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Federal Agencies and the Technologies of Observation, Detection, and Regulation

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Before turning to the substance of my remarks, I will take the liberty – as very likely the most senior person here, at least by years -- to say a few words about Roe. I don't remember when we first met – it must have been at least forty some years ago – but I do recall having been much taken with him right from the beginning. As a scholar, he has been imaginative and stimulating, drawing innovative connections between the history of technology and American history, and with the history of science. He has been a pioneering administrator, building the STS Program here at MIT into one of the world's leaders. No mean feat either internally, given its interdisciplinary character, or externally, given its location in an institution of science and technology. And then there has been Roe the human being, generous, empathetic, judicious, and a stalwart friend. All these qualities were abundantly evident when we coauthored a textbook history of the United States, *Inventing America*, together with the late Pauline Maier and Alex Keyssar. I treasure his friendship and am honored to be part of this symposium, which in keeping with Roe's outlook and by his own design, is not about his past achievements but about the future of his field.

I take my inspiration in this talk from Roe's *Military Enterprise and Technological Change,* a groundbreaking collection of essays that has been highly influential since its publication in 1985, generating important inquiries into the military's role as a stimulator of technological development with spinoffs into the civilian economy.[1] Looking to the future in the history of technology, I want to call attention to what we might think of as "Administrative Enterprise and Technological Innovation." The fact of the matter is that as part of the functions of the administrative state, federal civilian agencies have prompted the development of and depended on technologies and technological systems essential to the government's ever-expanding functions in detection, oversight, and regulation.

Federal regulation of technologies began formally in 1838, when, Congress authorized oversight of steam boilers and steam-driven engines on ships, and then in 1852 passed a regulatory bill with far more teeth.[2] Such regulation took off and expanded in scope during the Civil War in connection with currency and taxes. Secretary of the Treasury Salmon P. Chase and his successor in the office, Hugh McCulloch, faced two high-stakes issues that interleaved technical matters with cheating and criminality. The first arose from the Union government's decision in 1862 to print paper money (the so-called "greenbacks, after the color of the currency). The second derived from the decision to impose excise taxes on distilled spirits among numerous other domestically produced goods.

Secretary of the Treasury
Hugh McCulloch

To deal briefly with the first, by 1866, the paper money supply had expanded to $400 million in greenbacks and $293 million in National Bank Notes, and counterfeiting had grown in tandem with the expansion. In 1865, when McCulloch became secretary, Congress established the Secret Service, with a budget close to $75,000 ($1,473, 000 in 2024), to deal with the detection of

[1] Merritt Roe Smith, *Military Enterprise and Technological Change: Perspectives on the American Experience* (Cambridge: MIT Press, 1985).

[2] John G. Burke, "Bursting Boilers and the Federal Power," *Technology and Culture*, 7 (No. 1; Winter, 1966), 1-23.

phony currency and apprehend its perpetrators. Its work, which was assisted by the National Academy of Science, was held in strict secrecy – the Academy's effort was likely, in character, the first security-classified science advisory committee in the nation's history. Within a few years, the Secret Service came to include a technical branch, its purpose to develop technical methods for producing federal currency invulnerable to counterfeiting and for detecting counterfeit currency.[3] The technical story – one of printers, inks, and paper – is a vital, ongoing tale of technical warfare, between the Treasury and ever resourceful counterfeiters that awaits its historians.

The tax story concerns excise taxes on whiskey, or what were then commonly termed spirits. Information about it is readily available, which in contrast to the currency story, allows for a substantial account.

[3] Joseph Henry to Alexander Dallas Bache, Aug. 13, 1863, *The Papers of Joseph Henry, Jan. 1858-December 1865: The Smithsonian Years*, eds., Marc Rothenberg et al (Vol. 10; Washington, D.C.: The Smithsonian Institution Press, 2004) (hereafter *Henry Papers,* Vol. 10), pp. 323-24; National Academy of Sciences, "Rough Minutes [of meeting]," Jan. 7, 1864, "New York and Washington Meetings, 1863-1864," scrapbook , Archives, National Academy of Sciences (hereafter ANAS); Rexmond C. Cochrane, *The National Academy of Sciences: The First Hundred Years, 1863-1963* (The National Academy of Sciences, 1978), p. 331, n. 134; "Currency Committee" file, National Academy of Sciences.

