ABSTRACT

Title of Document: THE PRACTICAL ENGINEERS' REBELLION: EVANS PATENT SAFETY GUARD AND THE FAILURE OF SCIENTIFIC TECHNOLOGY IN THE STEAM BOAT INSPECTION SERVICE, 1830-1862

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The U.S. Congress's initiative to solve the problem of steamboat boiler explosions in the mid-nineteenth century resulted in the Steamboat Act of 1852. The Act brought radical changes to the western rivers, including reform of the engineering cadre, introduction of new safety devices and procedures, and the creation of a new bureaucracy (the Steam Boat Inspection Service). One of the new safety devices introduced by the Treasury Department was the controversial Evans Patent Safety Guard. This is the story of the safety guard as a central actor in framing the expertise of scientists, inventors, and practical engineers in attempting to make technology safe. The case study of the safety guard helps us to understand where expertise came from, how that expertise was defined and justified by government officials and inspectors, and why the notion of technological expertise depends on a complex mix of technical, institutional, and socioeconomic factors.

THE PRACTICAL ENGINEERS' REBELLION: EVANS PATENT SAFETY GUARD AND THE FAILURE OF SCIENTIFIC TECHNOLOGY IN THE STEAM BOAT INSPECTION SERVICE, 1830-1862.

By

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Preface

This is the story of the Evans Patent Safety Guard. The safety guard was a self-acting mechanism perfected by inventor Cadwallader Evans (son of Oliver Evans) in 1850 that warned the steamboat engineer of an unsafe condition in his boiler. Although the safety guard was an obscure invention, and one that apparently did not work well, nevertheless in the mid-1850s it became the technological centerpiece of the Treasury Department's steamboat safety initiative. The public never knew of the safety guard; it was acknowledged only by the inventor, government officials, their scientific experts, and certain segments of the steamboating community. Yet, this obscure invention was installed by the Treasury Department on hundreds of American steamboats by 1855 and dominated the relations between all of the technological actors in our story. Why was this so? Answering this question is the prime focus of this thesis. We will show how government regulation and policy regarding steamboat safety revolved around the safety guard, how the practical engineers aboard steamboats saw the safety guard as robbing them of their professional autonomy and control over their machinery (they labeled the guards "intolerable nuisances," "humbug," and threats to innovation), how Government officials believed that the self-acting control of the safety guard was necessary as an insurance policy against incompetence and neglect of the engineers, and how an engineers' rebellion occurred that brought the safety guard's career to an end by the early 1860s.

For historians of technology, the occurrence of the practical engineers' rebellion is fortunate. The conflict generated much archival documentation, mostly correspondence, that shows us how the Department worked with its inspectors, the steamboating community, and scientists in the attempt to execute its technological safety program. Many of these records, kept in the National Archives and Records Administration (NARA) in Washington, D.C., have not seen light in 158 years, and thus provide new material. A sizable portion of the correspondence focuses on the central component of the safety guard, fusible alloy metal, which was designed to perform as an "active thermometer" to monitor heat in the boiler. Therefore, much of our story explains how government and academic chemists tried to develop an accurate alloy, and how the inventor used scientific rhetoric to transform the status of his machine for employing the alloy, the safety guard, from that of a mere clever mechanism to that of a scientific instrument.

In these attempts to develop and showcase the safety guard as a progressive and sophisticated scientific instrument, a rich story unfolds of the relationship of science and invention to engineering, and all of these to government legal administration of technology in Antebellum America. As such, this story informs us of a different side of the so-called Steamboat Inspection Service than we are used to seeing in existing historical accounts, which have focused on the dry legislative history of the Steamboat Acts of 1838 and 1852. With a new micro-historical perspective, we will be able to see the inside workings of the Inspection Service with its human and technological actors, as well as gain a better understanding of the socioeconomic and institutional sides of expertise in the advancement of technology during this period.

Dedication

This thesis is dedicated to my father, John A. Bernhardt, Jr., an accomplished professional engineer who taught me the love of learning for its own sake.

Acknowledgements

The author gratefully acknowledges the assistance of Dr. Robert Friedel, Professor of the History of Technology at the University of Maryland, in guiding the work necessary to complete this thesis; the examination board consisting of Dr. Friedel, Dr. David Sicilia (Professor, History of Technology) and Dr. Whitman Ridgway (Professor, American History) for their reading and commenting on the manuscript; Mr. Charles W. Johnson and the staff of the National Archives and Records Administration in Washington, D.C., for their assistance in locating and providing records of the Steam Boat Inspection Service; Mr. Theodore R. Hazen, who took the time to explain the workings of Oliver Evans's revolutionary flour mills; Mr. Raymond Reese for his suggestions in the outlining phase; Mr. Robert Rasmussen for contributing technical understanding; and Mr. Edward Jones, who provided valuable assistance in editing the manuscript. Finally, the author deeply appreciates the love, support, and forbearance of his wife, Peggy Lynn Bernhardt, during the long course of research and writing.

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CHAPTER 1. INTRODUCTION

In December 1850, Captain Thomas J. Haldeman, commander of the Steamer *Yorktown,* recorded his firsthand impressions of the explosion of a steamboat docked near his own at a New Orleans wharf. He had just given the order to his engineer to start from the wharf when he heard two loud reports, the second an "awful crashing sound" as the 200-foot side-wheel steamboat *Knoxville* disintegrated before his eyes. Haldeman suffered a severe blast as the shock wave passed him. Bricks and debris rained down on several adjoining boats. He immediately went out on the wharf to the exploded boat and could see in the moonlight that she was a total wreck - - "a broadside from a seventy-four… could not have more completely torn her to pieces." He saw that two of the four boilers on the *Knoxville* had exploded, collapsing the flues of the remaining outside boilers and hurling them in opposite directions. One had landed in the ladies' cabin of the steamer *Griffin Yeatman* after passing through the cabin of the *Martha Washington*; the other landed on a nearby levee. The explosion launched the *Knoxville*'s iron safe skyward, whereupon it followed a ballistic arc over two boats and hit the steamboat *Buckeye*, tearing through its lower guard. Two boats at the wharf on each side of the now-obliterated *Knoxville* were "shattered," especially the *Martha Washington,* which in addition to suffering debilitating structural damage lost boiler pressure due to broken steam lines and was rendered unable to navigate during the subsequent fire. Haldeman's own boat, protected as it was by the *Martha Washington*, only suffered a few bricks falling through the hurricane deck and the mess of entangling debris descending on it from above. Haldeman quickly gave the order to get underway to avoid the conflagration and steamed downstream to recover at a safe distance.

Haldeman stated that this was the first time in his life that he had seen and felt the effects of an explosion. He wished it to be his last: "Never can I erase from my memory the awful shrieks and cries for help among those poor souls who were scalded and struggling in the river for their lives but sunk to rise no more." In Haldeman's eyes, with proper training there was no excuse for explosions, and the refusal of the *Knoxville*'s engineer to read texts on technical advancements designed to prevent such explosions was particularly galling. Haldeman wrote, "On the day of the explosion, [the engineer] was solicited on board the boat to purchase a pamphlet on the subject of explosions, written by Cadwallader Evans of Pittsburgh (the inventor of the [Evans Patent] safety-guard) but he declined and told the boy that he understood his business, and had no use for such books..... Unfortunately, we have too many engineers who think they can gain no knowledge of their business by reading books, and do not devote that time and attention to the subject of explosions, which is so necessary in order to understand the dangerous properties of steam under all circumstances." Haldeman advised that the federal government pass a law requiring owners to carry Evans' safety guard on steamboats, "or else these horrible, worse than gunpowder, explosions will never, *never* cease to occur." "So sure and so confident am I of the Safety of Evan's Safety Guard," he said, "that I would be perfectly willing to stand over a set of boilers and defy the artifice of man or the ingenuity of the world to blow them up."[1]

1.1 What This Thesis Is About

The Evans Safety Guard described by Haldeman was the direct product of a government-funded scientific laboratory. Haldeman's emphasis on this device shows how, as Edwin Layton has described, science was succeeding in guiding the mechanical arts in the United States in the first part of the nineteenth century. However, when we consider the story of the safety guard, we see that the authority and reputation of science had its limits, and in fact became weaker in influence once regulation began in 1852.[2]

Evans's device was introduced in the mid-1840s to prevent boiler explosions aboard steamboats. The device enjoyed some popularity in scientific and technical circles when first introduced, but within a few years it was plunged into ignominy and obscurity. In fact, it can be argued that, despite the highest levels of government support, the safety guard was doomed from the start. Why? What was it about this technology that evoked so much passion both on the part of the scientists, inventor, and government officials who supported it on the one hand, and the steamboat owners, practical engineers, and inspectors who opposed it on the other? As the prime focus of "insider" technologists of steam boiler safety in its day, the safety guard

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[1] 1852 4-24. (See the appendixes at the end of this thesis for details on all "date" references.)

[2] Layton, Edwin: "*Mirror Image Twins: The Communities of Science in 19th-Century America,*" in Technology & Culture, Volume 12, No. 4, University of Chicago Press, October 1971.

proved pivotal—in a most unexpected and negative way—in defining the expertise of steamboat safety. What were the features of this technology, and what were the factors at work that placed it in a central position of controversy?

The answers to these questions go to the heart of the subject of technological expertise, for through this case study we shall see that technological expertise, like technology itself, is shaped in large part by many non-technical factors. It may seem strange to think of expertise as an entity that filters a piece of technology through non-technical lenses such as cultural norms, institutional power, socioeconomic and geographic influences, and even personal ambition, but indeed if any central point emerges from this study, it is the notion that technological expertise is not a purely rational, disembodied, scientific or engineering entity that points like a divining rod toward the improvement of a technology. There is no doubt that scientific and engineering principles play a key part in the process of institutionalizing the necessary expertise, but these principles are not the sole players in the game, and in many cases they can easily be subverted or augmented in favor of more subjective human impulses. And perhaps in some cases this is justified. But the key question then becomes, Who has the right to decide what constitutes expertise? The scientist? The engineer? The government bureaucrat? The user? The public? The legal system? The labor unions? Should all of these decide (or some?) in similar (or different) proportion? Or, is this approach all wrong? Should the vetting of expertise be through some kind of pyramid in which those having the most power, authority, and economic means for research have the greatest freedom of action in deciding expertise? These are intriguing questions, and they have incomplete answers, but the characters in the story of the safety guard had to struggle with them, and their struggle points the way for us to view the human complexities of deciding upon what constitutes the "expert" point of view.

Regardless of the method used to validate expertise, the outcome is often chaotic and leads to surprising results: a skilled inspector is removed because of his political affiliation, a clever mechanism is rejected because it threatens to put members of a group out of work, a government official believes that a mechanism operates perfectly even though historical experience indicates otherwise, the engineer condemns the technology as useless because it interferes with his job, and so on. Just how does the consensus about technological expertise evolve, and what is the process of deciding which form a technology should take, or whether a given technology is even needed at all? We shall explore these questions.

At the institutional level, we will be able to observe in our study that institutions tend to husband their own notions of expertise, and that often they do not even provide enough information to outside groups to allow a proper debate on the subject. As historian Tracy McDonald described Heizen's notion of *vedomstvennost*, "an institution has cultures, political interests and constituencies that shape its actions, often in unexpected ways."[3] This is certainly true in the case of the Treasury Department in its attempts to impose its own brand of expert knowledge on its inspectors and the steamboat engineers. We shall explore how the theoretical scientific knowledge originating within scientific institutions such as the Franklin Institute conflicted with the practical knowledge of the engineers, who had their own institutional norms that were rooted in traditional shop culture. On a more personal level, but reinforcing this point, is the fact that the safety guard's inventor, Cadwallader Evans, did not grasp the scientific implications of his device for some 20 years. To Evans, the clever mechanism was the ultimate goal. Evans's myopia characterizes the compartmentalization of expertise: the inventor was in his own world, the scientists were in theirs, and the Department bureaucrats and practical engineers in theirs. Thus, we shall be able to observe how a common body of expertise could emerge only when the different perspectives of each group came into conflict, were negotiated, and were agreed upon (over a long time period of almost 20 years). Such agreement was often tentative since as we shall observe, one man's safe practice might constitute another man's scourge.

Finally, there are time dimensions associated with expertise that complicate the mix of factors defining technological praxis and products. In the earliest period (1810s-mid 1820s), American inventors and engineers focused their energies on increasing horsepower to overcome river currents and achieve speed. As William M. Gouge, a senior Treasury official, wrote, "The general rule was to prefer speed to safety…"[4]

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[3] Heinzen, James W., "Inventing a Soviet Countryside: State, Power, and the Transformation of Rural Russia, 1917-1929," University of Pittsburgh Press, 2004; reviewed by McDonald in the *Journal of Modern History*, Vol. 78, No. 3, September 2006, p. 785.

[4] Hunter, Louis C.: *Steamboats on the Western Rivers*, Harvard University Press, Cambridge, Mass., 1949, p. 528, from Gouge's report to Congress in *House Ex. Doc.* 10, 34 Cong., I and 2 Sess., 1855, p. 424.

By the mid-1820s, with the advent of more numerous and higher pressure engines and boilers and an attendant increase in explosions, elite members of the scientific, government, and engineering communities, as well as the press, shifted the emphasis from horsepower to safety. Scientists and inventors began expanding and adapting the arsenal of steam boiler safety devices from stationary to marine applications; new types of exotic inventions came on the scene. After 1852, the nature of expertise changed once again—to one having legal and bureaucratic dimensions. Here, we see the enshrinement of the safety guard in the Steamboat Safety Act of 1852, which established a powerful bureaucracy that resulted in the forced introduction of the device on the western rivers.[5] The meaning of the engineers' prior tradition of tampering with safety equipment now changed from an innocent but risky preoccupation to one of a serious crime punishable in Federal court.

So, with these points in mind, an exploration of the early Steam Boat Inspection Service shall delineate the complexities and difficulties inherent in defining technological expertise. The Federal government took upon itself the role of gathering the components of that expertise in order to solve the serious problem of steamboat accidents, perhaps not realizing the complexities of their endeavor. How that body went about the exercise of expertise is captured in the story that follows. It is not a story of a purely rational process, or one with easy answers. Rather, it is the story of a

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[5] The safety guard was not explicitly required by the Act, but a technical provision in the act encouraged advocacy for its use.

set of human problems to be solved; and as with technology itself, it carried with it the problems of human beings.

This thesis is divided into five chapters, each of which captures a slice of time in the development of the Evans Safety Guard in the context of the early years of the Steam Boat Inspection Service. The remainder of Chapter 1 provides background material on the Federal Government's early efforts to regulate steamboat boiler technology from the 1820s up to 1852. Chapter 2 gives a history of early laboratory research by the Franklin Institute in trying to develop a successor to the common safety valve (1830-1836), out of which emerged the first versions of the safety guard. Chapter 3 covers the period between the Steamboat Acts of 1838 and 1852, in which Congress invited western practical engineers in 1850 to help overhaul the unpopular Act of 1838. The chapter also charts the rise of the important associations of steamboat engineers, a hitherto obscure but important group whose members played a crucial role in shaping boiler safety expertise and whose power on the rivers offset that of the Treasury Department in Washington. Chapter 4 covers the passage of the watershed Act of 1852 and the ascendancy of the engineers as inspectors and powerful agents of government authority assigned to enforce it. This period marked a sea change in the situation of owners, captains, pilots, and engineers, who were now forced to deal with both a radically changed regulatory regime and the "humbug" safety guard that accompanied it. The chapter ends with the onset of the Civil War and the inspectors' quiet rejection of the safety guard, marking a final victory for the engineers and their indigenous shop culture over the scientific technology of the government (1860-

1871). Finally, Chapter 5 provides conclusions about the case study and about engineering expertise in general.

A Note on the Archival Source Material

Standard research on steamboat boiler safety has been limited mostly to the views and perspectives of the most powerful groups as revealed in official documents—those of Congress, the Treasury Department, the Franklin Institute of Philadelphia, and the press—and this has resulted in an overly simplified story of a unified, systematic, and altruistic government reform of an industry. Official and scholarly histories of the Steam Boat Inspection Service have largely based their accounts on legislative history, and on technical provisions contained in the Steamboat Acts of 1838, 1852, and 1871.[6] These provisions provide an easily traceable chronological snapshot of government and engineering "best practices" over the years and hence are attractive and convenient materials for assembling a factual history. However, in reality a body of laws can better be understood as representing merely an ideal that embraces the definition of technological expertise as understood by those in power. The recounting of laws and legislative history does not illustrate how effectually the technical provisions are carried out —and in the case of the safety guard, they were not—or

[6] For example, see Greene, Arthur Maurice: *History of the ASME Boiler Code*. The American Society of Mechanical Engineers, New York, 1955. See also Burke, John G.: *Bursting Boilers and the Federal Power*. In *Technology and Culture*, Vol. VII, No. 1, University of Chicago Press, 1966; and Hunter, SBOTWR, (1949). Of these, Hunter is the most sensitive to complexities; he does not reach some of the broad conclusions and generalizations that Burke does. Recent authors are in the habit of referencing Burke's article and thus reinforce the distortions of his approach.

how politics and patronage by government officials themselves interfere with the prevailing technical expertise on which, in part, the law is based.

Another easily accessed body of research is to be found in the annual reports of the supervising inspectors of steamboats. These are in fact sanitized snapshots of the implementation of the Steamboat Act of 1852, and present a biased picture of regulation. This was the side the supervisors wished to present: that the steamboat law was working. In fact, it was not working as well as the Supervisors portrayed. The explosions continued, remedies were based on debatable assumptions (as is the nature of the attempt to define expertise), engineers and government officials alike interpreted the law through the filters of their groups, and although the results were difficult to measure, the reports portrayed a guarded optimism that success had been achieved.[7] Still, the annual reports are quite important to mark events, and the present study used them where applicable (see index, Appendix A).

More candid and more reflective of the complexities of the Government's attempt to impose a safety regime on the steamboat community in 1852 is the body of internal correspondence of the Treasury Department (see Appendix B for an index of selected letters and documents to and from the Department from 1850 to 1862). The present

[7] David J. Denault of the University of Connecticut undertook a modern statistical analysis proving that the Steam Boat Inspection Service, while not making the accident situation worse, cannot be shown to have decreased the rate of deaths and injuries due to explosions. He demonstrated that sustained Federal boiler strength of materials knowledge transfer to industry contributed most to the reduction in explosions, rather than administrative oversight by the Inspection Service. See Denault, David J.: *An Economic Analysis of Steam Boiler Explosions in the Nineteenth-Century United States.* Ph.D. Thesis, The University of Connecticut, 1993.

study accessed more than 800 pages of these records. From the occasional sparse penciled notes in these letters, it appears that only journalists and a few historians from decades ago may have delved into them; the former for the purpose of investigating individual steamboat accidents (perhaps to commemorate the anniversary of an accident for the popular media), and the latter perhaps for the purpose of compiling accident statistics.[8]

1.2 General Facts about Steamboats on the Western Rivers

Steamboats were a relatively new technology in the United States at the beginning of our study period. At a time of expansion of commerce in general in the U.S., with increased settlements west of the Appalachian mountains, vast systems of transportation sprang up to meet demand. The Erie Canal, for example, constructed between 1817 and 1825, opened the northern regions and the Great Lakes. With the development of the practical shallow-draft steamboat, the vast river systems of the west -- i.e., the Ohio River, the Mississippi River, the Missouri, and their tributaries--had by the early 1820s become major arteries for the transportation of goods and settlers inhabiting the frontier beyond the "trans-Appalachian Gap." This natural barrier between the Atlantic Seaboard and the western rivers "favored steamboats as the primary, if not only, form of transportation for reaching and supplying the western settlements" until the advent of the railroad in the mid-1850s.[9]

[8] The letters can be found in National Archives and Records Administration (NARA), central repository in Washington D.C., Record Group 41, Records of the Steamboat Inspection Service (see Bibliography for details). To illustrate how fresh these records are, we note that one key multi-page letter was found folded into the binding of its volume; it had not been opened and read for nearly 160 years. To the author's knowledge, none of the correspondence revealed in the present study has ever been published.

Before the steamboat, access to the western settlements was limited. Goods and passengers could only be transported economically on non-powered barges one way, downriver. With steam power, it was now possible to bring cargo from the Atlantic Coast manufacturing centers to New Orleans and from thence upward through the river systems into newly settled areas. This was a market for transportation that the incomplete rail systems would not be able to serve for another three decades.

Development and growth was rapid after development of the specialized high-powered, shallow-draft steamboat, which was able to cope with the swift currents and seasonal changes of the western rivers.[10] Some statistics will illustrate the geometric growth experienced in the United States in general. The first steamboat operated on United States waters in 1807.[11] In 1825, at the start of a period of rapid expansion of steam technology on U.S. waters, 31 million passenger miles were logged aboard steamboats. In 1830, the figure stood at 62 million miles. In 1838, the year of the passage of the first comprehensive steamboat act, the figure was 385 million miles, and on passage of the second, the act of 1852, 1.6 billion miles. In 1860, near the end of our study and at the outset of the American Civil War, the figure was just a little

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[9] On the character of the river systems served and the trans-Appalachian barrier, see Hunter, SBOTWR (1949), p. 482. He stated that the need for steam technology was not for landed industry so much as for inland commerce, especially the commercial needs of the continent's interior basin (Mississippi and Ohio valleys). The principal technological agent that opened the frontier was the steamboat: "In the development of the greater part of the vast Mississippi basin from a raw frontier society to economic and social maturity the steamboat was the principal technological agent." And on page 3: "The wheels of commerce were almost literally paddle wheels."

