local governments and industries.⁷⁸ Efforts to standardize times and to create the uniform time zones we are familiar with today involved enormous political controversies, as large companies and national governments strove to maximize their influence.⁷⁹ With telegraph, railroads, and shipping spanning the globe, national and international agreements became essential.⁸⁰ As the nineteenth century ended, the demands of an industrialized economy required that many workers know the time with precision.⁸¹ At the International Congress on Chronometry held in 1900, one advocate of time coordination referred to the "late 19th century public, laden with business and always rushed, a public that has made its own the famous adage: Time is money."⁸²

The desire to coordinate time spurred inventors. After all, even when you could reach political agreement that, for example, the time in a small Swiss town should be the same as the time in Geneva, bringing this about in practice required technological advances. To coordinate clocks in Geneva with those elsewhere required sending precisely timed signals back and forth between the clocks.⁸³

Galison shows that during the time Einstein worked there, the patent office received numerous patent applications for coordinated clock systems.⁸⁴ Modern

72. See Dyson, *supra* note 71, at 43.

73. In particular, Galison weaves his account of Einstein's work together with an account of the work of the great French scientist and mathematician Henri Poincaré. *Id.* at 42-44.

74. See GALISON, *supra* note 3, at 13-47, 221-93.

75. Wise, *supra* note 71, at 73.

76. GALISON, *supra* note 3, at 222.

77. *Id.*

78. *Id.* at 92-161.

79. *Id.*

80. *Id.*; see also TODD D. RAKOFF, A TIME FOR EVERY PURPOSE: LAW AND THE BALANCE OF LIFE 10-33 (2002).

81. GALISON, *supra* note 3, at 222-27.

82. See *id.* at 224-25 (quoting Albert Favarger, a clock engineer and manufacturer).

83. *Id.* at 222-27.

84. *Id.* at 248-49, 253.

cities were eager to use this new type of technology; indeed, at the precise time Einstein was thinking through the problems with electrodynamics that led to special relativity, his daily walk to work took him past a series of electric street clocks recently coordinated with the central telegraph office.⁸⁵ In May 1905, when Einstein came up with the insights that he soon wrote down in his famous paper, he announced to a friend, “Time cannot be absolutely defined, and there is an inseparable relation between time and signal velocity,”⁸⁶ and then literally pointed to a Bern clock tower and to a clock tower in nearby Muri, before proceeding to lay out for his friend his theory of special relativity.⁸⁷

So, although the special theory of relativity concerned longstanding and fundamental problems dealing with the nature of light and electrodynamic theory, it was not by chance that Einstein’s solution focused on efforts to coordinate clocks. This real-world problem crystallized Einstein’s thinking. It was central to Einstein’s attack to think of time not as some abstract entity, but as a statement about the simultaneous occurrence of an actual event and the position of the hands on an actual clock.

Galison, of course, does not claim that special relativity was all about synchronizing clocks.⁸⁸ He recognizes that Einstein’s work combined theory and practice, science and technology, in a rich mixture.⁸⁹ But Galison rescues for us the importance of the work Einstein did in the patent office.

IV.

Galison also draws connections between the form of Einstein’s 1905 paper on special relativity and the style of the patent applications he was reading while at work. The paper, like a patent application, had virtually no footnotes and ended with assertions about experimental consequences that are reminiscent of the “claims” section of every patent application Einstein read.⁹⁰

Are there other connections between *On the Electrodynamics of Moving Bodies* and Einstein’s work as a patent examiner? I believe that certain similarities are revealed when we consider a patent examiner’s role in the legal system. From this point of view, Einstein’s style of thought is analogous not so much to that found in patent applications, but rather to that found in the opinions he wrote analyzing those applications. In short, Einstein’s approach is similar to that of a patent examiner or lower-court judge who is applying the law to the facts in a very concrete way. While we can never know precisely how much overlap Einstein himself saw between the ways he approached his day job and his revolutionary scientific work, the similarities we will see can still illuminate

85. *Id.* at 244.