Greenbacks of the Civil War Era

In February 1866, Secretary McCulloch asked the National Academy of Sciences for a report: He wanted "the best method" of determining the alcoholic strength of spirits for the aim of establishing whatever rules and regulations might be necessary to ensure uniform taxation of such beverages. The United States had been collecting import duties on spirits since the founding of the Republic, but the enormous cost of the Civil War forced the Union Government to impose excise taxes on numerous domestically produced goods, including distilled spirits. The tax per gallon of spirits was fixed at twenty cents through March 7, 1864; by January 1, 1865 it had soared to $2.[4]

[4] *Report of the Secretary of the Treasury on the State of the Finances for the Year 1865*, p. 79.

The tax was levied on quantity of alcohol, but spirits comprise a mixture of alcohol and water. Given that production was now to be taxed at the high rate of $2. a gallon, the Treasury Department was eager to ensure that it would have an accurate measure of the quantity and of the alcoholic strength of the spirits produced in each domestic distillery. But the high tax led distillers to cheat, to perpetrate "immense frauds" against the government, as the Commissioner of Revenue averred in his report for 1865. High among the practices of evasion was the distillers' removal of thousands of gallons from the scrutiny of the revenue agents.[5]

McCulloch turned again to the National Academy of Sciences, which was then headed by Joseph Henry, a world-class physicist, head of the Smithsonian, and an unquestionably upright man whom McCulloch knew and greatly admired. In 1866, his confidence in Henry and the

Joseph Henry

Academy likely buoyed by the work on the currency problem, McCulloch formally asked the Academy to come up with both a closely accurate means of measuring the quantity of alcohol in spirits and to devise a foolproof method of preventing domestic distillers from secreting spirits away from the government's tax inspectors. To levy import duties, the customs houses had long relied on hydrometers, which measured alcoholic content by percentage of volume, the standard that had been given statutory recognition in 1850. Henry's Academy committee quickly

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[5]*Report of the Secretary of the Treasury on the State of the Finances for the Year 1866,* pp. 55-56.

concluded that they were inadequate for measuring the continuous, often high-volume production by domestic stills of what the law called "first-proof" spirits.[6]

The language of "proof" in relation to alcoholic beverages dates back to the practice of the British navy. It determined the alcoholic strength of the rations of rum for its seamen by soaking a pellet of gunpowder in the spirit. If it then ignited on application of a spark, it was said to have passed the "proof test." The portion of alcohol in the spirits adequate to pass the test turned out upon eventual analysis to be close to 50 percent. By the end of the eighteenth century most of the nations of Europe had come to define "proof spirit" as containing 50 percent alcohol by volume– and to indicate the strength of the liquor at so many degrees above or below proof spirit, or proof.[7]

Henry's committee found that people in the liquor trade strongly preferred the proof system. They had been using it since the eighteenth century in contracts, branding, and other arrangements and they had continued to rely on it even after the adoption of the alcohol-by-volume system in 1850. Henry's group thus concluded to revive the proof system but in ways that facilitated its use. In April 1866, Henry presented to the Treasury a definition of proof spirit and a framework that rested on it that was free of any particular measuring instrument. It thus proposed that the tax law be modified to declare:

> That proof spirit shall be held and taken to be that alcoholic liquor which contains one-half its volume of alcohol of a specific gravity of .7939 at 60^0 Fahrenheit and the duties on all spirits shall be levied according to their equivalent in proof spirit.

The proposed law also authorized the Secretary of the Treasury to obtain and require the use of whatever instruments might be necessary to ascertain the strength and quality of spirits subject to tax.[8]

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[6] National Academy of Sciences, "Report of the committee on methods of inspecting and assessing tax on distilled spirits, 1866," *Report of the Proceedings of the National Academy of Sciences for 1866,* 40th Cong., Senate, 1st Sess., Misc. Doc. No. 44, Appendix III, pp. 18-20.

[7] William B. Jensen, "The Origin of Alcohol Proof," *Journal of Chemical Education,* 81(2004), 1258; *Reports from the Secretary of the Treasury of Scientific Investigations in Relation to Sugar and Hydrometers made under the Superintendence of Professor A. D. Bache by Professor R.S. McCulloch,* 30th Cong., Sess., Senate Ex. Doc. No. 50 (Washington, D.C.: 1848), "On the different proofs of spirits," pp. 101-105.