[10] The western rivers had swift and unpredictable currents over shallows and sand bars, which allowed little space for navigating; snags (logs and submerged fallen trees) that posed a collision hazard; seasonal flooding from river tributaries that produced new and unfamiliar navigation channels; and dense, muddy water.

[11] *House Ex. Doc*. 21, 25 Cong., 3 Sess., 1838, pp. 8-9.

over 2 billion passenger miles logged.[12] To put this growth in perspective, roughly between the time of the first U.S. steamboats and the beginning of the Civil War, there occurred a 65-fold increase in passenger miles logged, with about 40 percent of that growth occurring on the western waters.

The tremendous growth in the number of western steamboats, along with the technological changes that simplified the running of the steam engine, flooded the labor market with inexperienced engineers by the 1830s, creating a labor shortage for skilled practical engineers. This was of enormous importance later for the "look and feel" of the inspection service of 1852.

Celebrated inventor and steam-transportation visionary Oliver Evans (Fig. 1) first realized the need for a higher powered engine to propel steamboats against the swift currents of the Mississippi and Ohio Rivers, and is credited along with England's Richard Trevithick with the development of the high-pressure engine.[13] The engine's

[12] See Langois, Richard N.; Denault, David J.; Kimenyi, Samson M.: *Bursting Boilers and the Federal Power Redux: The Evolution of Safety on the Western Rivers*. University of Connecticut Department of Economics Working Paper Series, Working Paper 1994-01, May 1994, p. 4.

[13] Oliver Evans's importance and reputation in the arena of steam technology led to his figure being included in a mural entitled, *The Apotheosis of Pennsylvania*, in which he shares company with illustrious fellow Pennsylvanians such as William Penn, Benjamin Franklin, Robert Morris Hancock, General George Meade, politician Thaddeus Stevens, and Thomas Paine, among others.

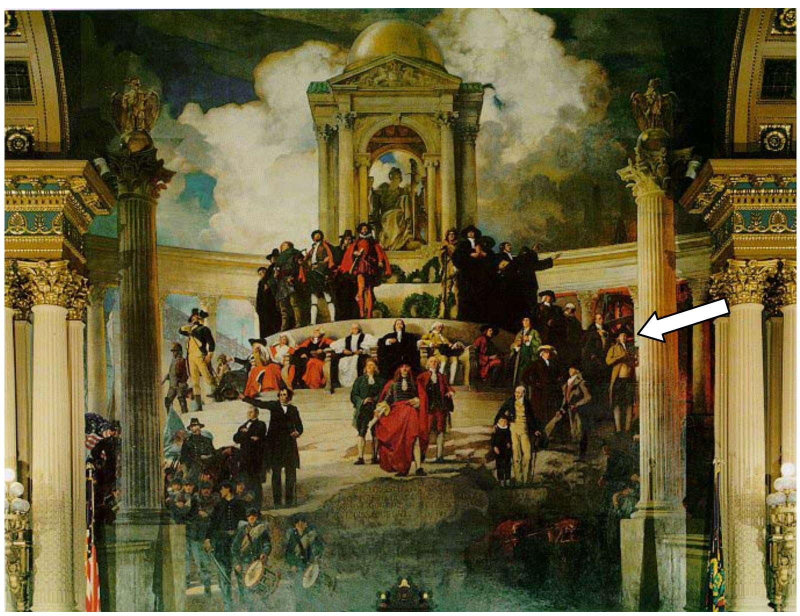

Figure 1. Inventor Oliver Evans (1755-1819) is immortalized in the 1904 mural, “The Apotheosis of Pennsylvania,” in the Pennsylvania statehouse.

design was radically different from the traditional Eastern “walking beam” engine (Fig. 2). Eastern steamboats running on relatively calm rivers used these Boulton and Watt-type low-pressure engines in the 4 to 8 psi range. The adaptation of this massive, vertically oriented cylinder-and beam design to a more powerful and compact version began with Evans’s 1804 patent for a high-pressure engine (Fig. 3). Through many years and small adaptations by Evans, engine builders, and steamboatmen, the successful western steamboat engine emerged by the mid-1830s, displacing the low-pressure model. Said Hunter, “The engine that became standard equipment on western river boats was a high-pressure, noncondensing, direct-acting, horizontal-cylinder affair with a cam-actuated valve gear. Crude and inefficient from an engineering point of view, it had the practical advantages of being light, compact, powerful, cheap to build, and easy to repair. It was admirably adapted to the conditions of navigation on the western rivers where shallow depth placed a premium on light weight, where swift currents called for great power, where scarcity of skilled labor dictated simplicity of construction and operation, and scarcity of capital favored low cost.”[14]

A further radical change was the amount of pressure carried in these engines; from 50 to 125 psi initially to more than 200 psi by the mid-1850s. It was this pressure that provided the power needed to overcome strong river currents. There were many complaints and fears lodged about these higher pressures; some early investigators blamed the use of Oliver Evans’s high-pressure engine for the spate of boiler

[14] See Louis C. Hunter, "The Invention of the Western Steamboat," The Journal of Economic History, 3 (November 1943), p. 201-220. Also see Hunter, SBOTWR (1949), pp. 122-133.

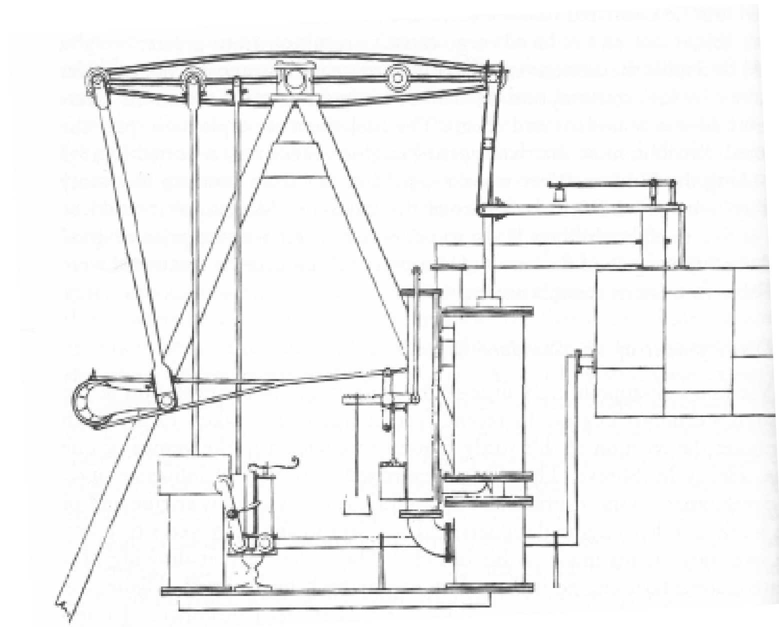

Figure 2. Low-pressure walking beam engine, ca. 1818.

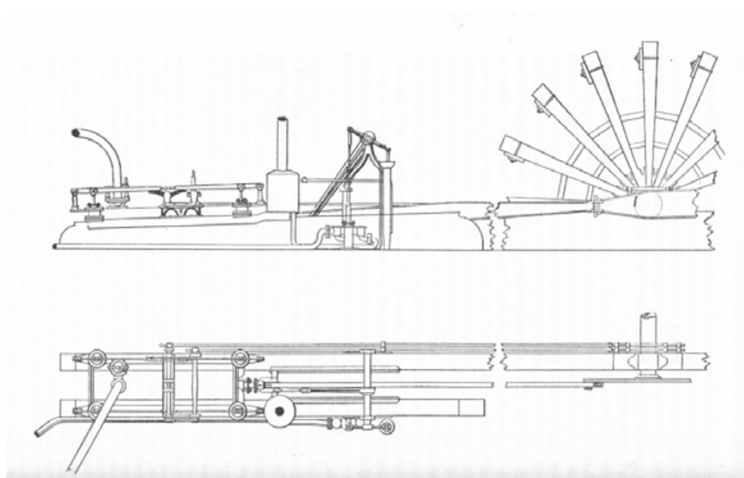

Figure 3. Standard high-pressure western river steamboat engine, ca 1837.

explosions, but prominent practical engineers believed that poor design and crude manufacturing processes were the true faults.

The Eastern steamboat hull required adaptation to Western waters as well; it evolved from a ship-like, vee-shaped hull to one with a shallow, flat bottom for negotiating extremely shallow riverbeds. In consequence of the reduction in volume below the waterline, the engine and boilers were moved up from the hold to the deck. Following the evolution from deep to shallow draft, and from low to high pressure engines with boilers and machinery on the main deck, by 1850 the western steamboat engine was more or less fully developed.

1.3 The Flip Side of Progress: The Phenomenon of Explosions

Cadwallader Evans noted in 1850 that "The commerce and wealth of the world will soon pour into our lap, to be conveyed by our own railways and borne on our steam vessels… bringing back… the richest and rarest commodities of the earth."[15] The statement was made in the context of hope that the growing phenomenon of steamboat boiler explosions might be overcome through the use of his safety guard; only when the explosion problem were solved could human progress continue.

Without experiencing a steam boiler explosion as Haldeman had in 1850, it is difficult for the reader to appreciate its violence (Fig. 4). A steamboat explosion released a tremendous amount of energy; for example, the energy of a cubic foot of boiling water at 60 to 70 pounds per square inch pressure matched that of a pound of gunpowder. Thus, a typical western steamboat boiler containing hundreds of gallons of water at 200 psi or more produced the equivalent explosive energy of about 300 pounds of dynamite; enough to propel a boiler more than two miles in the air and leave a mushroom cloud over the wreck. Aggravating the dangers of explosions were densely packed boats at wharves; passenger salons and steerage accommodations directly above or adjoining the boilers; and the clutter of ejected machinery and cargo, which could entangle victims.[16]

In many cases, passengers thrown into the river could not swim, and drowned. Another danger was that when one boiler exploded, it could set off a chain of explosions in adjacent boilers, multiplying the explosive force three or four fold.

In terms of the cost to human life, Haldeman collected his own statistics and forwarded them to the Commissioner of Patents in 1850. Although slightly exaggerated—4,660 persons killed and wounded over the 30-year period between 1818 and 1848 in 233 explosions (of the 4660 he includes 2,563 killed)--these figures

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[15] From Evans, Cadwallader: *A Treatise on the Causes of Explosions of Steam Boilers with Practical Suggestions for their Prevention to Which is Added a Description of Evans' Improved Safety Guard, or Engineers' Assistant*, 1850. In NARA RG 46, Commerce Records, Tray 26, folder 1 of 2, p. 67.

[16] Boilers occupied a sizable portion of the boat, being up to 40 feet in length and 4 or 5 feet in diameter, installed six or eight abreast.

Figure 4. Explosion of the Medora, Baltimore Harbor, 1842. "The scene presented by the boat afforded at once a mournful evidence of the immense power of steam, and of the ruin of which it can be the instrument." (Col. John Thomas Scharf, *The Chronicles of Baltimore,* Baltimore, 1874). At least three casualties (or possible casualties) of the accident -- John Hoofnagle of Baltimore, Joseph Cragg, C.A. (Charles?) Reeder, and A.G. Ramsey -- are listed as licensed steamboat engineers in the Third Supervising District in the 1857 *Proceedings*. It is possible that Reeder's son was aboard the steamer at the time of the accident, and was badly scalded. (Information on the *Medora* courtesy of D. Bryan, Chicago, Illinois).

were commonly accepted and in fact appear as late as the 1955 American Society of Mechanical Engineering (ASME) official history of boiler development. Denault conducted a review in 1993 and arrived at 2,221 killed in roughly the same period. Seventy-nine percent of these occurred on the western rivers, with more than twice as many steam boiler accidents occurring in these districts as compared with the remainder of the country. As Hunter stated, "Steamboat explosions were a peculiarly Western phenomenon. Next to racing they became the most prominent feature of the steamboat legend."

Hunter estimated that the maximum number of lives lost in the whole period of steamboat development from all causes (not just explosions, which constituted about seventy-two percent of the total) for the period 1807 to 1853 was 7,000. He put this in perspective: "[the death toll does not] appear to have been an excessive price to pay for the advantages of the steamboat (judged by the toll taken in other types of industrial accidents), particularly in the West where the whole development of the regions was so dependent upon it."[17]

Nevertheless, explosions and accidents stirred the public imagination and had very real and devastating social consequences. Mention is frequently made in the accident reports of prominent citizens suffering death or injury, as well as widows and orphans left to fend for themselves. There were special occupational hazards for the crew as

[17] Haldeman's figures are from a news article, 1850 12-23; Denault's are from (1993) p. 99; and Hunter's are from SBOTWR (1949), including the percentage occurring on the western waters, pp. 287 and 521.

well. The crew were the ones in closest proximity to the machinery tending the fire or checking gauges. Less sensational than explosions but equally deadly to engineers and persons near the engine room were flue collapses; these near-explosions were very common in the accident reports. In a flue collapse, crushing steam pressures smashed the flues' metal tube-like structures in an instant, twisting them like corkscrews and expelling the contents of the boiler--scalding hot water and steam--on unwary engineers and other persons in close proximity (often, from one to twenty persons or more were killed in this way).

Regarding their construction, boilers were not being built strong enough for the duty expected of them (Figs. 5-7). At working pressures, the expansive force of steam could exploit any weakness or flaw in boiler iron, which consisted typically of sheets of iron or copper of 3/16-inch to 1/4-inch thickness joined together with rivets.

Fractures could develop at rivet holes due to poor manufacturing processes, or at seams of improperly patched used boilers. In manufacturing, the quality of iron used was sometimes poor or of the wrong type (i.e., cast iron versus wrought iron); scientific engineers and government officials confronted manufacturers and distributors who introduced bad material into the market, *if* they could be found—the chief complaint was the fraudulent stamping of boiler iron. Many boilers were built of such thin plate that they could be seen to "pant," expanding and contracting their

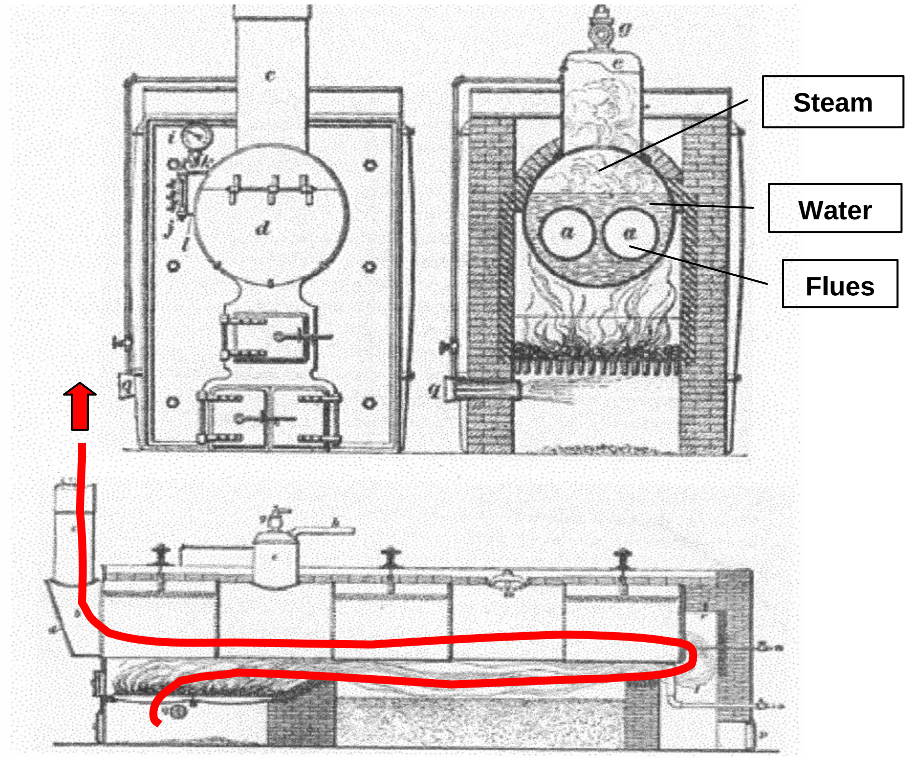

Figure 5. Intense pressures constrained within steamboat boilers contributed to accidents. A typical boiler of the period consisted of a firebox, a channel for the hot gases to pass under the boiler shell to reach the flues; the flue system for conveying the hot flue gases through the boiler (see "*a*" in top figure); a boiler shell to contain the heated water and steam under pressure; and an exhaust consisting of tall chimneys or stacks for gases to travel to the atmosphere. Because of the tall stacks, the draft produced air of "cyclonic" velocity, generating tremendous volumes of heat and passing them through the water. The resulting steam was drawn off and channeled to the engine to do useful work.

Figure 6. A Cornish boiler similar to those used aboard early American steamboats. The Cornish design had a single flue.

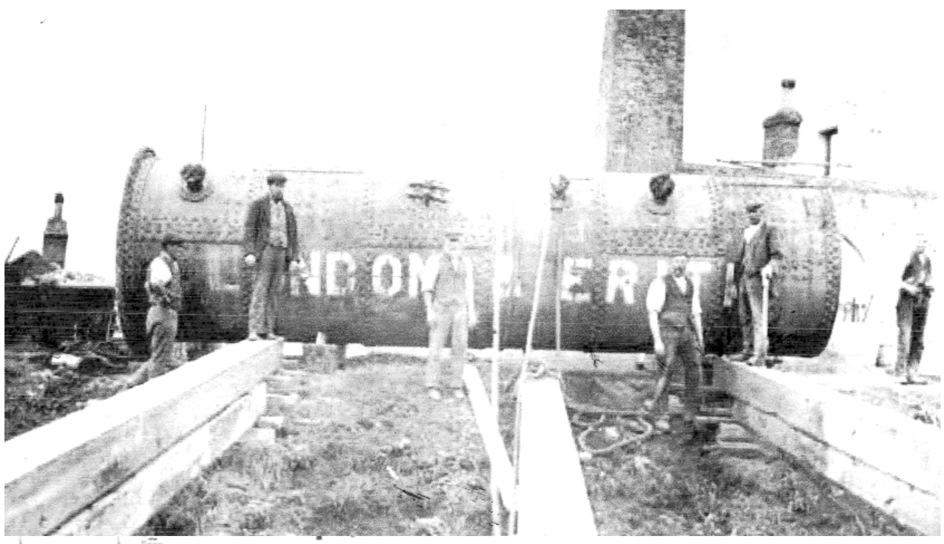

Figure 7. A Lancashire boiler shown here in a land application. This design was the most common used in steamboats at the time of the Act of 1852, and featured dual flues.

sides as the engine's valves opened and closed. This required the engineer to insert wedges in joints to make the boiler not just "water tight," but "steam tight."

Design was a problem also; steam pressure could exert a violent force on inadequately stayed internal flues, causing the flue collapses noted above. The government responded to this by enlisting the Navy in developing tougher boiler construction standards and by emphasizing that inspectors carefully note the internal stay systems when conducting their boiler inspections.

Quality manufacturing and reconditioning of steam boilers were hampered by the general economic conditions of the time. In reading contemporary correspondence, one is struck by just how strapped for cash were manufacturers, boat owners, captains, and crew. Everyone cut corners; safety was a secondary and especially expensive commodity, with safety devices costing tens of dollars or even 150 dollars or more; expensive manufacturing processes such as the production of wrought iron in place of cast iron was thought by many owners to be cost-prohibitive. Yet safety demanded stronger materials and better designs.

Most scientific and practical men believed overheated iron from low water was the main hazard leading to explosions and flue collapses. Once water fell below the level of the flues, the resulting red-hot iron of the flues could weaken and implode. The water level above the flues in a steamboat boiler was typically only one inch; in low-pressure boilers the clearance was six or seven inches; and in a locomotive boiler, some 14 inches. This in part explains why locomotive boilers suffered proportionally fewer accidents than steamboats. In steamboat boilers, forcing pumps kept the water level up, but these pumps ran off the engine and could not operate at a landing when the engine typically was not running. Inventors were particularly interested in detecting extreme pressures within the boiler as a result of heat build-up—for this purpose they invented mercury pressure gauges and other instruments. Subsequent scientific investigations focused on calculating the expansive force generated by a volume of overheated steam and tried to relate it to internal boiler temperatures. The emphasis of a key scientist in our story, Alexander D. Bache, was thus focused on heat and not pressure as the prime quantity to be measured.