86. *See id.* at 253.

87. *Id.*

88. *Id.* at 254.

89. *Id.* at 38–40.

90. *See id.* at 291–92.

our understanding of legal and scientific thought.

Before beginning down this road, a host of caveats are in order. Clearly, the differences between the work of scientists and lawyers far outweigh the similarities. Indeed, I believe that sensible comparisons of science and law begin with the differing goals of these enterprises. In the broadest terms, the scientific enterprise emphasizes *progress* while the law emphasizes *process*.⁹¹ Through the development and testing of hypotheses, scientists build up a cumulative body of knowledge about the natural world.⁹² The legal system, which deals with the world of human relations and values, emphasizes the development of processes for the peaceful resolution of disputes.⁹³ There often are no agreed-upon standards for whether a dispute was settled properly.⁹⁴ After all, the legal system is concerned not only with factual truth; it deals as well with fairness, perceptions of fairness, control of government conduct, and a host of other matters.⁹⁵ Even when factual truth is sought, the law cannot wait until scientific certainty provides an answer. In a human dispute, waiting means that one side or the other wins, so the law must often act on imperfect information.⁹⁶

These different goals are reflected in the work of practicing scientists and practicing lawyers. To give one example, to a scientist a hypothesis can come from any source, since it will stand or fall when it is tested. The German chemist August Kekule, for example, said he dreamed of the molecular structure of benzene while dozing in front of a fireplace.⁹⁷ But imagine a judge saying, "I had a dream; the Constitution forbids the death penalty." In law, the source of the hypothesis matters since it is part of a social process for resolving a difficult problem of history, values, and institutional competence, a problem that may never yield a clear conclusion.

These differences could easily be multiplied. When we consider the work of

91. See STEVEN GOLDBERG, *CULTURE CLASH: LAW AND SCIENCE IN AMERICA* 6–25 (1994). In a recent analysis, Professor Mashaw notes that the progress/process distinction animates discussions of law and science, asks whether the gap is reduced when we are concerned with engineering rather than science, and concludes that there is not much difference because the normative goals of the law make it hard to absorb the conclusions of science or engineering. Jerry L. Mashaw, *Law and Engineering: In Search of the Law-Science Problem*, 66 *LAW & CONTEMP. PROBS.* 135 (2003).

92. See GOLDBERG, *supra* note 91, at 7–9. Kuhn argued that in revolutionary shifts in science—paradigm shifts—factors other than “logic and experiment” determine the allegiance of scientists, but he stressed that progress was “the apparently universal concomitant of scientific revolutions” and that scientific communities reached “a firm consensus unattainable in other fields.” See *id.* at 9–10 (quoting THOMAS S. KUHN, *THE STRUCTURE OF SCIENTIFIC REVOLUTIONS* 93, 165, 172 (1962)).

93. See GOLDBERG, *supra* note 91, at 13–20.

94. See *id.*

95. See *id.*

96. See, e.g., *Daubert v. Merrell Dow Pharms., Inc.*, 509 U.S. 579, 597 (1993) (“Scientific conclusions are subject to perpetual revision. Law, on the other hand, must resolve disputes finally and quickly.”); see also Mashaw, *supra* note 91, at 138 (“[For scientists,] ‘we don’t know yet’ is not an admission of failure; it merely defines a research agenda. Legal institutions need to decide cases now and make policy soon.”)

97. See Bert Black, Francisco J. Ayala, & Carol Saffran-Brinks, *Science and the Law in the Wake of Daubert: A New Search for Scientific Knowledge*, 72 *TEX. L. REV.* 715, 758 (1994).

physicists like Einstein, for example, we are confronted with the central role of mathematics in modern science,⁹⁸ a role that has no obvious counterpart in the day-to-day work of lawyers and judges.⁹⁹

With all of these caveats firmly in mind, I believe we can look at Einstein's 1905 paper and compare it fruitfully with a portion of the legal process if we keep our focus narrow and precise. Albert Einstein was a patent examiner. The job he had is quite similar to the job patent examiners have in the United States today. If we look at that job and where it fits in the legal system, Einstein's paper shows some similarities to the opinions he wrote disposing of those applications.