[8] "Report of the committee on methods of inspecting and assessing tax on distilled spirits, 1866" pp. 18-21; Henry, "Desk Diary," April 20, 1866, *The Papers of Joseph Henry,* eds., Marc Rothenberg et al (Vol. 11; January 1866 –May 1878: The Smithsonian Years;

Henry's committee now sought a meter that would measure the alcoholic strength of spirits both with high accuracy and ease of use. In the interest of the latter, they fixed proof spirit at 100 percent, with no alcohol at zero percent of proof, and all alcohol at 200 percent of it.[9]

To obtain a sufficiently accurate meter with this scale, Henry's committee evaluated hydrometers offered by entrepreneurial inventors. In July 1866, they recommended a hydrometer devised and produced by a man named William Tagliabue, who had a shop on Pearl Street in New York City. In February 1867, the Treasury Department adopted Tagliabue's meter, which displayed a percentage-of-proof-spirit scale, as the instrument of choice for measuring alcoholic strength.[10]

William Tagliabue's Boxed Spirits Meter Set
Comprising the Hygrometers Above and the
Linear Gauge of Proof Spirit Below

Washington, D.C.: Smithsonian Institution in Association with Science History Publications, 2007) (hereafter *Henry Papers,* Vol. 11*),* p. 49.

[9] "Report of the committee on methods of inspecting and assessing tax on distilled spirits,1866," pp. 21-22.

[10] *Ibid.,* pp. 55-56; *U.S. Statutes at Large*, 39th Cong., 1st Sess., 1866, 14. Ch. 184, 157;True, *National Academy of Sciences*, pp. 239-242.

Tagliabue's Working Gauge of Proof Spirit, from 70 Proof (35% alcohol) to 200 Proof (100% alcohol)

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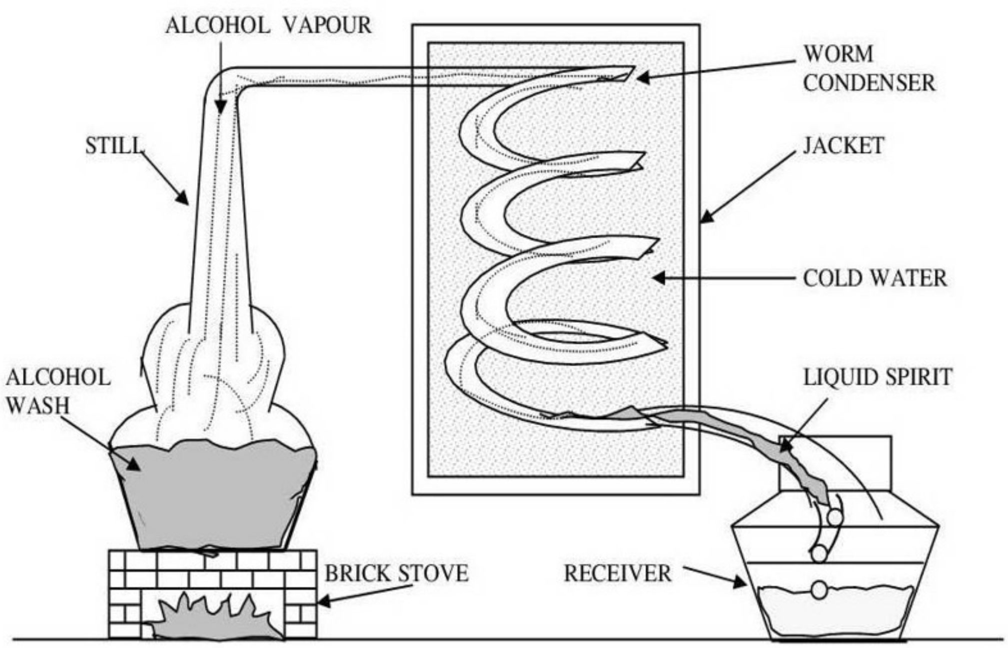
But the problems of fraud and cheating remained to be addressed. The Treasury Department believed that the most prevalent site of fraud was the machinery of distillation – the still. Whiskey is produced by boiling off the products of fermented mash, then arranging for the gaseous mixture of alcohol and water vapor to condense into liquid as it descends through a spiral pipe, and finally allowing the liquid to drip from the open end of the spiral into a cistern, from whence it is piped into barrels. The spiral is called the worm and the end of it, the tip of the worm. The size of the barrel would give the revenue agents the quantity of the spirits produced, and their alcoholic content would be measured using a hydrometer designed to work in the range of the specific gravity of an alcohol/water mixture. But not all the production of the still made its way into the barrels. Some of it could be diverted from the tip of the worm, then stored in a cache of barrels hidden from the hydrometers of the revenue agents.