***Navigational Difficulties of the Western Rivers*—**There were many challenges in adapting steam technology to shallow rivers like the Mississippi or Ohio Rivers, and this led to greater risks of accidents. The steamboat engineer had a much more difficult job than the stationary engineer who ran a typical land plant. A steamboat's engines and boilers rested on a floating foundation that "worked and strained under the buffeting it received in its passage along the rivers." This assemblage frequently collided with sand bars, snags, banks, and other vessels, producing shocks to the machinery. Machinery often was operated twenty-four hours a day for days on end. This kind of abuse frequently led to breakdowns and ad hoc repairs: "Leaking joints, cracked steam pipes, blown-out cylinder heads and broken shafts, wheel arms, and connecting rods were the inevitable consequences of the heavy stresses and sudden shocks to which the machinery was subject…"[18] In these conditions, engine driving was improvisational, and this led to the use of excessive steam pressures.[19]

The need for more power and higher attendant steam pressures even changed the way the engine was set up to function. At the same time that Evans high-pressure engine was being introduced, for example, engineers had begun on their own to temporarily disconnect the steam condenser on their low-pressure engines:

> "The shift from the low-pressure, condensing engine to the high-pressure noncondensing engine on the western rivers was largely effected during the first ten years of the steamboat age. It was not an abrupt change but a series of steps. First, there was a gradual raising of the pressures used in the condensing steamboat engines until they were really medium- rather than low-pressure engines. Next, there was evidently a tendency on the part of engineers to disconnect the condenser temporarily in order to obtain under difficult conditions of navigation the operating characteristics of the high-pressure engine. In this manner the condenser, the heart of the low-pressure engine, appears increasingly to have fallen into disuse, and in a final step it

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[18] Hunter, SBOTWR (1949), pp. 261-262

[19] This emphasis on pressure was a common focus of engineering experts in the 1820s and 1830s and has significance for our later story. Some practical engineers saw high operating pressures as a major contributing factor to accidents and urged Congress to limit pressures to 150 psi, or even less, to 100 psi. When the Act of 1852 was passed, that law stipulated a limit of 150 psi, which some practical engineers thought too high. In practice, even this pressure limit frequently was ignored, and inspectors after 1852 were satisfied if they could hold steam pressures to no more than 170 psi. The usual river practice was to run the machinery at between 175 and 200 psi. See 1853 4-12; 1853 12-15.

> was eliminated altogether, the advantages attending its use not proving worth the difficulty and cost of obtaining them."[20]

Inventors and design engineers in the engine-building centers at Saint Louis, Cincinnati, and Louisville were forced to make other adaptations to their engines as well, and these subjected boilers supplying the steam to dangerous pressures. Oliver Evans himself encouraged dangerous adaptations of his own designs, contrary to Burke's statement that explosions were due to a departure from Evans's design rules.[21] The encouragement by Evans of the "cam cutoff" and the technique of "steam pinching" were adaptations that produced instantaneous and often dangerously high steam pressures needed to achieve extra horsepower in tight situations.[22]

Significantly, in making these adaptations, engineers were caught in a classic Catch 22; they risked explosions but were loath to give up mechanical flexibility, for, paradoxically, their lives and those of their passengers depended on it. The lack of power in a swift current could lead a boat to collide with the rocky shore, another boat, or some obstacle; in such circumstances many more passengers had been drowned than been killed in boiler explosions. As Hunter put it, "That this method of

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[20] Hunter, SBOTWR (1949), p. 126

[21] Burke (1966) wrote, "Despite [Oliver] Evans' prudence, hindsight makes it clear that the rash of boiler explosions from 1816 onward was almost inevitable. Evans' design rules were not heeded." In fact, Evans proposed dangerous engineering practices in his early work, Abortion of the Young Steam Engineer's Guide, pp. 28, 49, as noted in Hunter, SBOTWR (1949), p. 149. Evans opposed the practice of unhooking condensers, however, because it was an infringement on his patent.

[22] "The principal reason of explosions having been more frequent of late, on the western waters, than formerly, is simply because the engineers work the steam higher; and this they are enabled to do with the same boilers by cutting off the steam shorter, not only with cams suited to that end, but by 'pinching' the steam at the throttle valve." Thomas Bakewell, Cincinnati, reporting in Nov. 1830,

obtaining extra power resulted at times in disastrous explosions did not deter what seemed to be a necessary practice."[23]

Once the prevailing techniques and adaptations became common practice, they became entrenched as rules and technological artifacts. This situation would (and did) naturally lead engineers to disable any device that would limit steam pressure or otherwise impair their ability to produce instantaneous power. We can see in this practice the rank-and-file engineers' inclination to habitually disable the safety valve, and later, the safety guard.

The Search for Causes of Explosions—The 1830s were spent searching for causes of explosions, some of which were based on vogue theories. The more common theories were: the formation of a combustible compound such as hydrogen in the boiler (accompanied by observations of a mysterious blue flame); low water, in which the water level fell below the boiler flues, causing the iron to become red hot; a variation on the low-water theme, the "flash theory," in which cold water came in contact with the red hot iron to generate prodigious quantities of steam, causing foaming and a sudden and dangerous increase in steam pressure; and electrically

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published in the *Journal of the Franklin Institute* (JFI), Vol. VIII (new series), No. 6, December 1831, p. 385.

[23] Hunter, SBOTWR (1949), p. 132.

induced explosions. These and similar postulated "causes" became the focus of a formal experimental investigation by the Franklin Institute beginning in 1830 (results were published in 1836). The intent was to separate fact from fiction and settle on the "true" cause or causes of explosion, and then use this newfound knowledge to frame the first federal boiler safety act.

Despite the attempt to pin each explosion on a particular cause, savvy engineers simply reverted to a strength of materials approach; explosions ultimately resulted from the carrying of a steam pressure greater than that of the tensile strength of the boiler iron used to contain it. Thus, astute observers such as steam navigation agent William C. Redfield showed more apprehension of the solution than most; in focusing not on specific causes but on building more robust boilers and employing qualified engineers to run them, boiler safety could be achieved. Indeed, gradually, the number of explosions declined and leveled off once improvements to the strength of materials were instituted (Fig. 8).[24]

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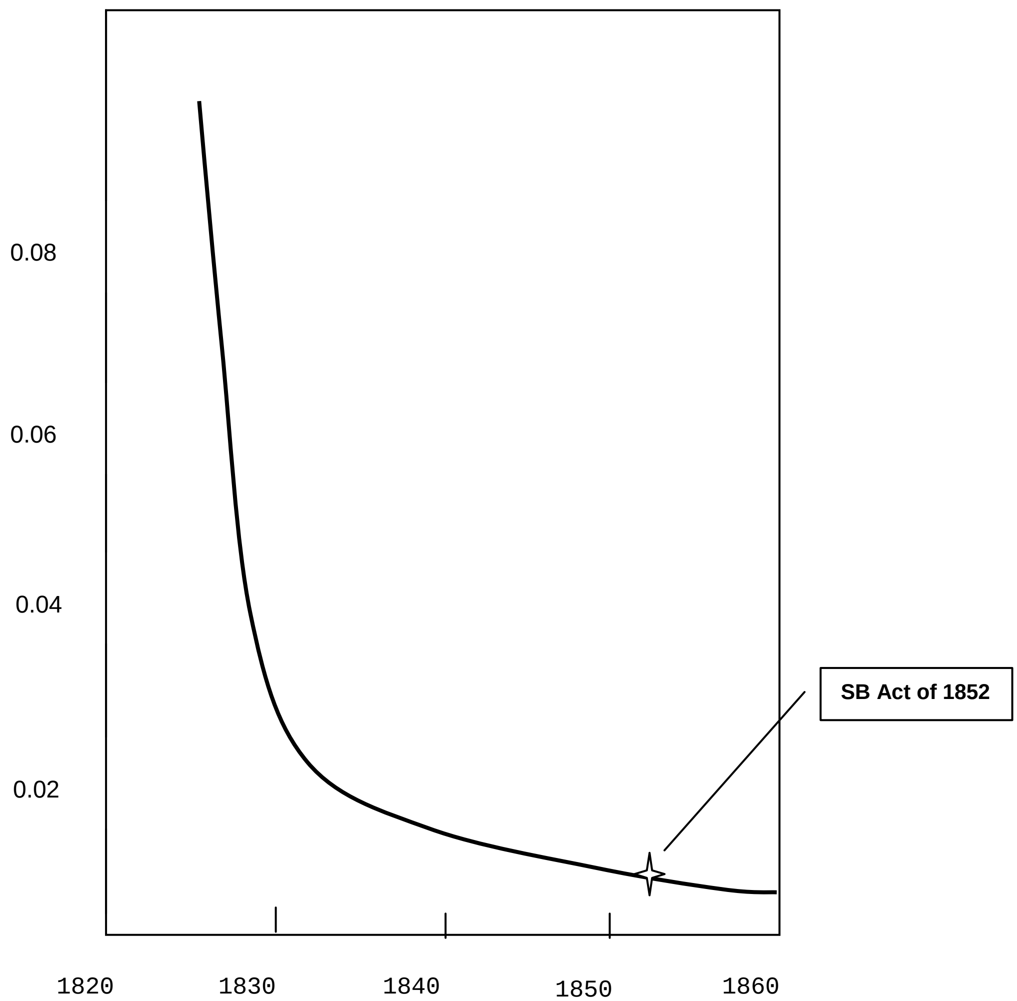
[24] Denault (1993) stated that government research during the period 1830-1850 led to better boiler construction and management techniques; along with these improvements, developments in the insurance and legal fields to properly assess risk and assign liability for accidents led to subsequent gradual improvements in the accident rate. Thus, there was a shift from the search for causes of explosions to a recognition that boilers were so intrinsically dangerous that overdesign was the only path to safety. Denault's historical revisionist work makes two key points in this regard. First, determinants of safety had become fixed by 1850. This is borne out by the NARA letters. While engineers and Treasury Department officials pondered over whether or how to use Evans's safety guard, the fundamental engineering practices for monitoring the boiler remained unchanged during the period of study; these were the basic safety measures such as the steam gauge, the water gauge, and the safety valve. Second, steamboats became larger over time and carried more persons per ton, increasing the level of congestion. This way, "even as the relative number of boiler explosions fell, each individual explosion became more dangerous because more potential victims were exposed to the danger of steam as the steamboat age progressed." (p. 190). Denault noted that explicit safety regulation may have been only a contributing factor in increasing safety over time. "Safety is not a static product; users of a technology learn over time. The first practitioners pay the highest cost in accidents, but newer versions of a technology may be safer than previous versions." (p. 178).



Source: Denault 1993, p. 184.

Figure 8. Statistically adjusted graph showing boiler explosions per million people miles, 1825-1860.

1.4 The Reaction of the Public, Press, and the Steamboat Industry to Boiler Explosions; Ineffectual Early State Regulations

Accidents, according to the historical accounts, made a strong impression on the public mind. Shock was manifested by townspeople when accidents occurred at their communities' doorstep; according to Hunter, accidents of this type could not be subconsciously dismissed by wishful thinking and "served as an intimate reminder of the hazards associated with steam power."

> "The unexpected suddenness and devastating force of steamboat explosions held a morbid fascination for the public, attracting greater attention and arousing more concern than other disasters on an equal and often larger scale. In total casualties, in the amount and degree of suffering, in the number of major disasters, and in the generally dramatic character of their occurrence boiler explosions outranked every other class of steamboat accidents."[25]

Newspapers contributed to the fear by sensationalizing accident accounts and expressing alarm in editorials. These multiplied years later, in 1850, during Congress's concerted efforts to draft the Act of 1852 creating the new inspection service. Congress was under severe criticism for the too-long delaying of the enactment of effective steamboat safety regulation. One newspaper wrote, "It is only

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[25] Hunter, SBOTWR (1949), p. 282. See also pp. 522.

a matter of wonderment, as it is of reproach, that national legislation has not been more effectually applied… and that members of Congress… should have been so criminally culpable, and derelict in their manifest duty..... None know better than these very members of Congress the extent of loss of life; the degree of physical suffering endured by those who escape a horrid death, to endure a miserable existence, maimed and mutilated; the bereaved households, the destitution of homeless and friendless widows and orphans, and the millions of property destroyed, by what are considerately called the casualties of steamboat navigation, but which in fact are the results of a criminal disregard of life, and shameless neglect of responsibility and duty." The editorialist further urged authorities to reform the "careless, ignorant, mismanagement among those who have the control of the immense fleet of steamboats which run upon our rivers and interior seas."[26]

Trade groups were a large factor in exerting pressure for reform using the print media. Letters and memorials appearing in the newspapers were often signed by "citizens of" some western city; these usually turned out to be owners of property (steamboat owners or merchants) or members of engineering associations. Newspapers also goaded the government to get involved in reform through regulation.

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[26] 1850 12, IMG 1093-1094. The approximate date of this article appears to be December 1850 because it is found among other similarly dated correspondence relating to Senator John Davis's deliberations in drafting of the Act of 1852 (Sen. Davis, 1787-1854, was chairman of the Steam Safety [Sub]committee, Commerce Committee, U.S. Congress). Source of newspaper unknown as the title is clipped off.

Interestingly, despite the glare of negative publicity about the dangers of steamboating, there was no outward indication of any extraordinary degree of concern among the members of the public who were in the most immediate danger save the crewmen themselves: western steamboat passengers. In fact, it appears that this group looked with only ordinary apprehension at the mode of travel chosen. Passengers bored of long trips on the Western waters could be found pressing the captain and crew to race with other boats when the opportunity arose (Fig. 9). "Those who failed to share the general enthusiasm for the sport usually found it difficult to make open protest and the more timid sought such safety as they could by retreating as far as possible from the boilers, there to follow the proceedings in trepidation," noted Hunter.[27] Winning such a race was the all-important goal. John G. Cassedy, in an 1830 issue of the Journal of the Franklin Institute, condemned the actions of a captain: "A boat had overtaken him; the steam was raised to 'blowing off;' he jumped upon the safety valve, and swore he would either 'beat her, or else blow up.'"[28] Alfred Guthrie, the first supervising inspector of steamboats in the eighth district (Chicago) similarly told of an explosion of the *Prairie State* on the Illinois River in which eight persons were killed. "This was beyond all question the result of great recklessness on the part of the engineers. I understand this was a race, probably the water shut off and the consequence was explosion."[29]

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[27] Hunter, SBOTWR (1949), p. 406

[28] JFI, Vol. IX (new series), 13, p. 95, 1830

[29] 1852 4-28, Supervising Inspector Alfred Guthrie to Senator John Davis.

Figure 9. Steamboat race.

The First Local Regulations—In the mid-1820s, municipalities and states began to investigate steamboat boiler accidents, but these efforts fell far short of formulating standard regulations for the entire industry. National regulation, and indeed regulation of industry in general, were anathema to some in those laissez-faire times and were thought alien to a progressive industry. Steam power was just coming into use and was considered an important means to attain progress and prosperity, especially in opening the West; many industry insiders thought it better to not hamper it when its tremendous benefits were just being realized. Steamship agent William C. Redfield, for example, believed that regulation "would do more harm than good, by alleviating owners of responsibility," and would invite interference by the national legislature.[30] Another problem was that river commerce straddled too many legal jurisdictions for regulation to be practicable. Hunter noted, for instance, that a boat could pass through ten states in the lower Mississippi region alone; trying to hold a violator answerable to state regulations in such a situation was a practical impossibility.[31]

The most retarding factor of all, however, was one of a lack of expertise: The causes of explosions simply were not known and the phenomenon held an aura of mystery; steam boiler technology was relatively new and no experimental authority had examined the internal workings of boilers save the compiling of rudimentary steam

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[30] *House Ex. Doc. 21*, 25 Cong., 3 Sess., 1838, p. 449.

[31] Hunter SBOTWR, (1949) p. 524.

tables.[32] The first step, therefore, was to collect information about boilers, and to study European safety practices and the available research. In this manner, the City Councils of Philadelphia set up one of the first boiler accident investigation committees in the United States in 1824; this consisted of prominent civic scientists and engineers, one member of whom was Jacob Perkins, a prominent Philadelphia inventor of early refrigeration and later developer of engraving technology for bank notes. Out of the investigation came three recommendations: install two safety valves on each boiler, one to be kept locked to prevent tampering (a French precaution); pressure test all boilers in a manner similar to that employed in the proof-testing of gun barrels, also a French practice; and finally, install blow-out sections in steamboats, to channel "the force of accidental explosions through a weakly constructed wall or roof." The committee's findings were passed on to the state legislature, but these were advisory only and were not made legally binding.

Some states, notably Alabama, reacted to the growing number of accidents with coroners' inquests and indictments of steamboat officers. These proceedings tended to place blame for accidents on personnel rather than on the technology itself, a habit that would prevail for many years to come and would plague the reputations of practical engineers in general. The associations of steamboat engineers, whose profession had begun to be stung by accusations of carelessness and negligence, tried to police themselves by conducting investigations when accidents implicated their

[32] Disagreement as to causes retarded regulation – Hunter, SBOTWR (1949), p. 525; French scientists had tried to relate steam pressure to temperature in laboratory experiments by the early 1820s.

own members.[33] In public documents, the association engineers tried to distinguish in the public mind the difference between the “good engineer” and the bad, but the influx of low-paid, untrained engineers aboard the boats continued to blur the distinction. Wrote engineer and Captain T.J. Haldeman in 1830: “There are now a great number of men engaged and engaging in the engineering business, through the influence of their friends and relatives, who are no mechanics at all, and scarcely know anything about either theory or practice; and as long as this course is pursued and allowed, so long will man be blown into eternity.[34]

In the 1830s, therefore, the first order of business among government, scientific, and engineering elite was to draft a well-crafted federal law based on sound technological principles; this required a truer understanding of the causes of explosions and effective preventative measures. Until a proper government-funded investigation could be conducted, this basis was entirely lacking.

1.5 First Steps to Federal Regulation: The United States Government Mobilizes Its Expertise (1824-1836)

After the explosion of the Steamboat *Aetna* in 1824 on the Hudson River, which killed 13 persons, Congress ordered the first federal investigation of steam boiler explosions. Burke (1966) summarized this first step: “A resolution was introduced in the House of Representatives in May 1824 calling for an inquiry into the expediency

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[33] For a history of state regulation and the involvement of engineering associations, see Hunter, SBOTWR (1949) beginning on p. 523.

[34] Correspondence from Haldeman to Congress dated October 30, 1830. See *House Report* 478, 22 Cong., I Sess. (1832), p. 93.

of enacting legislation barring the issuance of a certificate of navigation to any boat operating at high steam pressure. Although a bill was reported out of committee, it was not passed due to lack of time for mature consideration."[35]

There were other problems as well. As mentioned previously, scientists and practical engineers believed there still was not enough solid information on explosions to justify rules regulating the trade. What was needed was a proper experimental investigation to get at the facts. In 1830 a private Franklin Institute initiative to study explosions gained Treasury Department funding for a series of laboratory experiments.[36] Treasury Secretary Ingham approved the Institute's plan of experiments, and these first national scientific studies marked the beginning of scientists' involvement. Their expertise would eventually clash with, and attempt to redefine, the traditional craft expertise of the western practical engineers.

The 1830 investigation critically examined the familiar but unproven suspected causes--explosive gas buildup in the boiler, the "flash" theory of cold feedwater on hot boiler iron, and the electrical explosion theory, in which lightning as an ignition

[35] See Burke (1966), p. 9. The committee did issue recommendations, however. These were taken verbatim from a report of the select committee of the British House of Commons in 1817. The recommendations were similar to those of the Philadelphia committee's, and consisted of the enrollment and licensing of boats; use of copper or wrought iron rather than cast iron in the manufacturing of boilers; inspections incorporating the French proof test; and dual safety valves set to open at the maximum allowed pressure.

[36] Denault (1993, p. 175) cites Wildawsky (1988) in ascribing the change heralding the 1830 government involvement to a political reaction. Government is predisposed toward "anticipatory measures," the act of predicting and preventing dangers before damage is done. "An elected official never gets credit for improvements in safety that evolve without government interference, but they are sure to be excoriated in the event of an accident coupled with no interference… In examining the history of governmental investigations and actions in this context, it is interesting to note that the major federal investigations and actions were precipitated by well-publicized boiler explosions."

source of explosive gases was suspected. There was also an investigation into the properties of fusible alloy - - the operative component of the (not yet envisioned) safety guard - - that formed one of the legs of the "French system" of boiler safety.[37] French fusible alloy consisted of a plug or plate of base metal alloy placed in the boiler shell or flue that was designed to melt upon the buildup of excessive heat.

The Institute's experimental results were published in 1836. These results were used to frame the first steamboat act of 1838 following almost a decade of spectacular steamboat explosions.[38] Details of the Franklin Institute's 1836 findings will be provided in a later chapter, but for the purpose of this thesis, the results prescribed a special method for the use of fusible alloy. This method came to be interpreted as requiring Evans's safety guard.

Concurrent with the Franklin Institute's research, all through the period 1830 to 1838 the Treasury Department (using its Customs officers) gathered facts about explosions and steam engines, and considered proposals from industry and academic sources for purposes of framing legislation.[39] One proposal received from outside the industry is mentioned here because it represents the prevailing emphasis of the time on

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[37] The French system consisted of fusible alloy safety plugs, dual safety valves (one was locked to prevent tampering), and the hydrostatic test, all under government inspection and supervision.

[38] After the explosions in 1830 of the *Helen McGregor* (40 lives lost) and the *Chief Justice Marshal* (11 killed) until the first steamboat act of 1838, a "chorus for protest and a demand for legislative action" put the matter of explosions before Congress on a continual basis. Hunter, SBOTWR, (1949), p. 532.

[39] See Hunter, SBOTWR (1949), p. 525. Results of these inquiries were published in several reports, the earliest being *House Report* 478, 22 Cong., I Sess., in 1832. This document concentrated on observations and facts gleaned from reports of scientists and prominent practical engineers and esteemed engine builders.

reforming the engineering cadre. Charles Mapes, a major in the U.S. Army, proposed a national service with a live-in academy for aspiring young engineers. He proposed monthly compensation, a national machine shop, uniforms at government expense, commissions at various grades, and even buttons incorporating a national insignia. At graduation, the candidates would earn a commission as a steam engineer or assistant steam engineer. If young engineers could be trained and certified in a sort of national nursery according to the Mapes plan, the habit of employing dangerous rogue operators to run steamboat machinery would become a thing of the past.