Einstein, like most patent examiners today, was not an attorney.¹⁰⁰ But, also like examiners today, he had the job of applying a set of legal standards to the application in front of him and deciding whether that application met those standards.¹⁰¹ Moreover, like examiners today, Einstein wrote opinions that were ultimately reviewable in court.¹⁰²

Only portions of two of Einstein's decisions survive, because all papers in the office where he worked were automatically destroyed after eighteen years.¹⁰³ We know about these two because they are mentioned in reports of litigation.¹⁰⁴ In one case, Einstein rejected a patent claim as "incorrectly, imprecisely, and unclearly prepared,"¹⁰⁵ while in the other he ruled that a patent for a gyroscope, issued in 1885, did not preclude a later invention since the earlier machine could not work accurately in a craft at sea, the condition under which the later device functioned.¹⁰⁶

98. See SUSAN HAACK, *DEFENDING SCIENCE—WITHIN REASON: BETWEEN SCIENTISM AND CYNICISM* 105 (2003).

99. See OLIVER WENDELL HOLMES, *THE COMMON LAW* 1 (1881) ("The life of the law has not been logic: it has been experience. The felt necessities of the time, the prevalent moral and political theories, intuitions of public policy, avowed or unconscious, even the prejudices which judges share with their fellow-men, have had a good deal more to do than the syllogism in determining the rules by which men should be governed.").

While at any moment in history, mathematicians agree on axioms far more than lawyers agree on any set of assumptions, when one looks at the history of mathematics, one begins to see the kind of disputes over basics that mark much legal discourse. Steven Goldberg, *On Legal and Mathematical Reasoning*, 22 *JURIMETRICS J.* 83 (1981).

100. See Nancy J. Linck et al., *A New Patent Examination System for the New Millennium*, 35 *HOUS. L. REV.* 305, 308 (1998) ("Less than five percent of Patent and Trademark Office examiners have a law degree.").

101. See *id.* at 307 (stating that patent applications today are examined for "novelty, usefulness, and inventiveness"). On the Swiss patent law applied by Einstein, see FOLSING, *supra* note 9, at 103; GALISON, *supra* note 3, at 291.

102. For an example of a modern case proceeding from the patent examiner to the Board of Patent Appeals and Interferences to the United States Court of Appeals for the Federal Circuit, see *In re Oetiker*, 977 F.2d 1443 (Fed. Cir. 1992). On the existence of judicial review in the Swiss system under which Einstein worked, see FOLSING, *supra* note 9, at 103.

103. GALISON, *supra* note 3, at 249–50.

104. *Id.*

105. See *id.* at 249.

106. See *id.* at 249–51.

We get a fuller sense of Einstein's work by noting that he was rigorously trained by Friedrich Haller, the highly regarded head of the Patent Office,¹⁰⁷ who urged his examiners to "remain critically vigilant" when they analyzed patent applications.¹⁰⁸ After Einstein had a few years' experience, Haller said that he had become "among the most esteemed experts at the office."¹⁰⁹

From our perspective, Einstein's patent job fits into a familiar mold. The United States Supreme Court has described the work of a patent examiner as "quasi-judicial."¹¹⁰ Like many administrative officials, the examiner does not typically shape the law in any broad way. Instead, the examiner applies legal concepts like "novelty" to the factual materials presented in a patent application.¹¹¹ Of particular importance is considering the application in light of "prior art" to see if the invention is, in fact, new.¹¹² Thus, it is important to understand precisely the scope of the claim in an application as well as the nature of the prior art, as Einstein's decisions demonstrate.