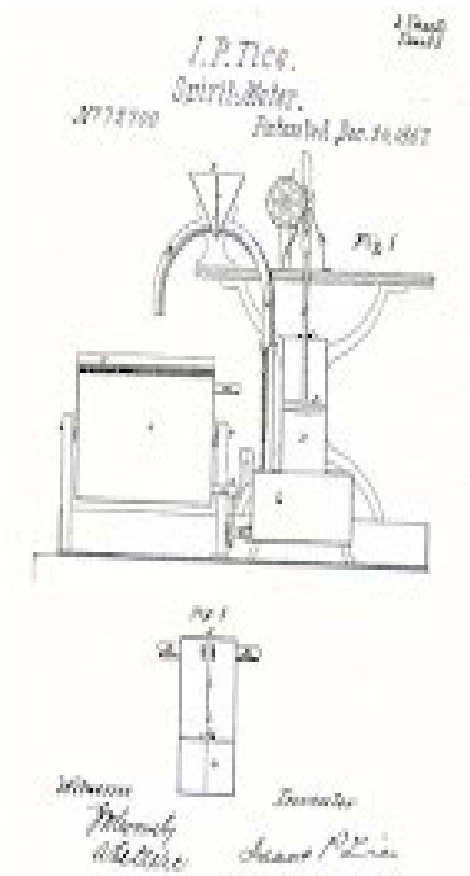


Schematic of a Spirits Still

The Product from the Tip of the Worm (at the lower right)

Could Easily be Diverted from the Receiver

Away from the Tax Inspector's Scrutiny



Isaac Tice's Spirit Meter, for which He Was Granted a Patent in 1867
The Drawing Is from His Patent Application.
His Meter Worked by Dividing the Flow of Distilled Spirits, which
Entered at the Top, into Two Equal Streams. The Two were then Directed into Separate
Cans on the Left. One Weighed the Portion, the Other Measured Its Volume, thus Enabling the
Determination of the Liquid's Specific Gravity and, Hence, Its Alcoholic Content.

Henry's committee thought that one way to solve the problem would be to affix a meter under lock and key to the tip of the worm that would register the quantity of alcohol produced by the still while simultaneously assessing its alcoholic strength. In a preliminary report to McCulloch, in April 1867, Henry noted that the "registration of results by mechanical means [might possibly] be rendered more trustworthy than those by human volition, and that the element of moral responsibility [might] be, in a greater or less degree, eliminated from the office of a subordinate inspector."[11]

By late 1867 Henry's committee had identified and recommended such a meter. It was designed and produced by Isaac Tice, the head of a small manufacturing firm in New York City. It simultaneously measured the weight and volume of the flow. It thus not only detected the quantity of spirit produced but also its specific gravity. The inspectors could convert that measure into percentage of alcohol, or proof, by consulting a detailed table derived by Henry's committee from extensive experiments that adjusted the measured values for both volume and proof to a standard at 60 degrees Fahrenheit.[12]

McCulloch adopted the Tice meter and ordered its installation in the country's stills at the earliest opportunity. Tice was slow to produced reliable versions of the instrument. It required some complicated supporting apparatus to prevent tampering. Only nineteen of them had been installed by the end of 1867, all of them in New York City or its vicinity.[13]

The distillers had to bear the cost of the meters and their installation, which was high, and in early 1868 they complained to Congressional representatives about the burden. The complaints prompted a prolonged, sometimes heated debate on the floor of the House and the Senate that centered on three salient claims: Henry's committee, being composed of scientists, had inadequate knowledge of the practical operations of whiskey production. The problem was rooted in morality, the alleged crookedness of some number of distillers and of the federal inspectors at the distilleries, many of whom had been appointed by President Andrew Johnson. And whatever the integrity of the scientists, a moral problem could not be solved by technology.[14]

In the middle of it all, the Chair of Ways and Means in the House appointed a new committee comprising men of practical knowledge, he said, to consider other meters. The chair presumed that the Tice meter had been recommended by a group appointed by the Secretary of the Treasury. The new committee, also to be appointed by the Secretary, did not include any members of Henry's group and seemed likely to ignore all the work they had done. Henry, out of town when the action occurred, learned about it on his return. Outraged, he hurried to the Senate,

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[11] Report of the committee on methods of inspecting distilled spirits subject to duty, 1867," *Report of the Proceedings of the Academy during the year 1867,* 40th Cong., Senate, 2d Sess. Mis. Doc 106, Appendix II, pp. 18, 27-31.