During the fact-finding initiatives, the practice of customs surveyors venturing into the hinterlands of steamboat country during 1830-1832 and circularizing owners, captains, and crews of steamboats for accident data and engine statistics met with a cool reception. Curiosity by government officials was viewed by steamboatmen as a prelude to passing restrictions and interfering in business. For example, a surveyor, Charles Kinsey, reported evasion by steamboat owners when he made repeated efforts to visit a steamboat in New York harbor in 1831 to collect engine and boiler information; the captain was always absent or indisposed.[40] This response was typical across the country. When the circular returns finally did come in, many answers were incomplete, mostly due to obstructionism or disinterest by the steamboat community.

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[40] *House Report* 478, 22 Cong., I Sess. (1832), p. 30. The form of the circular was contained in *House Ex. Doc.* 131, 21 Cong., 2 Sess. (1830, 1831).

For a long time, Congress did little with the information collected by the Customs Service. There were several reasons for both the passivity of the government and the industry; Hunter cites inertia and tradition, lack of desire to interfere with business, and an agrarian society that lacked experience with machines. He also noted that the collected data and the Franklin Institute's subsequent experiments revealed "wide disagreement among both practical and scientific men with regard to matters of both fact and theory" and that this effectively retarded legislation.[41]

***The Role of Inventors*—**Inventors of safety devices were especially active in the 1830s; they were eager to secure funding by the federal government to develop their ideas and perhaps receive a grant of monopoly for their inventions. First efforts at devices appear in hindsight to have been naively impractical since they sought to control the engineer by means of the vigilance of captain and passengers; as we have seen, the captain and passengers were frequent advocates of steamboat racing. A few inventions received a favorable hearing and provisional support from the government and the Franklin Institute, Evans's safety guard being a prime example. Development of the safety guard appears to have been closely orchestrated in concert with Alexander D. Bache of the Franklin Institute because of the invention's connection with French fusible alloy. The success of Evans's safety guard followed a series of failures and refinements in the 1830s until it reached its final form in 1850. There were more than 400 safety guard designs submitted for patents by 1848, with the

41 Hunter, SBOTWR (1949), p.525.

government making active efforts to force the adoption of some of them on steamboats.[42]

The river engineers resented the intrusion of impractical inventions into their engine rooms, complaining that inventors approached them at their boats with all sorts of apparatus. The label of "humbug" as applied by engineers to such inventions degraded the reputations of most such contrivances; expressions of contempt for the monopolistic intent of the inventors could also be heard.

Involvement of the Customs Service—Because of the complexities inherent in local methods of state regulation, by the mid-1820s appeals for regulation, as we have seen, ultimately fell upon Congress. President Andrew Jackson stated in his annual message to Congress in 1833: "The many distressing accidents which have of late occurred in that portion of our navigation carried on by the use of steam power deserve the immediate and unremitting attention of the constituted authorities of the country..... they are in a great degree the result of criminal negligence on the part of those by whom the vessels are navigated and to whose care and attention the lives and property of our citizens are so extensively intrusted..... That these evils may be greatly lessened, if not substantially removed, by means of precautionary and penal legislation seems to be highly probable."

[42] Hunter, SBOTWR (1949), p. 535; *House Report* 478, 22 Cong., I Sess. (1832), p. 19.

The chosen method of control involved the certification of a steamboat's customs papers. This approach was laid out in President Martin Van Buren's First Annual State of the Union address to Congress in 1837 in which he stated, "The distressing casualties in steamboats which have so frequently happened during the year seem to evince the necessity of attempting to prevent them by means of severe provisions connected with their customhouse papers." Since the time of the early republic, the Customs Service had been routinely inspecting ships in major ports for tariff and smuggling violations. Now Customs would be used as the primary administrative structure to exert political control over steamboat safety. Such a strategy signaled a shift from self-policing by industry to the expansion of regulation by a powerful and established federal government agency into the Western states.

The involvement of the established bureaucratic organization of the Customs Service in regulating steamboats is a very important point to keep in mind and is the key to understanding why western practical engineers reacted as they did to Evans's safety guard. The engineers were technical experts trying to do their jobs in a bureaucratically and politically charged atmosphere; they were unaccustomed to control of their profession from outside of their own engineering associations. The Customs Service brought to the mix a hierarchy of vested patronage positions, including a collector (a powerful political figure), naval officers, surveyors, weighers, gaugers, and inspectors. These were powerful men; the top officials were appointed by the President of the United States. As such, the new bureaucracy embraced considerable political maneuvering, infighting, and intrigue that was alien to the engineers.[43]

Further, Customs was virtually the only bureaucracy large and powerful enough to reach into the interior areas of the country. Thus, handing enforcement of steamboat safety over to Customs not only meant extending the collectors' and surveyors' powers beyond the mere monitoring of cargo manifests in the Eastern ports; it also meant enlarging Customs' operational area and scope of responsibilities to include the river ports in the West: Pittsburgh, Chicago, Cincinnati, Louisville, St. Louis, and New Orleans. There is a need for more research of the Customs Service and its venture into the western states, and its new charter to regulate technology in general after 1838, but we do know from scholars how the Customs operated in the East. Wrote one concerning the collectors along the Atlantic Seaboard in the early republic: "These officials collected the revenue that financed the United States government as reorganized under the Constitution. The collectors were also the key element in binding the ports of the nation to the national government. The collectors possessed direct contact with the electorate, Congress, and very often one or more cabinet members. They were the true links between the ports and the federal government."[44]

When Customs took control of steamboat inspections for the first time in 1838, the inspectors were notoriously ineffectual, and so there was little impact on the industry.

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[43] Historical Note, Records of the U.S. Custom House, Bristol-Warren, Rhode Island, Rhode Island Historical Society Manuscript Division, 1980, 1999; http://www.rihs.org/mssinv/Mss08sg2.htm.

[44] Smith, Joshua M.: *Sentinels of the Republic: Customs Collectors in the District of Maine, 1789-1820*. Masters Thesis, Department of History, East Carolina University, 1997.

However, with restructuring of the inspection service in the reforming act of 1852 under a board of supervising inspectors, the full bureaucratic power of Customs came to be felt on the Western rivers. This topic will be discussed in a later chapter devoted to the association engineers' reaction to the "lame" act of 1838 and their promotion to the ranks of inspectors under the Customs Service in 1852.

1.6 The Steamboat Acts of 1838 and 1852: The "Good" Engineer in Ascendancy

One of the chief concerns that emerged from respondents of the government circulars of 1832 was the need to employ a good engineer in the engine room of steamboats. Although originally the province of technical experts, technological and economic changes by the mid-1820s had driven out the most highly skilled practitioners and replaced them with cheaper, less qualified engineers (the terms used were, variously, "engine drivers," "six-weeks" or "three-months" engineers, or "strykers"). Forced out by competition, the skilled engineers found themselves returning to the shops or staying with the boats and compromising their former standard of safety. As Haldeman wrote, "There is scarcely one engineer in twenty that can make a calculation of a safety valve." He chided engineers who had not familiarized themselves with mathematics, chemistry, hydrostatics, or the hydraulics of steam. A steamboat engineer, Haldeman wrote, must be able to make "neat calculations of the pressure of steam, and know the strength of the materials that compose an engine."[45] Thus developed a classification scheme to distinguish good engineers from bad.

[45] 1830 10, *H. Rpt* 478 (1832), p. 92; see also "Practical engrs, some of whom are scientific," 1850 5-1, and "Not one in ten is a practical and theoretical engineer," 1838 10-1.

Scientific understanding was now becoming a requirement, in part because technical solutions could be arrived at more easily, without resort to the older cut-and-try methods. Sinclair wrote that “technical progress demanded more than traditional craftsmanship: if skilled mechanics understood scientific laws, the laborious process of experimentation by trial and error would be unnecessary.”[46] Enlightened engineers believed that the transition from artisan to scientific engineer would follow an evolutionary path of progress. Inventor Cadwallader Evans, for example, wrote that engineers would eventually “attain a higher elevation, and gain a thorough mastery over the laws of causes and effects, which, a familiarity with science, when blended with practice, never fails to impart.”[47]

Not all scientific practical engineers were wholly sympathetic to this point of view, if only because they believed scientists sometimes erred and were inconsistent in their experimental results. This did not cause the engineers to discount the aura and prestige of science, but they did approach science as a discourse or disputation in the pursuit of truth based on tangible physical observation and experience. For example, one practical engineer, Charles W. Hinman, challenged three “very learned gentlemen (two of them, in fact, professors in an institution which is the pride of our country)” that a set of boilers in 1838 burst with a gradually increasing pressure of steam and a sufficiency of water. Hinman believed the water in the boiler had foamed, misleading

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[46] Sinclair, Bruce: *Philadelphia’s Philosopher Mechanics: A History of the Franklin Institute, 1842-1865*. Johns Hopkins University Press, Baltimore, 1974, p. 138.

[47] Evans, 1850 Treatise, pp.16-17.

the engineer into thinking he had a sufficiency of water. Voicing his skepticism, he wrote, "I shall humbly cross the wake of the learned gentlemen at a respectful distance astern, and, standing on the shore of practical knowledge, carefully avoid the tide of theory entirely." In other words, practical knowledge was more reliable than scientific theory.[48]

The effort to educate the "bad engineer" through scientific enlightenment was in many cases harder than defusing the simple skepticism of the more skilled engineer. This was due to the poor class of persons being accepted as engineers. Many had come from land engines, or had little or no experience as strykers aboard the boats; many of them had drinking problems. Breaking these old habits and replacing them with a vision of engineering that embraced Whiggish morality, scientific understanding, and mathematical skill was a chief preoccupation of the association engineers after the mid-1830s. The engineer of wavering character and profound ignorance of steam would eventually cause an explosion, especially when urged by captain and passengers to increase speed. The opposite role model was a man of firm, sober, and steady character who also knew the limits of his machinery. Cadwallader Evans wrote that a good engineer was one "of sobriety and temperance in all things." "He should have a proper sense of the moral relations in which he stands to society. He should possess firmness, courage and self-possession. Neither obstinacy nor rashness should form an element in his disposition. He ought never, under any circumstances, to yield to excitement, no matter what the temptation or

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[48] Charles W. Hinman, communication from October 1838, in *H. Ex. Doc* 21 (1843), p. 76.

what the reward. Coolness and calmness should be daily practiced, until they become fixed habits..... Nothing should distract him from his business, or lull his vigilance into supineness or indifference."[49]

Hunter attributed recklessness and indifference of crew more generally to the unsettled, migratory character of steamboat life, which encouraged irresponsible behavior. "The prevailing temper and tempo of steamboat life favored the employment of the 'hot engineer,' who was able and willing to push his engines to the limit." The hot engineer was "the man who would get results by hard and continuous driving with little regard to risk—over the careful engineer who sacrificed speed to safety."[50]

Changes in technology also played its part in this shift; the advent of double-engine steamboats had saturated the field with the inferior engineers. Engineer W.W. Guthrie observed that in those days young men were coming in and replacing their tutors; they were hired by boat owners for no other reason than that they were "going for less wages."[51] Cincinnati engineers writing in the early forties noted that these men had destroyed the respectability of the business and were driving good men from the ranks. Only a board of examiners made up of qualified practical engineers could provide a remedy through careful examinations.[52]

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[49] C. Evans, 1850 Treatise, p. 19.

[50] Hunter, SBOTWR (1949), p. 261.

[51] 1853 12-15, IMG 1170-1173 and 1181-1187.

[52] "Government refuses to interfere and enforce the qualification of engineers, possessing no more knowledge of the business than any schoolboy may be taught in a few lessons. And such men, by

All of these factors contributed to efforts by the association engineers after 1838 to reform the engineering cadre, take their places as government inspectors, and reclaim their former status and respect aboard steamboats as certified top-grade engineers. Their motives and attitudes form a central part of the safety guard story, and serve as a framework for a proper definition of expertise in the inspection service after 1852. This is the subject of a later chapter.

The next chapter introduces the Franklin Institute and its role in the development of the safety guard, which began as a laboratory apparatus for detecting heat in a boiler.

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destroying the respectability of the business, and cutting down the price of labor so low as not to yield a decent support to those persons who have made the business their study, must finally drive all good men from the ranks; for botches in any business can always find too much patronage." These engineers pushed for "a board of examining engineers in each port of entry… to examine into the qualifications of those persons who are now practising or may heareafter be licensed to practise as steam engineers. The board should consist of the whole body of qualified practical engineers..." *House Ex. Doc.* 145, 27 Cong., I Sess. (1843), p. 14.

CHAPTER 2. THE FRANKLIN INSTITUTE, CADWALLADER EVANS, AND THE DEVELOPMENT OF THE SAFETY GUARD

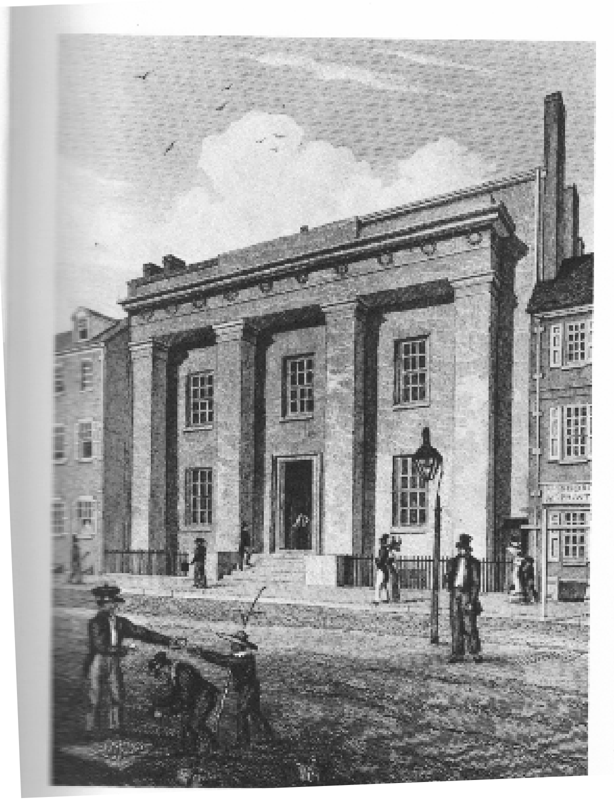
2.1 Introduction

Alexander D. Bache and the Instrumental Need to Measure Temperature in the Boiler

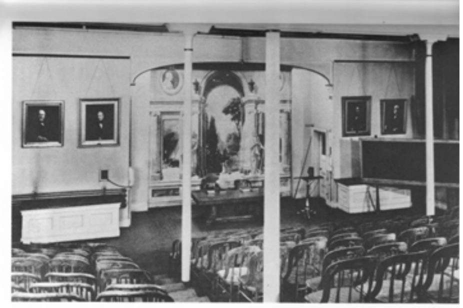
Evans's safety guard was more than a mere appliance. It represented the alliance of science, invention, and government in the nineteenth century, an alliance that sought to elevate the mere collection of facts and theories about steam boiler explosions to a more systematic discovery process. The pursuit of this discovery process employed scientific principles borrowed from Europe and the translation of this process into policy enforced through law. As in Europe, American scientists preferred that remediation for explosions be imposed from above, that is, through a top-down process passing from the country's elite scientists and legal institutions to the engineer in the factory or engine room of steamboats. There was a hierarchy of roles: The scientist's role was to discover phenomena and relationships through fact-finding and experimentation in the laboratory; the inventor's was to assist in the translation of scientific concepts into actual working instruments and machinery; that of government officials and legal minds was to weave all of this into law and ensure that the technical mandate was scrupulously carried out. With the Evans's safety guard, we can clearly see all of these roles in action over a period of roughly three decades from 1830 to 1859.

To establish the fact that the technical aspects of the safety guard were primarily a product of the United States scientific establishment, and in particular of the Franklin Institute of Philadelphia and its academic and government network, we will show the relationship of the ideas behind the invention to prominent Institute scientists and their engineering and mechanical experts (Fig. 10). We will also show how these ideas were conveyed to the inventor himself, Cadwallader Evans. It was Evans who refined and improved the safety guard concept and who was allowed to reap the benefits of a government monopoly through a clause in the boiler regulation of 1852. In this evolutionary process, Evans was guided primarily by the Institute's Committee on the Explosion of Steam Boilers, founded in the spring of 1830. We will also establish the fact that legal aspects of the safety guard were grounded in the conclusions of the Committee. This will be shown by the relationship of the important legal code of 1852 to chief scientist Alexander Dallas Bache's "pressure principle," which stipulated that mechanisms like the safety guard had to meet certain technical requirements--requirements that had emerged from the Committee's published findings in 1836.

A larger story emerges from this connection between the Franklin Institute and Evans's device, however, and this story explains the path that the safety guard would take throughout its career in both the laboratory and on board steamboats. A central argument of this chapter is that the famous series of experiments undertaken by the Committee between 1830 and 1835 were from almost the beginning integrated (i.e.,



Library of the Franklin Institute, Seventh Street building, c. 1920 (courtesy of the Franklin Institute).



Lecture hall of the Franklin Institute, Seventh Street building, c. 1920 (courtesy of the Franklin Institute).

Figure 10. The Franklin Institute of Philadelphia, founded 1826.

designed in an interlocking fashion) for the purpose of achieving one primary goal—to create a practical safety device that would supersede the common safety valve, which Bache considered defective. This is in contradiction to the common impression given that the experiments constituted a "shotgun" approach to discovering the causes of explosions. Further, we will show that the whole intent of the experimental program by 1831 was to use the prevailing thermodynamic theory of the day, the theory of caloric, to focus on heat as the ultimate cause of explosions (and to de-emphasize proximate causes and other phenomena that *were not* heat centered), and to demonstrate that the only valid safety device was one that sensed heat and provided a mechanical remedy to alleviate it.

There are three reasons why historians have missed this underlying focus of the Committee: (1) the focus was not explicitly discussed in the Franklin Institute's published work, probably because attributing a single cause such as heat to explosions at that early date would have been presumptive and controversial; (2) the Committee's final report was technically difficult, reading like an extended laboratory report of experiments and lacking general features; and (3) historians have lacked context because they had no exposure to the NARA records. These records show that the majority of time and effort Institute scientists (and later, their government sponsors) spent on technical issues of boiler safety revolved around a specialized material for detecting heat: French "fusible alloy." Evans's safety guard depended on this material to sense and communicate dangerous levels of heat to the invention's alarm mechanism.

In pursuing these aims, as with the Franklin Institute's earlier waterwheel experiments, a more exacting scientific process was needed whereby heat could be precisely measured and ameliorated. Evidence that this occurred can be found in the activity of the Committee as well as a careful examination of the types of experiments its members conducted. The Committee's chairman, Alexander Dallas Bache (1806-1867), built specialized temperature measurement tools and techniques, supervised empirical studies to determine the effect of heat on steam pressure, and painstakingly analyzed fusible alloy as the best material suitable for a heat detector and alarm mechanism. Bache even created his own crude safety guard in 1832 as an improvement over the safety valve and then guided Cadwallader Evans through his inventive process to perfect the idea. Walter Johnson, a professor of chemistry, worked closely with Bache and ran elaborate and exacting experiments on the evaporative characteristics of water in contact with red-hot iron in which it was assumed that heat transformed water into "ebullient" steam.

Even the Committee's non-heat-related investigations of theories of explosion were geared toward development of a heat-sensing fusible alloy safety device: experiments investigating pressure buildup in the boiler; investigations of common water-supply deficiencies; strength of materials tests of boilers; principles of boiler design; and tests of explosion theories postulating hydrogen gas and electrical phenomena.

Evidence that the Institute's patron, the Treasury Department, followed the Committee in single-mindedly urging the use of fusible alloy safety device can be found in the NARA records. All through the 1850s, the Department and its inspection service defended fusible alloy against hostile criticisms by engineers that the alloy was defective. These officials commissioned expensive investigations of its weaknesses, and went to elaborate lengths (including theft) to reformulate its patented formula to shore up its reputation with the steamboating community. Department officials pushed their Board of Supervising Inspectors to incorporate the use of fusible alloy and to bar engineers from interfering with the safety guard mechanism that employed it. One engineer who had been caught engaging in this activity in 1859 was prosecuted in federal court as an example to other engineers.

Evans summed it all up in 1850 when he accentuated the operative word and the stratagem it represented: "HEAT is the only effective, practicable and sure principle to be adopted as the means of preventing explosions."

Thus, from 1830, the new paradigm of steam boiler safety was to be a thermodynamic one, summed up as follows: *Heat was the ultimate cause of explosions (pressure was only the proximate cause); and the common safety valve, operating as it did based on pressure, was defective and should be superseded by a better device that sensed heat.* The fact that the boiler investigation was dedicated primarily to creating a single new invention confirms historian Bruce Sinclair's statement that the orientation of the country's only scientific research institute during this period was "useful research, as opposed to pedantic theorizing, [depending] upon a new and dynamic combination of science and craft skill."[53] The Institute's predilection for practical experimentation and invention also provides a deeper level of granularity in characterizing the expertise of the Institute as it was conveyed to the steamboat community. Although this communication process turned out to be flawed (the Committee's results were not widely disseminated for some years), the techniques employed throughout the investigation centered almost entirely on empirical data gathering and not esoteric theory. The Institute's science was fundamentally practical; it was devoted to its traditional charter of improving American inventions and manufactures of national importance so that American goods could compete favorably with Europe's.[54] Steam technology was a prime example of a national product that was in need of improvement, and the safety guard was the Institute's answer to the much-needed improvement of the most risk-bound of these, the steam boiler.[55]

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[53] Sinclair, Bruce: *Philadelphia's Philosopher Mechanics: A History of the Franklin Institute, 1842-1865.* Johns Hopkins University Press, Baltimore, 1974, p. 137.