So in some respects a patent examiner is like a trial court judge deciding a legal question. Unless she wants to be reversed, the judge cannot change the law that the higher courts have pronounced. She can, however, apply that law to new situations, and can write an opinion explaining her result. That decision may well follow a rather conventional form: a statement of the issue, a description of the governing law, an analysis of how the law applies to the facts, and a conclusion.

Do we see these characteristics in Einstein's 1905 paper? Once again, we must begin with the obvious differences. The question before Einstein did not come from a patent applicant, nor from contending parties in court. Nor was Einstein subject to review by a higher court which might not share his willingness to overthrow Newtonian science. The ultimate review of his ideas would come from empirical testing and from the acceptance of his peers in the scientific community.

However, I believe we can still see important similarities in the structure of *On the Electrodynamics of Moving Bodies* and the reasoning of a quasi-judicial official like a patent examiner. Einstein begins by stating the issue. He tersely explains an anomaly in Maxwell's equations. While no patent applicant brought this problem before him, it was presented not by Einstein's imagination alone, but by outstanding and lively questions in the physics of his day.

Einstein then defines the concepts of motion and time with precision and

107. *Id.* at 243–46.

108. *See id.* at 243.

109. *See id.* at 246.

110. *United States v. Amer. Bell Tel. Co.*, 128 U.S. 315, 363 (1888); *Butterworth v. United States ex rel. Hoe*, 112 U.S. 50, 67 (1884). Lower courts have followed this terminology. *See, e.g.*, *W. Elec. v. Piezo Tech.*, 860 F.2d 428, 431 (Cl. Ct. 1988).

111. *See U.S. PATENT & TRADEMARK OFFICE, MANUAL OF PATENT EXAMINING PROCEDURE* § 2116.01 (8th ed., rev. 2004).

112. *Id.* § 2121.

clarity before setting forth postulates about the impossibility of distinguishing rest and uniform motion, and about the speed of light. Einstein, of course, had a good deal of freedom in deciding which definitions and postulates were relevant to the problem before him. But his postulates did bind him since they came from his view of empirical reality. Like a lower-court judge facing a precedent, or a patent examiner confronting prior art, Einstein was working within constraints. He then applied his definitions and postulates to the problem through an analysis of clocks and measuring rods that led to the conclusion that absolute time and space are illusory.

In formal terms, some judicial and quasi-judicial opinions do not look so different from this. A trial judge cannot choose her issue without reference to the parties, but her ability to frame the problem is far from mechanical and is always quite important. A good judge or examiner states her definitions and her relevant postulates—precedents, statutes, and prior art—with precision and care. In some cases she will, like Einstein, have considerable freedom in deciding which definitions and postulates are relevant. Finally, a judge or examiner applies the definitions and postulates to the problem in a practical way. She might make her point by using hypothetical factual situations and showing how they come out given her assumptions. These hypotheticals are likely to be based on real-world concerns, just as the hypothetical measuring rod and clocks used by Einstein in his analysis came from the practical synchronization concerns of his day.

It is in reaching conclusions, however, where the distinction between Einstein and a judicial official is most dramatic. Einstein had the courage and the freedom to go where his brilliant reasoning led him, regardless how radical the result. Even for a scientist, it was not easy to stay with the assumptions that you cannot detect the difference between rest and uniform motion and that the speed of light does not vary when those assumptions lead to the collapse of the Newtonian world view. As the physicist Banesh Hoffmann wrote, “a lesser man finding this calamitous consequence of two seemingly innocent postulates would immediately have abandoned one or the other.”¹¹³

For the judge or the patent examiner, if certain assumptions lead to a radical conclusion, there is a tremendous temptation to choose different postulates or to read them in a different way. A judicial postulate is not as fixed as the speed of light. Precedents, statutes, and prior art are subject to interpretation, and there is a wide variety of them to choose from. Recall the social role that law plays. The judge or patent examiner is part of a system for peacefully resolving disputes in a socially acceptable way. The law does not have the primary goal of arriving at ultimate truth. To put it another way, while novelty may be the road to fame for a scientist, it is often the road to reversal for a lower-court judge or patent

113. HOFFMANN, *supra* note 5, at 73–74. Hoffmann argues that Poincaré failed to discover the special theory of relativity because “his nerve failed him and he clung to old habits of thought and familiar ideas of space and time.” *Id.* at 78.

examiner.