[12] "Report of the committee on methods of inspecting distilled spirits subject to duty, 1867," pp. 18, 27-31.

[13] Ibid., pp. 43-44.

[14] *The Congressional Globe,* January 9, 1868, pp. 421-433; Jan. 21, 1868, pp. 651-652.

where he declared that the original committee had been appointed by the Academy at the request of the Secretary and that he "considered the proceedings of the House as an indignity offered to the Academy." The Senate promptly resolved that the new committee should be a commission that would deliberate jointly with Henry's original committee. In the meantime, the mandate that the nation's distilleries were to install the Tice meter was suspended, pending the report of the Commission.[15]

In March, the Commission reported in favor of the Tice meter, and in July the Commissioner of Revenue adopted it and ordered its installation once again. However, many distillers resisted its installation and competitors cast doubt on its reliability. In June 1871, the Treasury Department discontinued its use.[16]

Nevertheless, the campaign for spirit meters was by no means wasted. It provided the government, manufacturers, and scientists at the time with reliable meters for gauging the strength and quantity of alcohol – the Tice meter for a few years, the Tagliabue meter for decades into our own time. Key elements of the episode made their way into lasting law. McCulloch's Treasury Department found the Henry committee's proposals in 1866 altogether meritorious. In the tax act of July 1, 1866, Congress legislated the committee's definition of proof spirit into law, and in February 1867, sent the meters – some 500 of them as of late 1867 -- to inspectors throughout the United States and instructed them to use it in accord with a manual that Henry's committee had devised.[17]

The definition of proof spirit enacted in 1867 remains part of the federal code.[18] More important, the proof scale that Henry's committee devised and that Tagliabue incorporated into his meter remained the legal measure for alcoholic strength until the mid-1980s, when it was replaced by the standard of 1850 -- alcohol by volume, or ABV.

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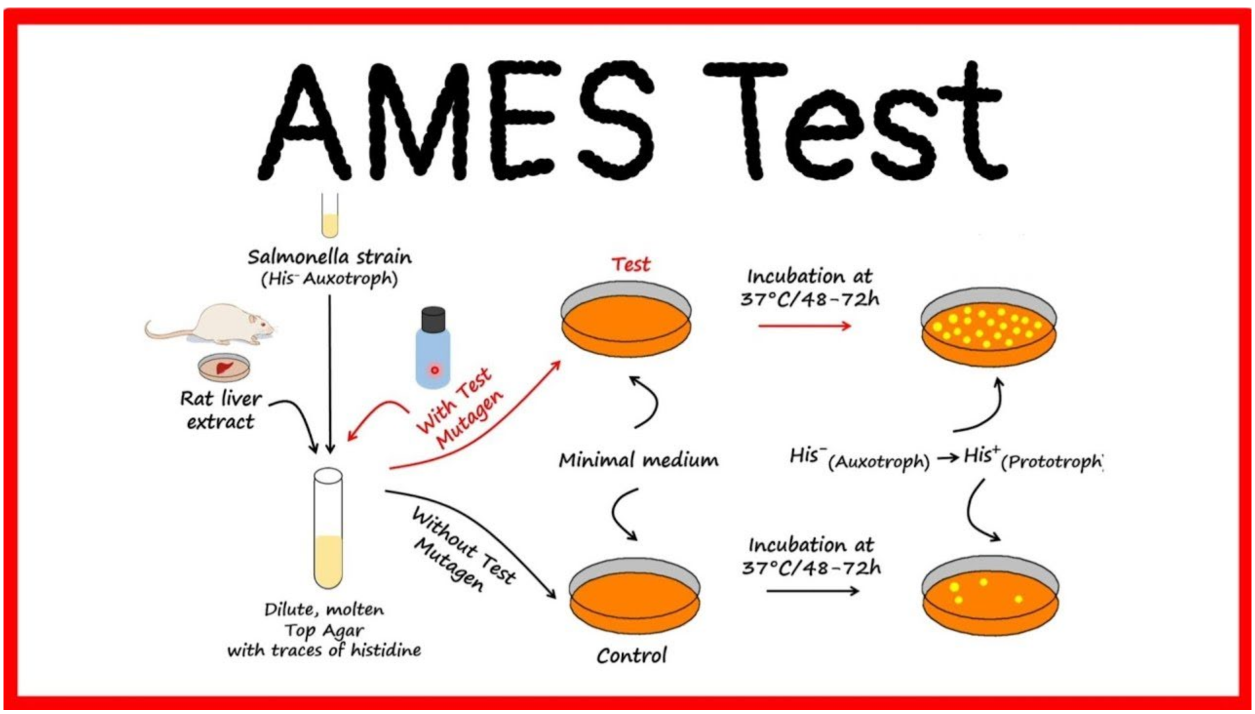
[15] Henry to Lewis M. Rutherfurd, Feb. 14, 1868, *Henry Papers*, vol. 11, pp. 173-74; Frederick W. True, *A History of the First Half-Century of the National Academy of Sciences, 1863-1913* (Baltimore: The Lord Baltimore Press, 1913), pp. 246-47.