[54] Sinclair (1974), ibid., Ch. 4 and p.100.

[55] Sinclair (1974), ibid., notes the various motives of the Franklin Institute in investigating steam boiler explosions: (1) to gain "sustained income and authority," for the Institute's scientists (pp. 191-194); (2) to tackle technological problems of national significance ("The Board of Managers [was] . . . absorbed with concerns of national consequence.")(p.105); (3) to assuage national embarrassment, dishonor, and fear of falling behind in commercial competition with rivals (chemistry professor William Keating had said the numerous accidents "impair[ed] the confidence of the public in the merit of an invention which has shed vast honor on the American name and which has contributed to the prosperity of this country," p. 174); and (4) to favorably compete with British and French manufactures and scientific institutions (Sinclair noted that Institute leaders saw "a critical need to stimulate the improvement in techniques which would raise [production] to a competitive, if not dominant, position at home and abroad," (p. 105), wished to "lift American manufactures from languor and technical backwardness to efficiency and prosperity," (p. 99) , strove to outdo the Europeans by means of domestic exhibitions that were meant to "encourage manufactures equal to or superior to the imported article." p.100, and desired to command international notice and respect for American scientists, p. 195). The Institute was the logical organization to undertake the boiler investigation because of its geographic location (Philadelphia was the iron-making and steam center of the United States) and because of its leaders' connections with European scientific and government institutions. These foreign institutions (particularly France) had developed early boiler codes of their own and had had much experience regulating stationary (land) boilers.

The Steam Boiler Investigation, 1830-1835

To show that the safety guard was a product of the scientific establishment, and that heat was the primary focus of its experimental program, let us turn to the Franklin Institute's steam boiler investigation of 1830-1835.[56] The investigation consisted of a carefully designed set of experiments meant to engage the results of preliminary fact-finding efforts by the Institute from 1825 as well as a similar survey of manufacturers, engineers, and steamboat observers gathered by the Treasury Department over the same period.[57] Ostensibly, the experiments were to focus on proving or disproving prevailing theories of explosion as well as to investigate fundamental physical phenomena associated with boilers. The experimental design was in large part to favor the investigation of a negative premise: The effect of the experiments, it was hoped, would be to "turn the minds of ingenious men away from false hypotheses." The Committee set out to show "not only what are some of the

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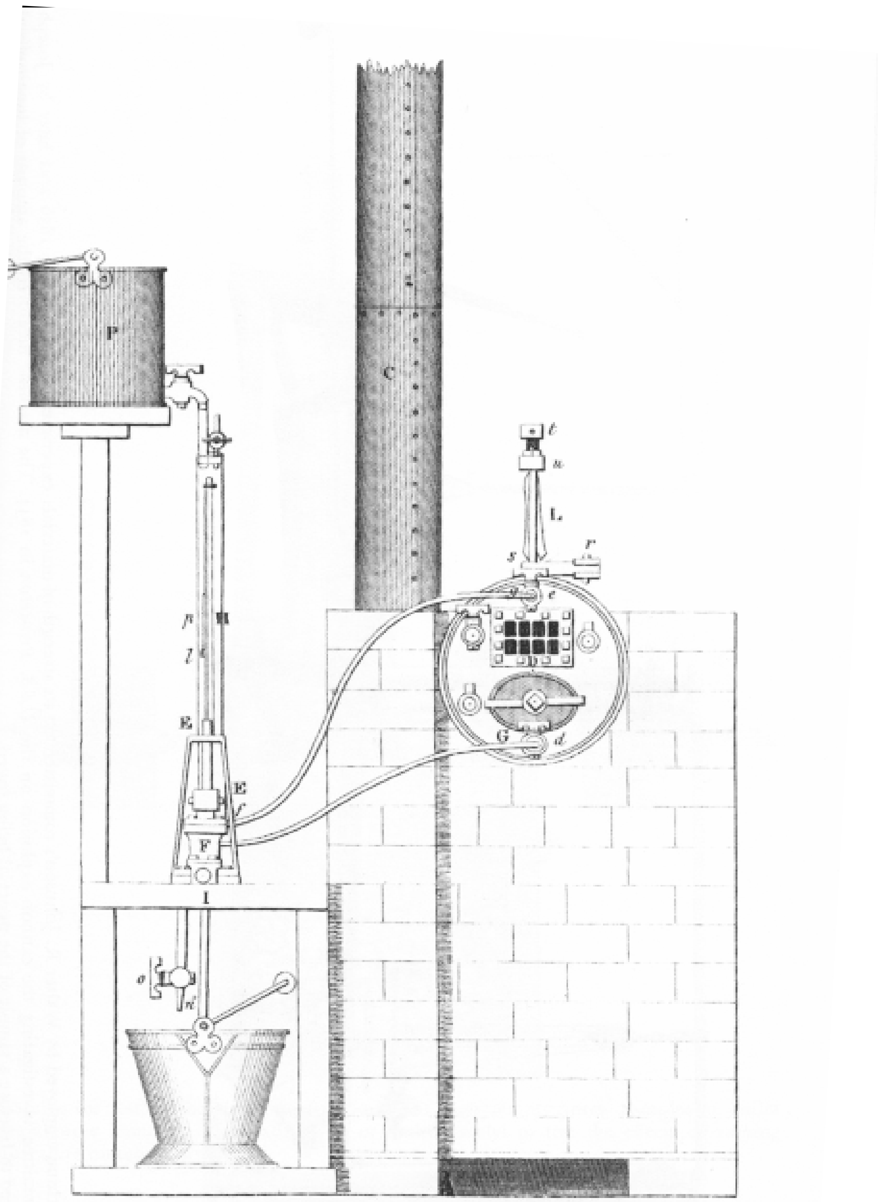
[56] This thesis offers a brief summary of the Institute's investigations; to learn the full details, consult Sinclair (1974) and the Journal of the Franklin Institute reports in two parts (1836) (see bibliography). Alexander D. Bache (1806-1867) led the investigation, which consisted of a committee of scientific and engineering experts: professors of chemistry William H. Keating (1799-1840), Walter R. Johnson (1794-1852), Robert Hare (1781-1858), Thomas P. Jones (1774-1848), and Dr. John K. Mitchell (1793-1858); Professor Robert Patterson (natural philosophy and mathematics); civil engineer George Merrick; fire-engine manufacturer Samuel V. Merrick (1801-1870); engine manufacturer James Rush (who managed Oliver Evans's Mars Works after Evans's death in 1819); type-founder and industrialist James Ronaldson; waterworks engineer Frederick Graff; iron manufacturer Benjamin Reeves; attorney George Fox; machinist and engraver Matthias Baldwin (1795-1866), who would go on to build locomotives; and meteorologist James P. Espy (1785-1860). The subcommittee conducting the experiments was made up of Bache, Reeves, Keating, Baldwin, Lukens, and Merrick. Most of these men had connections to the University of Pennsylvania and the Franklin Institute, and by the time the investigation was underway, to key Treasury Department sponsors. Dates are from The *Dictionary of American Biography* (Oxford 1999) and other biographical sources. Facts on committee composition are from Sinclair (1974), pp. 175-177.

[57] Results of the Customs Service's fact-finding initiative can be found in *House Report* 478, 22 Cong., 3 Sess., dated May 18, 1832, under the title, "Steamboats." When the Treasury Department learned that the Franklin Institute was conducting its own survey, the two factfinding efforts were consolidated. See Sinclair (1974), p. 176.

causes of explosion, but… what are certainly *not* causes."[58] The more popular suspected causes were: (1) hydrogen gas accumulated in the boiler, with witnesses reporting a mysterious "blue flame" just before explosions, (2) the flash theory, in which cold water injected into the boiler to increase the water supply made contact with hot metal, causing a sudden "ebullion" of steam pressure, (3) electrical explosion caused by lightning or other electrical phenomena, (4) overheating due to an insufficiency of water covering the hot flues, (5) steamboat hull design characteristics—i.e., careening (the tipping of the boat as passengers or animals crowded to one side of the boat; this disturbed the equilibrium of the boilers and emptied the water out of the uppermost boiler, exposing the flues to heat), (6) poor boiler design and construction, including the use of cast iron instead of wrought iron heads, copper versus iron plate, inadequate stays affixing the flues within the boiler shell, rivet damage from poor manufacturing processes, and poor quality iron plate.

To test the theories, the Committee commissioned the construction of two small test boilers, one of which contained a glass window for observing the internal activity of heated water and steam; it also set up full-sized boilers in a quarry for the testing of safety devices (Fig. 11).

[58] Journal of the Franklin Institute (JFI) 1836 Final Report of the Committee on its investigation of steam boiler accidents. Franklin Institute leaders recognized that the main problem was the deficiency of information regarding explosions: Bache wrote, ". . . of the numerous explosions on record, few are made to subserve the cause of humanity by a knowledge of their proximate causes." Sinclair, p. 173.



End view of the experimental boiler, showing the glass plate through which the effects of the foaming action of water could be observed and the pump which supplied the boiler with water.

Figure 11. Franklin Institute experimental boiler, 1830.

The Committee's leader and the scientist who personally conducted the experiments was Alexander D. Bache (1806-1867), professor of natural philosophy (physics) and chemistry at the University of Pennsylvania (Fig. 12).[59] He was a rising scientist and academic reformer, having graduated from West Point first in his class in 1825, served in the Army Corps of Engineers from 1826, and received an appointment at the University of Philadelphia in 1828. His family connections to prominent Philadelphia scientists and politicians placed him squarely in the circle of Philadelphia's political and scientific elite: he was a great-grandson of Benjamin Franklin (1706-1790); his uncle, George Dallas (1792-1864), was vice president in James Polk's administration; and his grandfather, Alexander James Dallas (1759-1817), was Secretary of the Treasury under President James Madison (1751-1836). Most significantly, Bache was a powerful and charismatic scientific and educational reformer, and his chief claim to fame was his role in professionalizing the United States' most prominent scientific institutions. These included the American Philosophical Society (1830s), the Coast Survey of the United States (1843), the Lighthouse Board (1844), Office of Weights and Measures (1844), the Smithsonian Institution (1846), the American Association for the Advancement of Science (1850), and the National Academy of Sciences (1863). Bache's organizational skills and Whiggish vision of institutional science shaped his approach to reform. Over the next few decades, he upgraded staffs to a more credentialed scientific status, created a niche for the employment of professional scientists, modeled a framework for

[59] "The [steam boiler reports] are published under the direction of a committee, but the experiments were entirely made by Prof. Bache." Sinclair (1974), p. 188.

Figure 12. Alexander Dallas Bache (1806-1867). In the days of the boiler investigation (left, 1836), and as the dean of American scientific institutions (right, 1860).

organizing scientific research on an institution basis, and gained political patronage and funding for American scientific institutions, bringing them into line with similar institutions in Europe.[60]

Bache was the chief of the "Lazzaroni," or "scientific beggars" of Philadelphia, a group of ambitious scientists who sought to professionalize science in the antebellum period. The Lazzaroni hoped to achieve this by acquiring full-time employment status for scientists; promoting a research ethic geared toward advancing esoteric and specialized bodies of knowledge (rather than the merely practical); developing a service ideal aimed at gaining support from the public; embracing commonly shared high standards of quality; and devising a means of formally certifying scientists. All of this activity was closely allied with Bache's interest in reforming educational institutions to make them compatible with his new vision of a professional scientific cadre. On the individual level, Bache advocated economic and moral development as part of a Whiggish religious attitude toward society and the individual. He wished to cultivate "habits such as industry and prudence that individuals developed in the process of working toward material ends [and] also supported the higher moral growth of the individual."[61] These principles of moral responsibility and service would similarly suffuse the steamboat inspection service two decades later and lend that institution its essentially Whiggish character in its founding years.

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[60] American National Biography, Vol. 1, Oxford, 1999, p. 819.

[61] Slotten, Hugh R.: "Science, Education, and Antebellum Reform: The Case of Alexander D. Bache." *History of Education Quarterly*, Vol. 31, Issue 3, Autumn 1991, pp. 323-342. In the article, the author also notes that historians of science have argued that the antebellum period saw the launching of American science, and he argues that Bache advocated the intervention of the public sector through central planning of internal improvements, public schools, and commercial policy.

In beginning the boiler investigation, Bache's first goal was to explore the most common refrain heard from the survey respondents: that the root cause of explosions was excessive heat caused by low water in the boiler. Some engineers believed that when the boiler's internal flues became overheated, the iron gave way as steam pressure increased to dangerous levels. Engineer and inventor William C. Redfield, for example, wrote that "the deficiency of water is always to be considered a source of danger, and of certain injury to the boiler."[62]

There were two conditions that were thought to cause a dangerous buildup of heat. These were (1) stops at steamboat wharves and landings, and (2) "careening." Stops at steamboat wharves and landings exhausted a boiler's water supply, uncovering the flues. As J. P. Van Tyne wrote, "[During] the temporary stopping [of] the boat… It is evident that the contents of the boiler must soon become exhausted, exposing the boiler to intense heat."[63] Careening was a situation whereby live deck loads such as people or livestock moved to one side of the steamboat at the wharf (Fig. 13). The steamboat then rotated about its long axis, causing the water in the boilers to pass through an interconnecting pipe from the outboard boilers to the inboard ones. This in turn caused the water level in the outboard boilers to drop below that of the flues. When the boat righted itself, water re-covering the flues was thought to generate catastrophic steam pressures.

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[62] The respondents were professors of chemistry, practical engineers, engine-builders, boat operators, and passengers. Redfield quote, see *House Ex. Doc* 21, 25 Cong., 3 Sess. (1838), p 435.

[63] J.P. Van Tyne: *H. Ex. Doc* 21, p. 392.

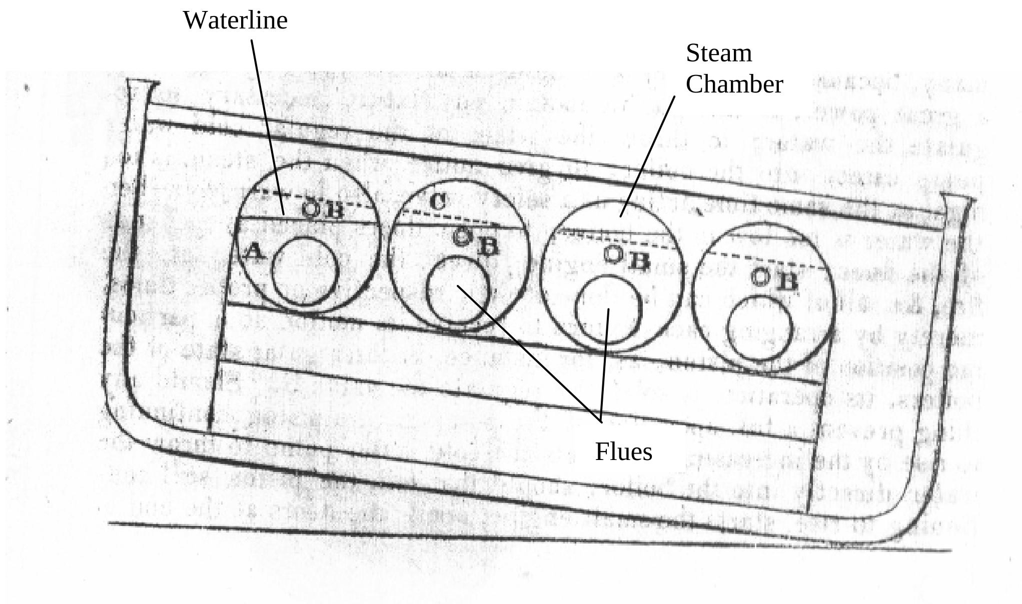

Figure 13. Careening.

At stops and landings, a working forcing pump (also called the "doctor") was thought to be the answer for keeping up the water supply, but the pump was mechanically dependent on the steamboat's engine. At river landings, the engine did not run. Therefore, because a steamboat made frequent and extended delays at such stops, the water level often fell low enough to uncover the flues, allowing the intense heat to weaken them.[64] In 1830, one engineer, Eben A. Lester, attributed a steam boiler explosion aboard a low-pressure steamboat in New York harbor to the forcing pump being out of order. "The water had not been kept up," he reported, and when repairing the boiler, he found the iron to be "hard and brittle in those parts where it was much exposed to the heat."[65]

At routine stops and landings, the engineer typically tried to relieve steam pressure caused by overheated iron by opening the safety valve or by injecting cool feedwater. Professor James Renwick believed the opening of the safety valve in such cases actually *caused* explosions rather than prevented them.[66] Bache knew of Renwick's theory, and focused on it when considering the deficiencies of the safety valve:

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[64] One recourse was to resort to "clumsy and wasteful practices such as keeping the paddle wheels in slow motion at the landing, or moving the vessel in a circle while passengers and cargo were carried to and from the shore in yawl or flatboat." Hunter, SBOTWR (1949), pp. 161-162. There are numerous examples in the literature from the early 1820s of scientists and engineers holding the view that the interruption of the water supply injured the boiler iron. Thus, a concentration on making the forcing pump independent of the engine was a prime strategy for achieving safety by the 1830s. See *H. Rpt* 478 (1832), p. 61.

[65] *Loc .Cit.* The Steamboat was the *Legislator*.

[66] James Renwick (1792-1863), professor of natural philosophy and chemistry at Columbia College, New York, focused his career on "disseminating and applying scientific knowledge of direct economic relevance for the early American republic." In addition to educating students, he "served as a scientific consultant on numerous engineering projects and brought in new scientific knowledge through editing and writing." American National Biography online, http://www.elmhurst.edu:8413/articles.

> "… the escape of steam [from opening the safety valve … relieves the water within the boiler from pressure; the fluid rises in foam; and being thrown into contact with the heated sides of the boiler, (or, as is supposed by some, being projected into the hot and unsaturated steam,) is flashed into steam, too considerable in quantity to find a vent through the valve, and of an elastic force sufficient to defy the controlling power of the materials used in the construction of the boiler."[67]

In this case, the safety valve, ironically, became a liability to safety. As Bache declared, "[the safety valve] not only ceases to deserve the name of *safety* valve, but the opening of it, by hand, may be the very means of producing an explosion."

Bache's Emphasis on Heat; the Program of Experiments

Bache's distrust of the safety valve soon translated into a search for an alternative. His search was a departure from traditional perceptions and approaches because it concentrated on *heat*, not pressure, as the root cause of explosions. To Bache and his committee, the steam engine was a practical version of the ideal heat engine with its conveyance of "caloric" through the boiler and engine to do useful work (viewing heat as a moving fluid). The traditional emphasis by practical engineers on pressure, which focused on strength-of-materials limits of the boiler shell, was helpful in

[67] This was called the "flash theory of ebullient steam." Bache, "Safety Apparatus for Steam Boats," JFI Vol. VII (new series), No. 4, April 1831, p. 217 (erroneously labeled page 28 in the article).

designing more robust boilers. However, this approach avoided underlying scientific principles of heat theory. These principles could be used to understand what was happening physically and chemically in the boiler and how heat could cause the production of water-foam, high steam pressures, and fatigue in interior metal parts such as flues. Therefore, through its experimental program the committee sought empirical information characterizing the phenomenon of heat in a working boiler, and from this, a better practical understanding of the role of heat in explosions.

It was with these thoughts in mind that, by 1831-1832, Bache undertook a series of experiments that would provide the data that would allow him to measure and limit the amount of heat in a boiler using a “perfect thermometer” as instrumentation. The strategy behind the experiments was to protect against a careening scenario. This would be accomplished by (1) beginning with the known tensile strength of a typically sized boiler shell; (2) determining the pressure of steam generated when a quantity of red-hot metal was placed in contact with a quantity of water (simulating when a careened boat was righted); and (3) limiting the temperature of the boiler to some margin of safety below that which could produce pressures exceeding the boiler’s tensile strength. The outcome of the research program would be a temperature-limiting device that would be superior to the common safety valve.[68]

The prototype device that eventually emerged was not an incidental product of the investigation but rather a key product of the Committee’s experimental strategy. This is a crucial point that has been overlooked in the historiography. There was a pivotal connection between the Committee's experimental program, the tangible need to improve existing safety devices, and the evolution of Bache-Evans's safety guard as a temperature-limiting device. Further, Bache strove to develop his device with the view in mind that it would act in a last-ditch capacity to prevent explosions—with or without an operator's having conscious control of the machinery. He believed a self-acting safety device based on heat would activate long before the boiler reached a dangerous condition of high steam pressures.[69]

The Institute was well equipped with the various types of experts required to carry out not only the experimental program but also the fabrication of the safety device. For example, Institute scientists could relate temperature to pressure, make precise measurements of heat, and calculate strength of materials of the various boiler types. Practical men (including solicited inventors) would assist with the calibration of an alarm mechanism as well as design and build the prototype mechanism that would connect the heat sensor to the alarm.

An important aspect of the experimental program was that analysis would be exacting and quantitative. Any builder, engineer, or inventor could treat the qualitative symptoms of dangerous conditions arising within the boiler—i.e., by inventing

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[68] At first, Bache thought a simple plate or plug designed to melt at a low temperature would serve the purpose. It was found, however, that these had problems and a more intricate device (a safety guard) would be needed.