But while there are enormous differences between the 1905 paper and the work product of a patent examiner, there are similarities as well. The focus on a real-world issue and the application of clearly stated definitions and assumptions leading to a practical resolution of that issue are common to both.

If I had to choose one word to describe what the two activities have in common, I would say that both are *grounded*. Judges and patent examiners are accustomed to getting down to cases, and Einstein had that frame of mind as well. Whatever his image later in life, the Einstein of the patent office was not doing metaphysics or philosophy or theology. His patent office experience was one of interweaving fact and precedent in a way very familiar to attorneys.

While it is tempting to think of Einstein's work as more analogous to a great Supreme Court opinion than to a humble application of the law to the facts, in reality the latter is the closer comparison. The Supreme Court's unreviewable ability to interpret the Constitution sets it apart from lower federal courts.¹¹⁴ The Court interprets broad constitutional phrases hundreds of years after they are written¹¹⁵ and can even overrule its own precedents.¹¹⁶ It faces no boundaries like the higher-court opinions that constrain lower courts, or the physical realities that constrain scientists. It is the social role of the Court as the arbiter of the Constitution's meaning that frees it from review, not the Court's unerring ability to find the truth. As Justice Jackson put it, "We are not final because we are infallible, but we are infallible only because we are final."¹¹⁷

About a decade after leaving the patent office, Einstein received a letter from a friend, Heinrich Zangger.¹¹⁸ Zangger, a professor of forensic medicine, wanted Einstein's opinion of a text he was writing on medicine and law.¹¹⁹ Einstein replied:

I read your correction proofs and enjoyed very much the parts that deal with concrete cases. But I did not like some of the abstract parts; they often seem to me to be unnecessarily opaque (general) and in the process are not worded clearly and pointedly enough (not every word is placed clearly and consciously). Nevertheless, I understand everything; it may well be possible that

114. See, e.g., Ashutosh Bhagwat, *Separate but Equal? The Supreme Court, the Lower Federal Courts, and the Nature of the "Judicial Power"*, 80 B.U. L. REV. 967, 968 (2000).

115. The Court, for example, has interpreted the "liberty" protected by the Due Process clause to include the right of parents to educate their children in private schools, *Pierce v. Soc'y of Sisters*, 268 U.S. 510 (1925), and the right of gays to engage in intimate sexual activity, *Lawrence v. Texas*, 539 U.S. 558 (2003).

116. See, e.g., *Brown v. Bd. of Educ.*, 347 U.S. 483 (1954) (overruling *Plessy v. Ferguson*, 163 U.S. 537 (1896)).

117. *Brown v. Allen*, 344 U.S. 443, 540 (1953) (Jackson, J., concurring in the result).

118. See GALISON, *supra* note 3, at 251.

119. See *id.*

my perpetual ride on my own hobbyhorse and the conventions at the Patent Office have driven my standards to exaggerated heights in this regard.¹²⁰

In his enjoyment of “concrete cases” and his emphasis on placing every word “clearly and consciously,” this veteran of the “conventions of the Patent Office” would not have been out of place in the company of lawyers.

120. Letter from Albert Einstein to Heinrich Zangger (July 29, 1917), *in* 8 THE COLLECTED PAPERS OF ALBERT EINSTEIN 361 (Ann M. Hentschel trans. & Klaus Hentschel consultant, 1998).