[16] True, *National Academy of Sciences,* pp. 246-47.

[17] *U.S. Statutes at Large*, 39th Cong., 1st Sess., 1866, 14. Ch. 184, 157;True, *National Academy of Sciences*, pp. 239-242.

[18] See, for example, 26 U.S.Code § 5002, 2016.

The detection technologies for taxation were soon joined by technologies of oversight and regulation, including for food and drugs as well as environmental protection. At the time of the passage of the Food and Drug Act, in 1906, scrutiny hinged on whether the products were true to their labels or were adulterated, especially with toxic substances. The regulatory task required little more than analytic chemistry. By the 1960s, however, the scope of scrutiny had expanded to include whether the products themselves might cause disease, including, notably, cancer. The testing technologies long relied on the use of animal models, a time-consuming and expensive process, but then, in the 1970s, Bruce Ames, a biochemist at Berkeley, developed what came to be called the Ames test, which used bacteria and was a far quicker and cheaper technology for testing for carcinogens. It was quickly adopted by the FDA.[19]



During the last thirty years, regulatory agencies, notably the Environmental Protection Agency (EPA), have developed computational models that anticipate adverse effects by

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[19] Angela Creager, “The Political Life of Mutagens: A History of the Ames Test,” in *Powerless Science? Science and Politics in a Toxic World*, eds.Soraya Boudia and Nathalie Jas (New York: Berghahn Books), 46–64.

calculating the probability of their occurrence in the future. These tools have come to be increasingly used along with experimental evidence in the process of risk assessment. For example, what is termed "structure-activity relationships," or SAR, have enabled EPA to assess the toxic risk of a chemical by characterizing its molecular structure and, in the absence of experimental data, determining its biological activity in the body. SAR is, in short, a technology for identifying the risks of new industrial chemicals that has been widely adopted across the world, especially in Europe.[20]

Nowadays, a mind-boggling variety of technologies – from chemical to electronic to computer surveillance and analysis, and very likely AI -- have come to figure essentially in detecting hazardous corporate practices, criminal behavior, and the activities of terrorists. They are indispensable in tracking climate change; measuring pollutions of air, earth, and water; and maintaining oversight of financial activities that range from corporate investment and banking to the tax filings of families and individuals. We tend to take the technologies for granted, as seemingly natural parts of the infrastructure of American life, but they all have their histories. Some, from satellites to seismometers, have received the attention of historians.[21] But many more, especially in the domestic arena, await historical attention. Joined with those already in the literature, they form a branch of the history of technology that we and our students can recognize and pursue as indispensable elements in essential branches of the modern state such as economic regulation, environmental protection, and the maintenance of public health and safety.

[20] Henri Boullier et al, "Inventing Prediction for Regulation**:** The Development of (Quantitative) Structure-Activity Relationships for the Assessment of Chemicals at the US Environmental Protection Agency," *Science and Technology Studies,* 32 (No. 4; 2019), 137-157.

[21] See, for example, Deborah Coen, *The Earthquake Observers: Disaster Science from Lisbon to Richter* (Chicago: University of Chicago Press, 2012) and Rachel Rothschild, "Environmental Awareness in the Atomic Age: Radioecologists and Nuclear Technology," *Historical Studies in the Natural Sciences*, 43, no. 4 (2013).