[69] The experimental strategy is not explicitly stated in the JFI and Congressional reports, but was reconstructed by the author based on the types of experiments making up the Committee's experimental program, along with the evolutionary details of the safety guard.

devices to alert the operator to secondary conditions, such as the low-water condition. However, without the scientist's theoretical-instrumental approach, such devices could not possess the precision required to prevent explosions. Scientists would be able to quantify the processes at work in the boiler in order to prevent explosions, and this would lead to an effective device.[70]

Bache's Investigations of French Fusible Alloy as an Improvement over the Common Safety Valve

Focusing on Renwick's flash theory and the careening phenomenon for the first set of experiments, Bache's committee set out in 1831 to measure the evaporative effect of a mass of red-hot metal on a quantity of cool water. Immersing heated iron samples in water, principal chemist Walter Johnson derived a set of relations between the weight and temperature of the metal and the amount of steam generated.[71] He calculated that within a typical boiler, for every nine pounds of iron heated to a red heat, a quantity of water (representing the amount of water required to cover the flues after a careening situation occurred) added one pound of atmospheric steam to the boiler. This translated into an enormous pressure amounting to 906 pounds per square

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[70] An analogy of the Institute's empirical-quantifiable approach can be made to its earlier waterwheel experiments at Philadelphia's Fairmount Waterworks (see Sinclair [1974], p. 144). Any design that was not based on a quantitative approach would only be an approximation; the design could not be optimized. In the case of boiler safety design, the situation was even more critical; an approximation when dealing with the vagaries of temperature and pressure in a confined pressure vessel had more import than simply increasing the efficiency of the design. Inexactitude could be catastrophic.

[71] Professor Walter Johnson (1794-1852), professor of natural philosophy and chemistry at the University of Pennsylvania, and principal of the Institute's celebrated high school.

inch. He published tables of his findings in a report to Congress.[72] Sinclair did not mention these important experiments or their connection with Johnson's later work on the strength of materials aspects of boilers. However, Johnson's early evaporation experiments were the first step in the Institute's attempt to understand heat as a thermodynamic property of boilers, as well as an attempt to put boiler chemistry on an instrumental, quantifiable footing.

Meanwhile, while Johnson was conducting his experiments, Bache was concentrating on making accurate measurements of temperature in the test boilers. French scientists had developed specialized mercury thermometers for this purpose. One thermometer was placed deep inside, in the boiler water, and another was placed only a short distance into the steam chamber. The method of protecting the thermometers was to isolate them from steam pressure using sealed gun barrels. An 1829 French report gave the reasons for protecting the instruments in this manner: "The thermometer… was not to be directly exposed to the pressure of the steam, for if even it could bear it without breaking, it would have been necessary to keep account of the effect of compression [from the steam pressure] which it would have been difficult to estimate. To obviate this inconvenience, two gun barrels were introduced, shut up at one end, and thinned so much as to leave only the resistance necessary not to be crushed during the experiments."[73] Bache reported that the French tubes had their limitations. He wrote, "…The fragility of the instrument, its inconvenient length, or position in

[72] See *H. Rpt.* 478 (1832), approximately pp. 100-104.

[73] See *H. Rpt.* 478, (1832), p. 155, which included the report of the French Academy of Sciences, dated 1829.

certain cases, and its not acting as an alarm, are the principal objections to its use."[74] The operative words in this selection, "not acting as an alarm," clearly indicate Bache's intent to build an alarm that reacted precisely to heat.

If the French thermometer would not serve Bache's purposes, then what would? An alternative was French fusible alloy. Plates made of this alloy were already in service on French industrial boilers as a complement to the safety valve. They offered an attractive substitution for the conventional thermometer because they were robust, could be placed anywhere desired in the boiler, and could serve to activate an alarm. In addition, in theory they could be made to melt at a precise, pre-selected temperature. The plates became Bache's next object of investigation.

Fusible alloy plates were a mandated safety device in stationary (mill and factory) boilers in France from 1823 (Fig. 14). The plates were composed of a "eutectic" alloy of lead and tin, were about 8 to 10 inches square, and were thin (between 0.04 and 0.15 in.). They were applied with screws to cover one-inch diameter relief holes in the outer shell of the boiler, just below the water line; often they were placed on the interior flues because the greatest heat occurred there. The plates were designed to melt upon the boiler metal's exposure to the heat of hot combustion gases (either directly through contact with hot metal if the flues were uncovered, or indirectly if heat built up excessively in the water surrounding the flues).

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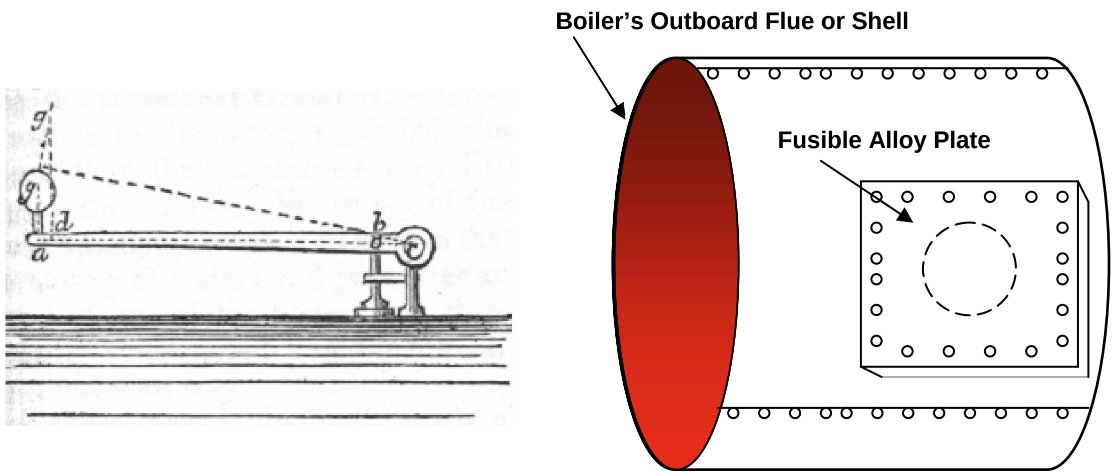
[74] "Report of the Committee… on the Explosions of Steam Boilers," JFI, Vol. XVIII (new series), No. 5, November, 1836, p. 297.



(a) Common safety valve.

(b) French fusible plate.

Figure 14. Common safety devices before 1831.

Upon melting, the plates would rapidly release steam pressure (the sound issuing forth from this operation was sudden and was described as a “loud blast”). These were “one time use” devices; they required replacement at a steamboat landing after the boiler had cooled down. What made the plates highly sensitive as thermometers was the fact that the melting point of the alloy could be altered by changing the proportion of its constituent metals. In considering them for his heat monitor, Bache wrote in 1831 that “Experience has shown that these plates can be relied on, confidently, to answer the ends proposed.”[75]

The Committee could now select the appropriate formulation of fusible alloy to limit the boiler’s operating temperature using Professor Johnson’s heat calculations. The final task would be to make it possible to reuse the alloy and also make it easier to alert the captain and passengers of an overtemperature situation. What emerged was the first crude safety guard.

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[75] In the JFI article in question, Bache summarized the history of these plates: “The French Academy, when called upon, in 1823, to report to their government, the precautions to be used to prevent the explosions of steam boilers, satisfied of the insufficiency of the common valve to insure safety, required that in addition to two safety valves of the ordinary construction… there should be two plates of fusible metal covering apertures in the boiler… whether the steam be very elastic or not, so soon as it, or the boiler, arrives at the temperature requisite to fuse these plates, they melt, and the steam is discharged; this, too, below the limit of temperature at which such as discharge of steam would . . . be attended with danger.” See JFI, Vol. VII (new series), No. 4, April 1831: “Safety Apparatus for Steam Boats, being a combination of the Fusible Metal Disk with the common Safety Valve,” p. 218. On the sensitivity of the plates to temperature, see a compilation of notes of Treasury senior clerk William Gouge, 1856 11: “So very susceptible are fusible alloys of the action of heat, that they form an important part of a very delicate thermometer invented by Dumas for determining the heat of vapors.” A eutectic alloy is one that has a lower melting point than any of its individual constituent metals. Eutectic alloys are useful in modern sprinkler systems because they can be formulated to trigger at a range of relatively low temperatures.

Bache's 1831 Combination of French Fusible Alloy with the Common Safety Valve

Bache's 1831 invention reflected his rejection of the common safety valve (which operated according to pressure) and his elevation of the fusible alloy plate (which operated according to temperature). The result was a hybrid of the two devices, but with the safety valve component effectively neutralized as a safety monitor (Fig. 15).[76]

Details of the device indicate a departure from conventional approaches. Previously, the fusible plate(s) had been located apart from the safety valve. Bache now combined the plate and the valve into one unit and moved it forward to a location where it could be easily monitored by the captain. The new apparatus locked the safety valve in the *open* position using a stanchion ("to raise the valve sufficiently above its seat").

With the stanchion, Bache effectively immobilized the safety valve and used it for an altogether different purpose. When an overtemperature situation occurred, the fusible plate was calibrated to melt, releasing steam through the valve opening, creating a loud noise. The crew, captain, and passengers would be made aware of the problem, and the engineer would seek out the cause and undertake a remedy such as pumping feedwater into the boiler to restore the water level.

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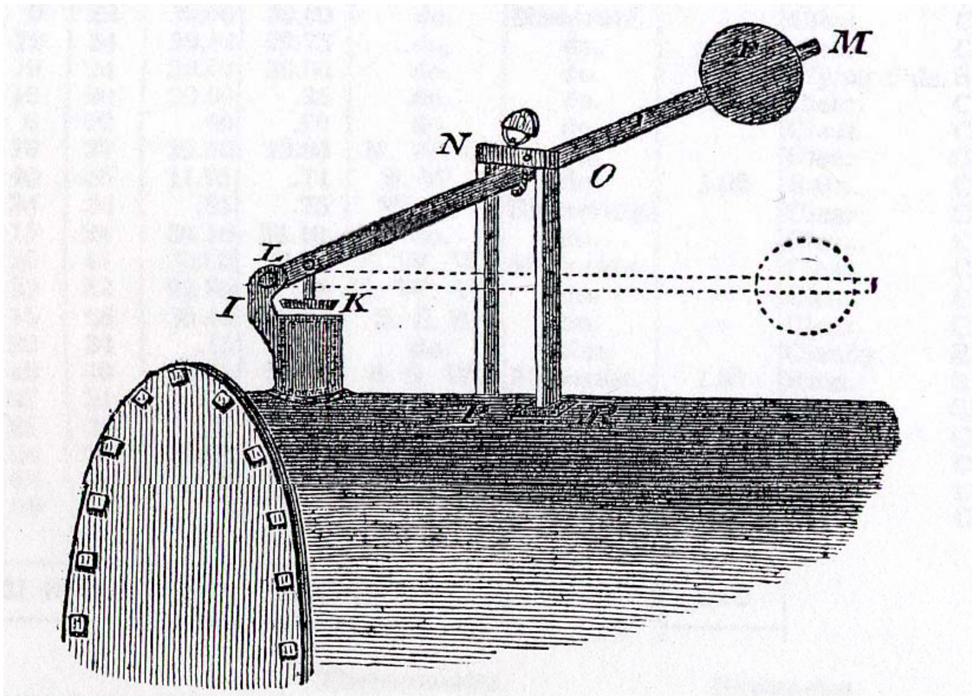
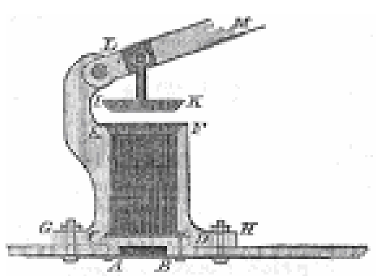
[76] Sinclair's (1974) statement on page 180 is inadvertently misleading: "The committee gave considerable attention to valve design, and Bache himself developed safety devices which acted on both steam pressure and heat to signal an alarm." While the device was designed to react to pressure, this was a secondary effect of heat.





(Detail)

Figure 15. Bache’s combination, 1831.

Why was it necessary to have a safety valve at all in the combination if the purpose was simply to detect high temperatures? Would not a fusible plate alone do the job? The answer is that combining the two components promised to solve a technical problem with fusible plates that was peculiar to marine applications—the ability to restore power quickly after loss of steam pressure due to the melting and blowing out of the plate. Activation of the fusible plates could incapacitate a boat. Bache wrote:

> "The reason why this plate has been considered inapplicable to steam boat boilers… is obvious; when the plate melts, all the steam must escape from the boiler, and the apparatus must cool before it can be replaced by a similar plate; this sudden desertion of the prime mover of the engine might, in certain cases, put the lives of the passengers in almost as great jeopardy as an explosion; instances, in an exposed navigation, will readily occur on reflection, such as a boat on a lee-shore, &c. In all cases such a desertion would be attended with very great inconvenience."[77]

Bache's design allowed the captain to use his key to unlock and close the safety valve, containing the pressure that remained. This allowed the engineer to rekindle his fire and navigate with the remaining reserve of pressure to a steamboat landing to

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[77] JFI, Vol. VII (new series), No. 4, April 1831, "Safety Apparatus for Steam Boats, being a combination of the Fusible Metal Disk with the common Safety Valve," p. 217.

replace the plate.[78] The reason for combining plate and safety valve, therefore, was that the arrangement gave the captain flexibility in maneuvering his vessel to safety, albeit under reduced power. Thus, Bache was changing the safety valve from its conventional role of pressure reliever to that of a propulsion device (an ersatz throttle), an ironic reversal of the device's purpose. A more remarkable irony, however, was the fact that this was precisely the traditionally illicit role assigned the safety valve by tamperers, who needed extra horsepower to move the steamboat along quicker in a race or avoid hazards in the river.

Another benefit of the safety valve/alloy plate arrangement was its tell-tale "guard" function. Situated at the forward end of the boiler, the apparatus would occupy an exposed location. Bache specifically mentions the fact that the engineer would not be able to sneak to the back of the boiler out of view of captain and passengers and pour cool water on the alloy plate to neutralize it, a form of tampering observed by the French. This spying by captain and passengers was in keeping with the prevailing (and somewhat naïve) notion that scrutiny of the engineer would help prevent deadly accidents. More importantly, such thinking reinforced the idea that control must be wrested from the engineers, who on numerous occasions had demonstrated insensitivity to danger in their boilers.[79]

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[78] This valve will be habitually open and when required to be used to prevent escape of all the steam, will be pressed down, as is usual, by a weight acting by the intervention of a lever.", JFI April 1831, Bache: "Safety Apparatus for Steam Boats…" ibid., p. 219.

[79] "This apparatus should be placed upon the boiler as to be seen by the passengers, who are thus enabled to know that all is right…" Bache: Safety Apparatus for Steam Boats… JFI, April 1831, p. 219. Inventions such as tell-tales that warned of boiler troubles through mechanical signals were common ideas before the steamboat act of 1852. See also a government engineer's report on Alfred Guthrie's steam gauge, "I have had an opportunity to witness the operation of new machinery invented

Bache thought that his invention would keep the engineer alert to his responsibilities and this would lead to a weeding out of inferior men: "The vigilance of the engineer would almost be insured by the use of these plates, from a knowledge that his inattention could not escape detection and its consequences. Passengers would be guarded against the results of carelessness, should it exist, and captains, as well as the public, would have the means of knowing accurately the value of those employed in the responsible station of engineers. The want of patronage which would inevitably attend an ill-regulated engine, would soon correct evils now so formidable."[80]

Thus, Bache's invention was an improvement and extension of the simple French fusible plate, allowing it to be adapted to marine use. More significantly, by virtue of the plate being designed to react to temperature and not pressure, it was thought superior to the slower acting safety valve.

Bache apparently did not patent this device, and we are not sure it was ever constructed. Nevertheless, notice of the device evidently served as an inspiration to inventor Cadwallader Evans. After 1831, a flurry of Evans's inventions followed Bache's lead; a host of mechanisms were invented that employed fusible alloy as the central component. Each device was designed to react to heat and relieve steam pressure through a poppet valve, give an audible alarm, or put out the boiler's fires.

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by Mr. A. Guthrie, of this city, for the purpose of preventing Explosions of Steam Boilers, and for conveying to the Cabin, for the benefit of the passengers, an early intelligence of any dangerous stage of water in the Boilers, or of any undue pressure of steam, which may be used by the engineer on any Boat to which the invention may be applied." 1851 12-2 (IMG 1133).

[80] Bache: "Safety Apparatus for Steam Boats…" ibid., JFI, April 1831, pp. 220-221.

Cadwallader Evans, Son of Oliver Evans

Although Cadwallader Evans (1799? – 1854) is a relatively obscure inventor, he was well connected to Philadelphia and its centers of steam technology, including the Franklin Institute. Evans contributed articles and ideas to the *Journal of the Franklin Institute* from 1832, and was likely a collaborator (if only through correspondence) with Bache. It is possible that the two met and discussed their ideas, perhaps at meetings of the Franklin Institute, or at the Mars Works, a large manufactory of steam engines, boilers, and machine parts owned by Cadwallader's father, Oliver Evans. It is certain from correspondence in the *Journal* that there was a cross-pollination of ideas between the two men regarding the development of the safety guard in the crucial years of the invention's emergence in the early 1830s. It is also certain that Evans's safety guard idea made its way into Bache's laboratory during the boiler explosion investigation. It is even possible that Evans built a prototype under contract to the Franklin Institute, although there is no evidence to support this. Leaders of the Institute maintained close relationships with inventors at this time; they organized annual inventor's competitions to promote American inventions. Therefore, it is possible that Evans was a member of this inventor's community.[81]

Cadwallader Evans was one of seven children born to celebrated inventor Oliver Evans. Widely considered America's first truly great inventor, Oliver Evans

[81] Evans's 1799 birth date is conjecture. In his 1850 Treatise on Steam Boiler Explosions contained in the NARA records (the document was written in 1849), Evans stated that he had 40 years of experience in the trade. The assumption is therefore made that he began his apprenticeship in 1809,

(1755-1819) led the development of steam technology in the United States from the 1780s, developing an amphibious steam carriage and dredge called the *Orukter Amphibilos* ("amphibious digger") in 1805, and most famously, inventing the lightweight, high-pressure steam engine that made navigation on the western waters of the United States practicable. Because Oliver was an innovator in engine development from the 1780s, there is circumstantial evidence that he contributed key early engine design and propulsion ideas to pioneer steamboat designer John Fitch.[82]

Oliver Evans also expended his creative energies in industrial enterprises. He began building his first revolutionary automated flour mills in 1785, and, by 1831, Cadwallader's name accompanied his father as an "arranger" on a merchant flour mill driving four pairs of 5-foot millstones (Fig. 16).[83]

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three years after the Mars Works was founded. If we guess that Evans was 10 years old when he began his apprenticeship, this puts the year of his birth at 1799.

[82] On Oliver Evans's novel high-pressure engine, Professor James Renwick mentions in an 1820 reference: "… we must reject the views of Robison and Watt as wholly impracticable; and indeed the impossibility of using the condensing engine was ascertained and admitted by Watt. Evans not only was the first to entertain correct views, but was also the first to submit them to practice." Professor Renwick on Steam Engines, 1820, p. 257, from Evans 1850 Treatise, back cover. Also see an excerpt from "The Scientific Class Book" on the same page: "The high-pressure steam engine invented by Oliver Evans, of Philadelphia, in 1784, and for which he obtained a patent from the State of Maryland in 1787, is the original of all those powerful machines which, for the last few years, have astonished the world with their wonderful performances." Hunter wrote, "It was Evans who in private correspondence, in published writings, and in the public press proclaimed widely the superiority of this type of engine to the conventional Boulton and Watt type and who, years before the introduction of steam navigation in the West, urged the special value of his engine for overcoming the difficulties of navigation on the Ohio and Mississippi rivers (Louis C. Hunter: "The Invention of the Western Steamboat," *The Journal of Economic History*, No. 3, November 1943, pp. 201-220). On the consultations with Fitch, see Sutcliffe, Andrea: *Steam: The Untold Story of America's First Great Invention*. Palgrave Macmillan, New York, 2004, p. 176.

[83] Evans, Oliver: *Appendix to The Young Mill-Wright and Miller's Guide* by Oliver Evans, www.angelfire.com. For reference: *The Young Mill-Wright and Miller's Guide*, Arno Press, New York, 1972 (c. 1834), call no. McK TS2145.E9 1972.

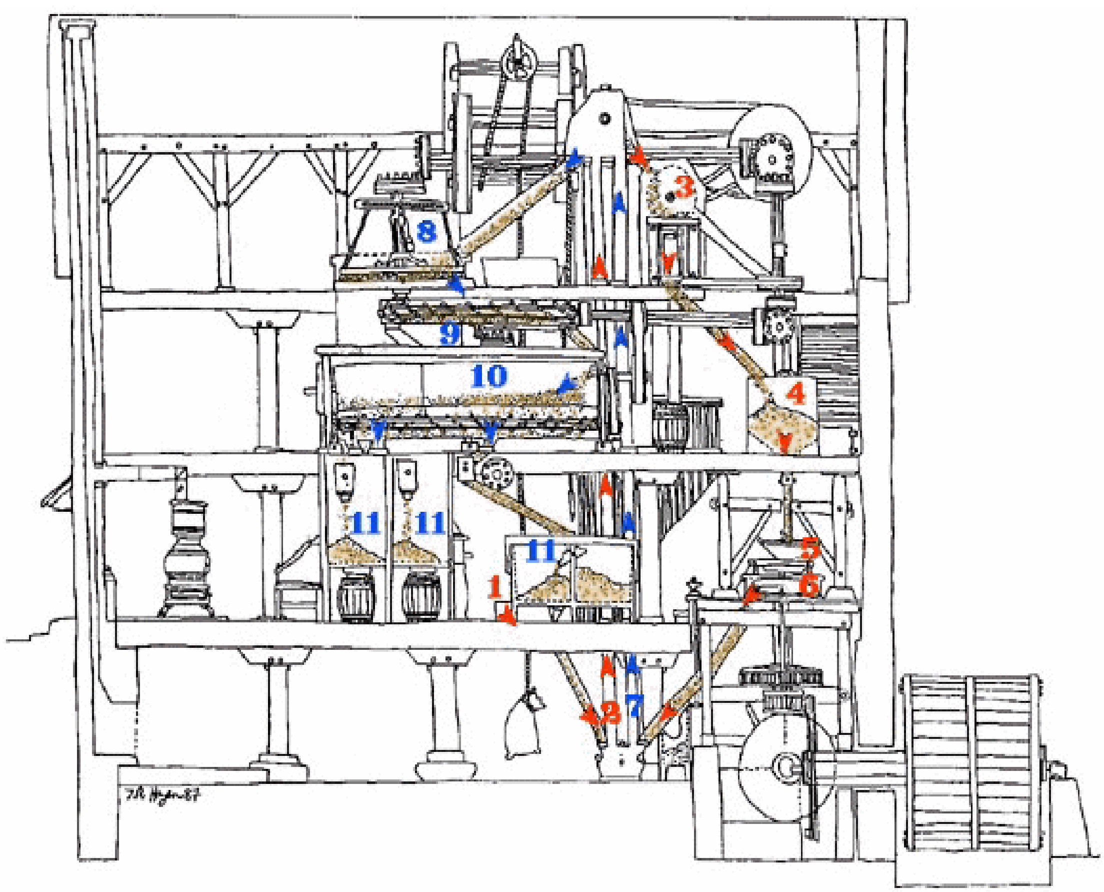

Figure 16. Oliver Evans's automated flour mill. Cadwallader Evans invented an apparatus for tamping the flour into barrels. T. R. Hazen notes that "Oliver Evans would eliminate forever 'the bag and shoulder boys' working in the mills of the time." Oliver Evans improvements consisted of the elevator, the conveyor, the hopper boy, the drill, and the descender. Evans's "New Process" mill became obsolete in the 1840s-1850s when Mennonites from the Ukraine brought hard wheat to the United States (Evans's mill was designed to process soft or English wheat). A surviving Evans mill is currently undergoing a third restoration at Rock Creek Park, Maryland. (Source: Personal correspondence with Mr. Hazen, and his *The Automation of Flour Milling in America*, published online at LycosAngelfire. Drawing from "Peirce Mill Drawing," by T.R. Hazen. "Today at Peirce Mill-How it Works" (text and drawing), Peirce Mill (folder), G.P.O. 1990, reprint 1991, revision and reprint 1995.)

These mills featured a chain of mechanical systems (belts, gears, elevators, rakes, and shafts) that eliminated human intervention at many steps of the milling process. Together the systems facilitated "an integrated, fully mechanized operation, which produced fine flour that was drier and less likely to spoil in a bag or barrel." These mills were unique in that they required only one miller to tend them.[84] It is significant that Oliver Evans became embittered toward the end of his life by his decades-long struggle to protect his estate from the wholesale violation of his mill patents.[85] The problems with patent and license infringement led Oliver to retreat to the manufacture of steam engines, boilers, and machine parts at his Mars Works. As his official biography conveyed, this was hardly the innovative technology Evans was capable of creating but it produced dependable if modest wealth. His health began to fail in 1816, and just before he died, his Mars Works burned to the ground in April 1819. Oliver's frustration over proprietary matters evidently translated into caution in Cadwallader, who later demonstrated much secretiveness over the manufacturing processes of his safety guard's fusible alloy component, compelling the Treasury Department to try to steal his trade secrets.

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[84] American National Biography, Oxford, 1999, p. 617, and see entry for Oliver Evans in The Encyclopedia Britannica, 1964 ed. Theodore R. Hazen (www.angelfire.com) tells of how two millers traveled to inspect Evans's self-acting flour mill on Red Clay Creek in 1785, but found the mill trundling away on its own with no living soul overseeing its operation. The visitors found Evans "working in a nearby field because it was haying time." "The millers had found the mill clean and in perfect working order, and for the most part were greatly impressed. However, the strange sounding machinery to them sounded like 'a set of rattle traps.' " Interestingly, Evans's mill machinery featured a bell alarm on a leather strap that signaled "low grain" in the millstone hoppers; this is similar in concept to Cadwallader's "low water" bell alarm.

[85] As his biography states, "By the turn of the century the Evans method had become widely adopted and yet Evans ultimately spent almost as much money in lawsuits as he made in selling licenses." American National Biography, Vol. 7, Oxford, 1999, p. 617.

It is clear that Cadwallader's interest in developing the safety guard proceeded from his talents and experience with chains of mechanisms for the automated mills as well as for steam machinery developed in his father's workshops. In an 1854 letter, he wrote of his early background: "I was raised and bred up under my father the late Oliver Evans, to the business of Manufacturing Steam Engineer, and as a Machinist generally, I have planned and superintended the construction of many engines for various purposes."[86] In another document, he wrote that, "for the past forty years" he had "labored physically and mentally… with the mechanism and use of the steam engine." "My first lessons were received in the work-shop of my father, Oliver Evans, whose name is identified with the history of high-pressure boilers and the locomotive engine."[87]

Oliver Evans had opened his Mars Works in 1806, and a smaller foundry in Pittsburgh around 1811. We know that Cadwallader managed one of the mechanized steam-powered flour mills there in 1840. Although no records of the Pittsburgh foundry survive, that establishment almost certainly employed Cadwallader as an associate with his brother George Evans by the 1830s. It was George who, from the geographically strategic vantage point of Pittsburgh, started the manufacture and distribution of Oliver Evans's high-pressure engines to the Western country. Writes Hunter of this outpost, "In 1811-1812… [Oliver] Evans was establishing there the first manufactory of steam engines in the West, with his son George in charge of the

[86] See 1854 1-26.

[87] Evans 1850 Treatise, p. 15.

works. Other men quickly entered the new field, and Pittsburgh became the first center of steam-engine and steamboat building west of the Appalachians."[88] Later, Evans wrote that in his formative years he became "well acquainted with Steam Navigation on the Western Rivers, and [had] examined with much care the defects of the engines, such as tend to cause explosions, with a view of pointing out those defects as well as the remedy for preventing such accidents." He added, "I have projected and brought into use many improvements now incorporated with the high-pressure apparatus."[89]

Details of Evans's life and whereabouts are unknown to us during his Philadelphia years - - i.e., between the early years of his apprenticeship at the Mars Works and his move to Pittsburgh. We do know that his interests in steam boiler safety devices intersected with those of Bache's in the pages of the *Journal of the Franklin Institute* in 1832.

2.2 Scientist and Inventor Devise the First Safety Guard, 1832-1850

Evans's Improvement of Bache's Concept, 1832

Within a year of Bache's article in the *Journal of the Franklin Institute* introducing his 1831 combination safety device, Evans put forth several variations of his own

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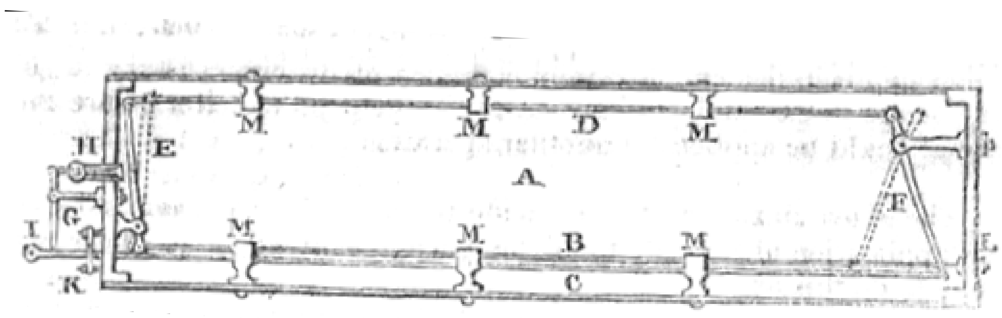
[88] See Hunter (1943). Although there is no documented link between Cadwallader Evans and the Pittsburgh workshop, it is highly likely he contributed his labors to the works because he established his residence in Pittsburgh sometime before 1840 as a base of operation for his start-up safety guard business.

[89] See 1854 1-26; and Evans 1850 Treatise, p. 15.

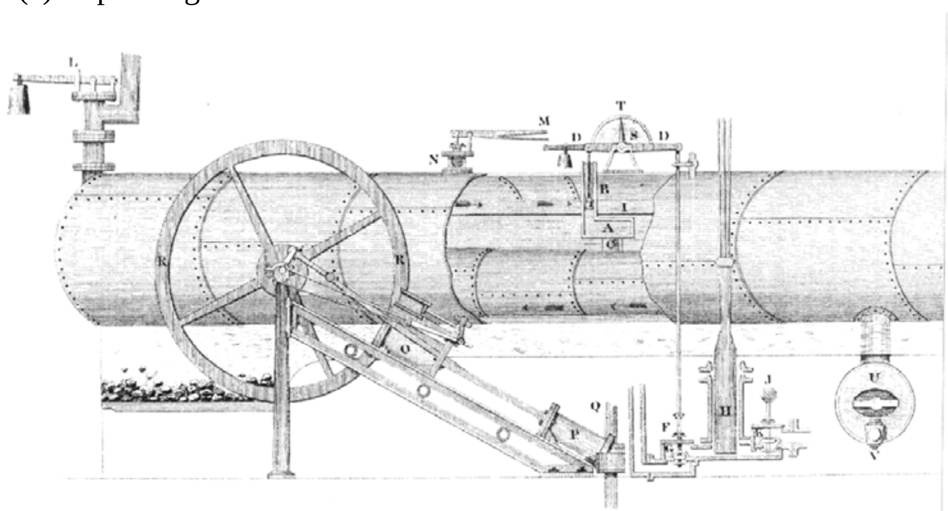
safety devices in a reply article (Figs. 17, 18).[90] These included float mechanisms, differentially expanding rods, a “doctor” pump, and a mercury safety guard. The float mechanisms and the doctor pump focused on alleviating the low-water condition whereas the expanding rods and mercury safety guard concentrated on detecting excessive heat.

Many early safety inventions were based on the principle of flotation. As the water level in the boiler decreased to unsafe levels, i.e., began to uncover the hot flues, a float activated a sequence of mechanical steps to open the safety valve, sound an alarm, or put out the fire in the firebox. But floats had the drawback of being subject to fouling in the harsh interior environment of the boiler. Evans spoke of his struggles with them: “My first attempts [at a safety guard] were various plans for the application of floats, to regulate the height of water in the boilers, as well as to give notice of an undue depression of the water, by opening a small valve, and blowing a horn or whistle, without using stuffing boxes. I succeeded in causing these contrivances to work well, particularly in clear water, but soon concluded that all fixtures arranged to work within the steam and water in a boiler, were more or less liable to derangement by sedimentary matter collecting about

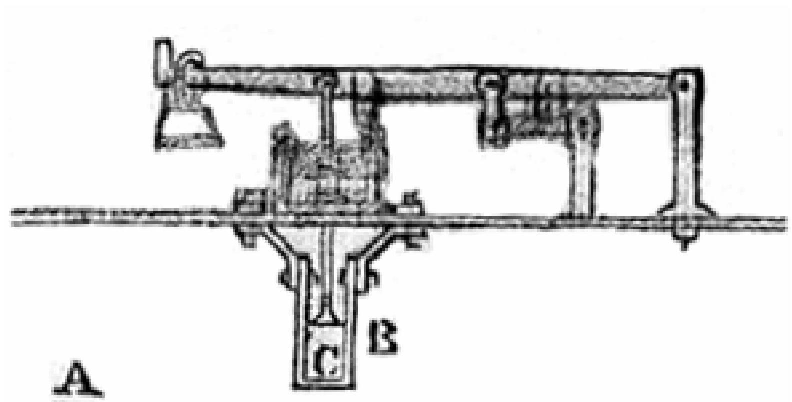
[90] The reply was in response to a solicitation for inventors’ ideas by the Committee. Evans’s article was entitled, “Further observations for the consideration of the Members composing the Committee on the explosion of steam engine boilers, of the Franklin Institute.” JFI,Vol. IX (new series), No. 2, February 1832, p. 93.



(a) Expanding rods.



(b) Mercury safety guard.



(c) Fusible alloy safety guard.

Figure 17. Evans's brainstorming of safety guards, 1832. The third idea caught the eye of the Franklin Institute. The fusible alloy C filled the bottom of cup B. When the alloy melted, the plunger and stem descended, opening a poppet valve and releasing steam.

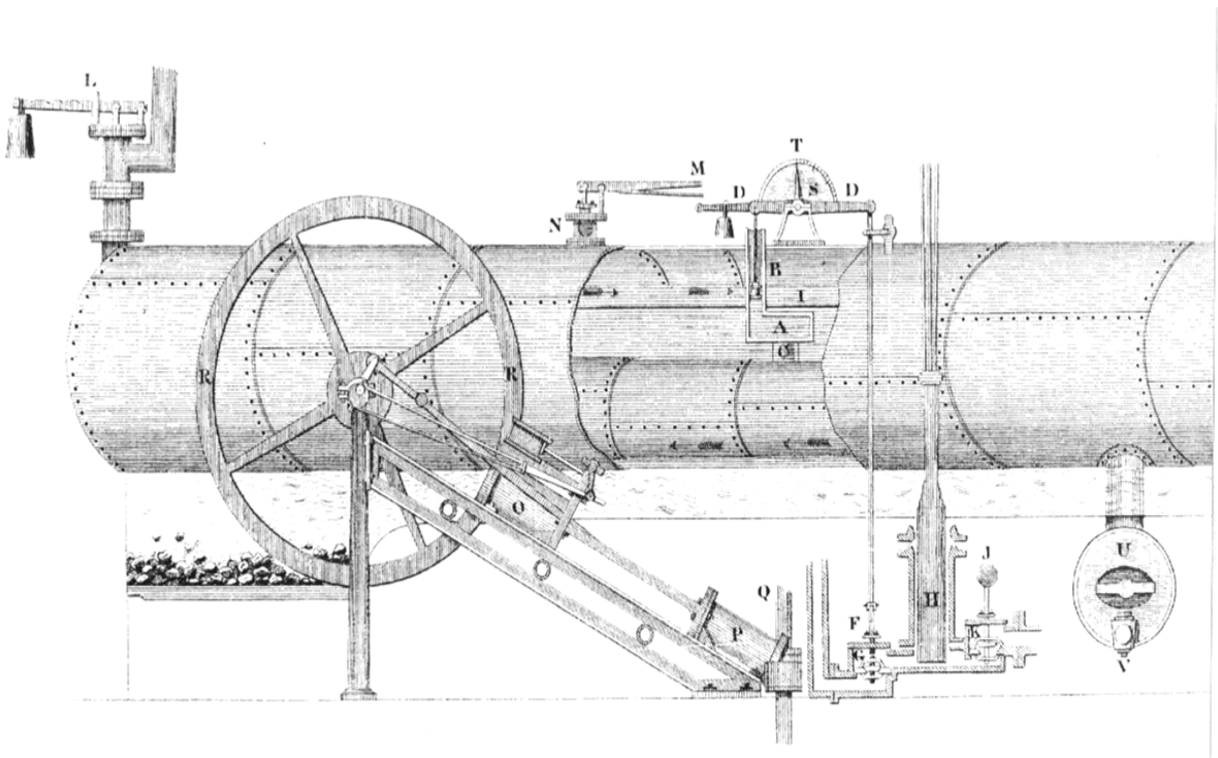


Figure 18. Close-up of Evans's mercury safety guard (1832). The mercury was confined in a cup (see A). The expansion of mercury activated a plunger, which opened poppet (F) and safety valves (N) to release steam pressure, and simultaneously started a feedwater pump (O-P-Q-R).

the joints, or by the valves becoming deranged from various causes, such as breaking, jamming, chips, packing yarn, et cetera…" (Fig. 19). [91]

At the end of the article, almost as an afterthought, Evans appended a small drawing of a fusible alloy safety guard, a device vaguely similar to Bache's 1831 combination safety-valve/plate (see Fig. 17c). However, in place of the fusible plate was a plug of fusible metal placed in the bottom of an extended cylinder or cup. As the alloy melted from the temperature of steam in the steam chamber, a plunger mounted atop the fusible alloy descended, activating a release of steam through an alarm cock. Unlike Bache's device, there was no mechanical connection between the alloy and the safety valve. Instead, Evans had extended and sealed Bache's cylinder, moved it from an external to an internal fixture, and changed the plate into a plug of fusible alloy acted upon by a stem and plunger linking the interior to the exterior of the boiler. Evans's cylinder was a slight modification of Bache's, but he was putting it to a new use: "What I consider to be an improvement is the use of the cylinder, which prevents the metal [from the plate] from being lost, and is always ready for a new operation. I believe in all other applications of the fusible metal, it would be necessary to get the

[91] Evans 1850 Treatise, p. 25. The mercury safety guard had none of these drawbacks. It used a reservoir of mercury placed on the flue. When the mercury expanded from heat, it mechanically activated a water injection pump. This guard was in many respects similar to Evans's final 1850 fusible alloy safety guard; it reacted to temperature at the flue, and the mercury was isolated from the effects of steam pressure. However, unlike fusible alloy, the mercury was difficult to work with and could not be calibrated to specific temperatures, and hence this invention fell by the wayside. The expanding rods idea also fell away because Evans could not get them to react to sufficiently low levels of heat.

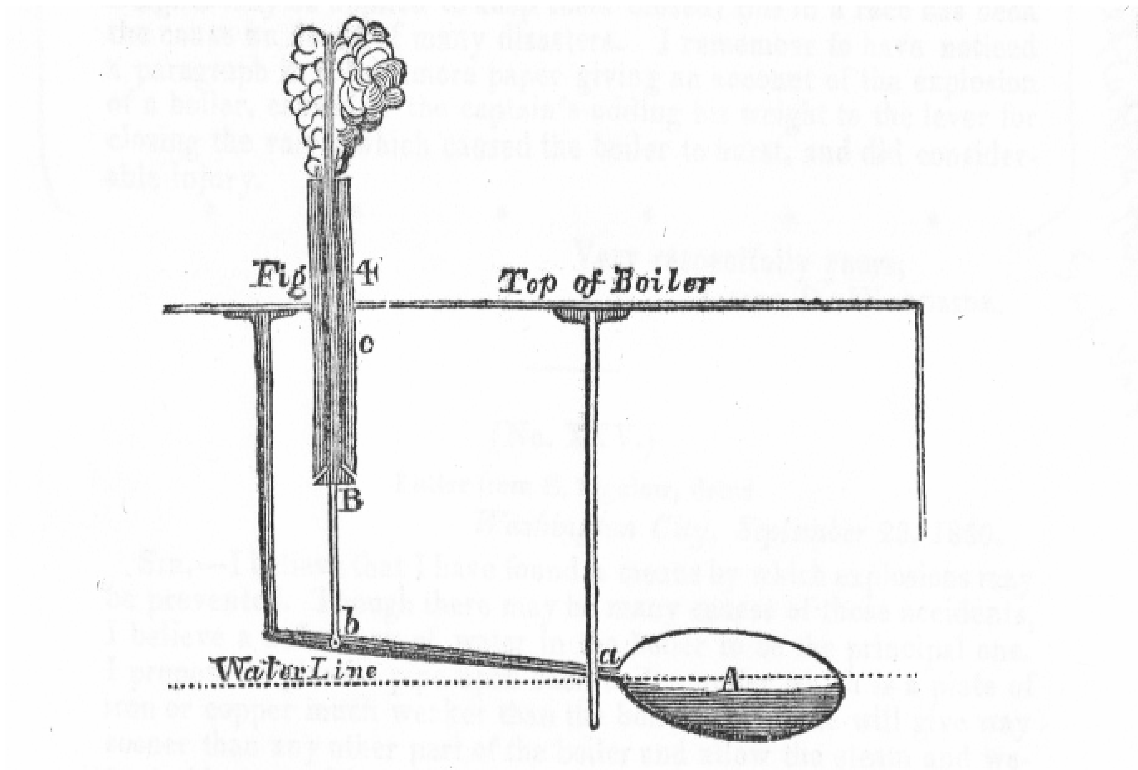


Figure 19. Floats were subject to fouling, making them ineffective safety devices. This was owing to muddy river water being injected into the boiler, which clogged interior mechanisms.

steam down, and, in some cases, to empty the boiler before the metal could be applied for another operation."

Evans was a practical engineer and inventor; he had used no scientific principles to develop his concept (although the device *was* mechanically imaginative). For example, Evans had not mentioned the thermometer-like quality of the alloy, wherein the alloy was portrayed as reacting to temperature rather than pressure. Instead, Evans's primary focus was on preserving the fusible alloy for reuse. [92]

It is possible there had been an informal collaboration between Bache and Evans to arrive at Evans's sketch. If so, Evans made no attribution to Bache for Bache's improvements on the French fusible plate or his incorporation of a cylinder in his device (even though Evans had radically changed the function of the cylinder). From Evans's point of view, he had merely made Bache's idea practicable as a "one operation" mechanism for purposes of preserving and reusing the alloy.

Although at the time Evans probably did not see the departure his plunger design represented among all the other alternatives he had set forth in his reply article, this simple sketch nevertheless represented most of the qualities Bache had been looking for as an alarm or safety mechanism based on the detection of heat: it was compact and simple (especially when compared to the mercury safety guard and expanding

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[92] Evans played up the temperature-sensing angle nearly two decades later in his 1850 Treatise. The rhetoric Evans used in the Treatise effectively upgraded the status of his safety guard from a mere invention to a piece of scientific laboratory apparatus.

rods); it could be reset in seconds by the engineer; it acted independently of the harsh conditions of pressure and fouling within the boiler; and after just a few minutes following resetting, its alloy would solidify and the steamboat could be made ready to resume its trip.

A mere practical invention in Evans's mind, Evans's concept fit in well with Bache's scientific approach, which sought to focus on the accurate determination of heat. The key idea to indicate the new emphasis is captured in Bache's phrase describing the limitations of Evans's expanding rods: "The expanding rods proposed by Mr. Cadwallader Evans are ingenious; they give, however, not the local temperature of the boiler, but its *general temperature* along the lines to which the rods are applied." (Emphasis added). Fusible alloy would thus furnish an improvement in accuracy. Bache went on to promote Evans's device:

> "A much more appropriate device, is the application of fusible metal proposed by [Cadwallader Evans]. This is intended to take the place of the ordinary fusible plate, and to avoid the difficulty, originally existing, but since remedied, of replacing the plate when it had fused…*The Committee prefer this to the apparatus acting by the expansion of mercury."[93]

[93] *Report of the Committee of the Franklin Institute of the State of Pennsylvania for the promotion of the Mechanic Arts, on the Explosions of Steam Boilers*, Part II, containing the *General Report of the Committee*, JFI Vol. XVIII (new series), No. 4, October, 1836, p. 297.

It is improbable that when Evans developed his apparatus he recognized how his invention would become an integral part of Bache's strategy for accurately measuring temperature in the boiler. He had simply thought of a better way to preserve the alloy and reuse it.

Experiments with Fusible Alloy Plates and Plugs, and Bache's Pressure Principle

At the same time Evans's reply article appeared in February, Bache was busy investigating the temperature-sensing properties of French fusible alloy plates. Chemically preparing and calibrating the alloys so that they would fuse (melt) at a variety of different temperatures had no prior history. Bache wrote, "The examinations which must have been made to determine the proportions of the metals necessary to produce an alloy fusing at a given temperature, and the circumstances of fusion, have not, as far as the committee know, been made public."[94]

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[94] *House Ex. Doc* 162, 24 Cong., I Sess., Feb 1836, p. 27. This was a similar problem to that of the lack of good steam tables available to American scientists in their calibration efforts; see also p. 38 of same document (in footnote). In looking over the available literature of their time, the Committee found that the world's scientists could not agree on the published steam table calculations linking pressure to temperature. Steam tables worked out by French investigators disagreed with those of American-British inventor-engineer Jacob Perkins (1766-1849). German chemist Martin Heinrich Klaproth (1743-1817) had come up with yet different results. See *H. Rpt* 478, 22 Cong., I Sess., (1832) for a summary of Academy of Sciences of Paris experiments, p. 145; Perkins's theory of explosions arising from the interaction of water and steam on hot iron, ca. 1827, p. 179; and Professor Walter Johnson's experiments, p. 97.

Complicating matters was the fact that, in a series of experiments, Bache had discovered chemical problems with the plates.[95] The difficulty occurred in the state transition from solid to liquid when the alloy was exposed to pressure. When fusing, the alloy exhibited the undesirable tendency to separate into its constituent metals; the lead component separated from the tin fraction and this formed a near-solid matrix of metal that blocked the escape of steam. In a run of thirteen experiments, the problems started to appear in experiment number six. In that experiment and in the three that followed, the fusing point appeared too high. Bache wrote, "No. 6 [experiment] presents a curious fact; the point of yielding of the plate, given by four experiments, is actually above the point at which the alloy from which it was composed became liquid; this would appear inexplicable to one who had not attentively observed the mode of fusion of these thick plates, and would lead to the suspicion of error… the explanation is [that…] the more liquid parts of the alloy are forced out, the less fusible remain, and if strong enough to resist the pressure, the process goes on; this takes place unequally in different alloys." He went on to note that substituting fusible plugs of greater thickness as had been directed by a recent ordinance in France would provide no remedy.[96]

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[95] Bache noted that "many trials to discover the cause of the separation of metals" had been undertaken, and referred to "perplexing circumstances, which had occurred throughout these experiments, and which had led to so many trials to discover their cause." See *House Ex. Doc.* 162 (1836), p. 37.

[96] The thick plates were approximately one-half inch thick. Bache's statement presaged what Professor Smith later noted about alloy of greater thickness: "Fusible plugs have not been found to answer as well as was expected." (Extracts from a lecture given by Dr. J.L. Smith before the New Orleans Lyceum, JFI Vol. XXI (new series), 1851, p. 414.) In the plates, fusing (melting) caused the alloy to behave like sand: ". . . if any part of the metal becomes fluid before the rest, and gives way, the rest being in the sandy state, just spoken of, the particles seem to act like those of sand in a similar

This problem was significant because a smooth phase transition of the alloy was crucial to its calibration for purposes of accurately monitoring heat in the boiler. To give an idea of the importance of this goal of calibration (if we may judge from the percentage of text discussing the properties of fusible alloy in the final report), the effort to test the alloy's properties as a thermometer consumed a considerable portion of the committee's energy in experimentation--nearly twenty percent. Most of this effort was expended trying to understand the inconsistent fusing points of the alloy.

One benefit Bache saw in Evans's early alloy-preserving device was that it promised a solution to the separation-of-metals problem. By enclosing the fusible alloy in a cup to permit easy recovery, Evans had inadvertently isolated it from the pressure of steam (the cup idea had arisen because of Evans's need to use a cup or tube to contain liquid mercury in the mercury safety guard, and he had simply extended this same idea to the containment of liquid fusible alloy). Bache seized on Evans's cup as the solution to the pressure problem: "The true remedy is to be sought in inclosing the fusible metal in a case, in which it shall not be exposed to the pressure of the steam, but only to its heating effect."[97] Like the French thermometer, the alloy required protection from the direct effects of steam pressure to register an accurate temperature. In addition, the peculiar metallurgical properties of the alloy -- in which pressure caused a separation of its constituent parts -- required isolation from

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case, and to oppose an effective resistance to the pressure of the steam." The discussion can be found in *House Ex. Doc* 162, pp. 27, 35, and 38.

[97] *House. Ex. Doc*. 162, Ibid, p. 38.

pressure. With both of these problems solved, the safety guard became (in theory) a practical mechanical analog of the mercury thermometer.

For discussion purposes, we shall call Bache's prohibition of exposing the apparatus to steam pressure the "pressure principle." The pressure principle would eventually be incorporated into the 1852 steamboat act as a legal requirement for safety guards; the principle would dictate the type of safety guard permissible under the act, and this was to have far-reaching implications for steamboat engineers and for the Treasury Department.

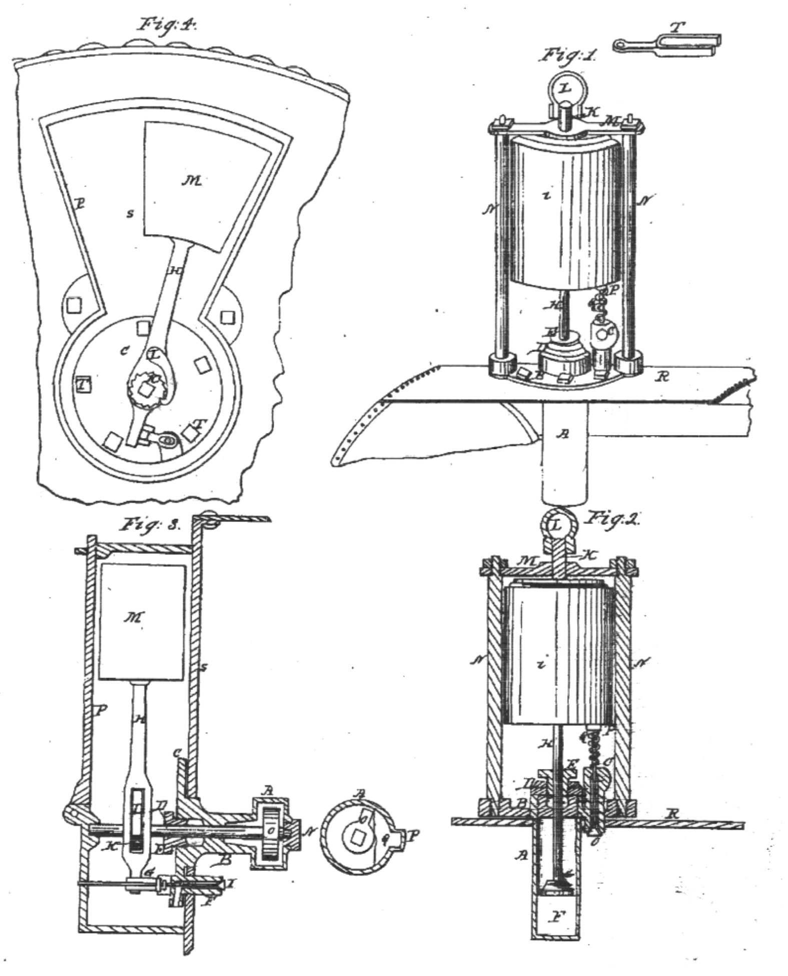
Evans's Patents of 1834 and Bache's 1836 Apparatus

By 1834, Evans sought to establish his priority as the inventor of the 1832 safety guard. In his 1834 patent application (Patent Number 8185X, entitled, "A new and useful improvement in the mode of applying a fusible alloy as a guard against explosions of Steam Engine and other Boilers"), Evans introduced two new devices that refined his notion of making the fusible alloy recyclable as a means of repeatedly triggering a warning mechanism. Neither device made direct contact with the flue, and thus each was intended to react only to general steam temperature in the boiler.

The two variants were refinements of Evans's 1832 idea. Both devices illustrate Evans's originality and ingenuity with mechanisms, apparently a gift from his father on the model of the automated flour mills, as well as his skill in machine-shop technique. The first design was similar to the previous Evans and Bache machines in employing a piston-like action (Fig. 20b). In this device, mounted on the outside of the boiler head, a weight with stem plunged downward following the melting of an alloy ingot. This action set off an alarm cock, which gave notice "that the water is too low." The weight forcing the stem down can be seen to be massive, and the reason for this had to do with oxidation/congealing problems Evans had experienced with the alloy.[98] Evans's claimed improvement consisted of "the employment of an air tight tube or vessel to contain the alloy by which it will be protected from oxidation or waste for a great length of time, and in which it can be used many times in succession for indicating a certain elevation of temperature without the necessity of renewing its [alloy component]…"

The melting of the alloy in the cup activated the downward thrust of the weight, triggering a stop cock that in turn released steam, causing "considerable noise." The engineer would then be made aware of the increased temperature of the boiler, caused by too high steam pressure or low water. "The engineer will then proceed to examine the safety valve to see that it works freely, and the gauge cocks to try the height of the water. He will then know from which of the two causes the alloy had fused and proceed to correct the evil." Evans specified that the apparatus should be enclosed in a cast iron cover under lock and key "so the engineer cannot get at it, the key being kept by the captain or other person whose duty it will be to raise the weight when

[98] The heavy weight overcame blockage at the bottom of the cup caused by oxidized metal. This residue kept the piston from fully descending and setting off the alarm. Evans fought a losing battle with steamboat engineers over the reliability of the alloy due to this defect.



(a) Mallet Concept (b) Plunger Design

Figure 20. Evans's 1834 patent drawings.

the apparatus has gone into operation and to place the forked piece S between the guard and the handle so that the alloy may congeal in its place and be ready for another operation."[99] The fork could then be removed, the safety guard reset, and the box locked up again.

Evans's second device, a variation of the first, featured an internal weight shaped like a mallet mounted on the boiler shell turning axially on a horizontal shaft (Fig. 20a). On the melting of a small sample of alloy placed in the keyhole-shaped body of the safety guard, the mallet rotated, opening an alarm cock and alerting the crew.

What is most interesting about this device was the rotating mallet fixture. This feature shows that Evans was thinking of a rotating mechanism at this early date (in a later description of his final "improved" 1850 version of the safety guard, we shall see how and why Evans made the rotation of the spindle a key feature).

While Evans developed these variations on his basic safety guard idea, Bache conceived and built an experimental apparatus in the laboratory of the Franklin Institute that was a near-copy of Evans's earlier 1832 device (Fig. 21). He used this apparatus in his continuing quest to relate temperature to pressure within a working

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[99] The forked piece is marked "T" in the patent drawing.

boiler.[100] Conceptually, Bache's design changed the use of the tube from that of a metal-recovery feature to that of a pressure-isolation and heat-detection chamber.

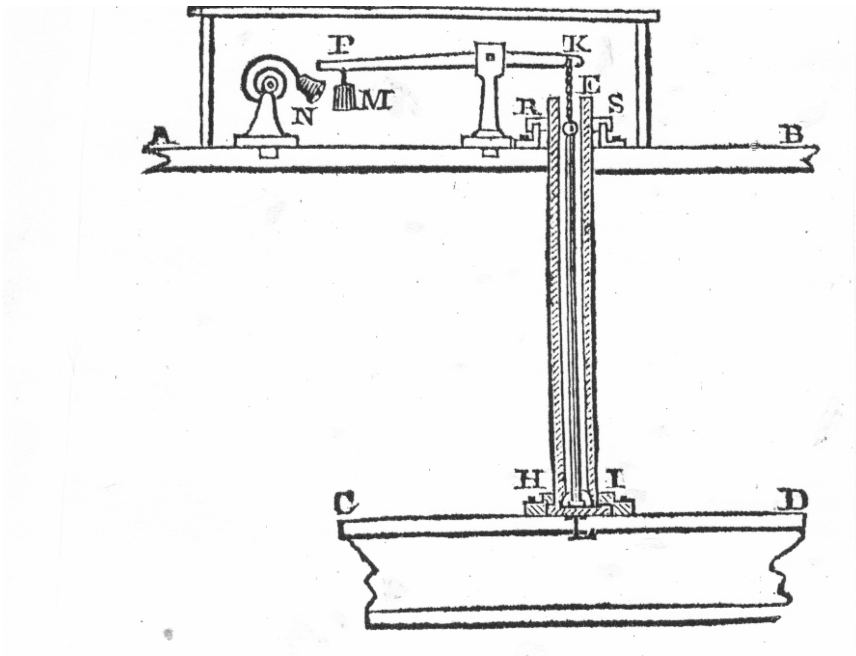

Figure 21. Bache's safety guard was quite similar to Evans's 1832 concept, except that Bache's extended the tube down to the flue (C-D) in order to calibrate the alloy to the hottest point in the boiler. The melting alloy released the stem upward to activate a bell alarm. Bache published his design in the boiler committee's 1836 general report.

[100] The device was described in the Committee's general report of November 1836, on p. 298. It was specifically designed to help establish the Committee's steam tables relating temperature to pressure using French fusible alloy.

Physically, the apparatus was a slight and almost cosmetic variation of Evans's 1831 device whereupon Bache reversed the direction of the plunger from "push down" to "pull up" to alleviate the alloy-congealing problem.[101] Another important feature of Bache's variation was that the tube extended all the way down to the flue so the alloy was in direct thermal contact with it. This would give the "local temperature" that Bache wanted in order to properly measure heat in the hottest part of the boiler. (Evans did not extend the tube to the flue until one of his 1839 designs). Having the alloy in direct contact with the flue metal also had the benefit of preventing overheated iron due to the low-water condition. This was the postulated dangerous condition in which the supply of water evaporated off, leaving the flues exposed to intense heat. A safety valve reacting solely to steam pressure could not detect this condition, but a safety guard affixed to the flue could. With this refinement, the safety guard became the dual-purpose device intended to sense all potentially dangerous conditions.[102]

A pronouncement in the boiler committee's 1836 final report foreshadowed the usefulness of the Bache-Evans safety guard concept on steam boilers and at the same moment expressed the lowering of status of the safety valve. Heretofore, the safety

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[101] Bache's idea to make the stem traverse up instead of down upon the melting of the alloy was calculated to reduce the same mechanical problem Evans was having with the alloy. The alloy was found to be vulnerable to rapid oxidization with each re-heating. Upon re-heating, the alloy formed a thick layer of dross, which accumulated in the bottom of the tube. This decreased the effective distance the plunger could travel, hampering its movement in the downward direction.

[102] The safety guard could thwart either (1) an overpressure condition, even with plenty of water in the boiler, or (2) a low-water condition in which steam pressure was low but the flues were weakened from heat. In Case One, heat would be absorbed by the water, steadily increasing steam pressure to the boiler shell's bursting point. (The committee had found in its quarry experiments that plenty of water was no guarantee that the boiler would not burst.) In Case Two, the flue metal would soften, causing a

guard would constitute “a manageable, and useful check, in ordinary cases, upon the safety valve.”[103]

There is no documentary evidence of any friction between Bache and Evans over the obvious commonality of the various designs of Evans’s 1832 design and Bache’s 1836 apparatus. It is possible, therefore, that Bache and Evans shared information about their designs and were in harmony in their working arrangements. Evans patented his 1832 concept in 1834; Bache sought no legal protections for his modification of Evans’s 1832 idea. Only after Evans had died did the issue of patent infringement come up, in 1855, probably because makers of “mongrel” safety guards were using Bache’s 1836 clone of Evans’s safety guard, or variations on that theme, in an attempt to evade Evans’s patent, which was by then controlled by the inventor’s widow, Jane Evans.[104]

Evans’s 1839 Patent

Throughout the 1830s, Evans continued to develop new safety devices and establish patents for them. Evans’s 1839 filing (Patent No. 1,122, dated April 15, 1839 and

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collapse or explosion. Although in this case, pressures were not great enough to burst the shell, they were sufficiently great to induce catastrophic collapse of the flues and attached boiler head.

[103] *H. Ex. Doc*. 162, p. 40. Offered as further support for the idea of demoting the safety valve were the results of the Committee’s tests on those devices, which suffered inaccuracies due to mechanical problems, see p. 86.

[104] Some sort of safety guard was necessary to meet the requirements of the ninth section of the act of 1852 to protect the fusible alloy from the pressure of steam. Jane Evans likely would have considered patent evasion a very real threat to her income. She is almost certainly the individual behind a query from chemist James Booth to the U.S. Attorney General in 1855 (just after Evans’s death) asking him to investigate Bache’s device as an infringement on the Evans patent. See 1855 3-17.

reissued November 23, 1852) expanded his earlier safety guard ideas to include "certain new and useful improvements in Steam-Boilers and Steam boats for the Purpose of Preventing the Explosion of Boilers." In actuality, these consisted of some new ideas in combination with Evans's older conceptions: a float-and-fusible-alloy-safety guard hybrid design, a passenger-monitored water gauge, and an apparatus for holding a steamboat fast against a wharf or landing so that it would not careen (this apparatus included his 1834 piston device and his firebox deluge system) (Fig. 22).[105]

What is most interesting about these devices is that, at this fairly late date, Evans was still focused on mechanisms and not on Bache's heat theory. His old 1834 piston safety guard, now employed in combination with a float mechanism, left optional the

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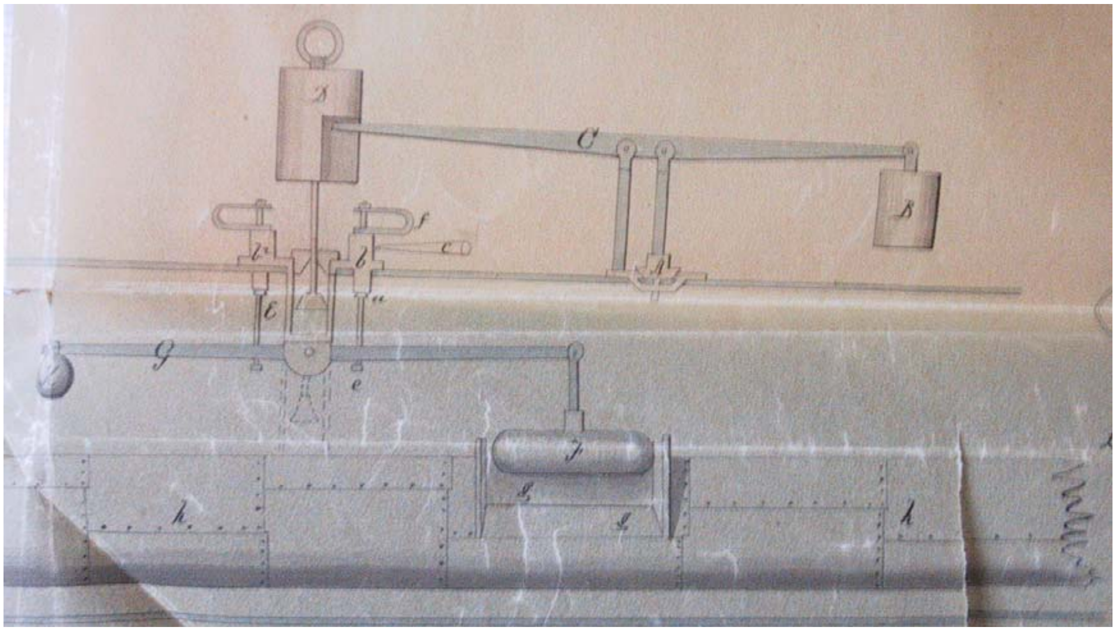
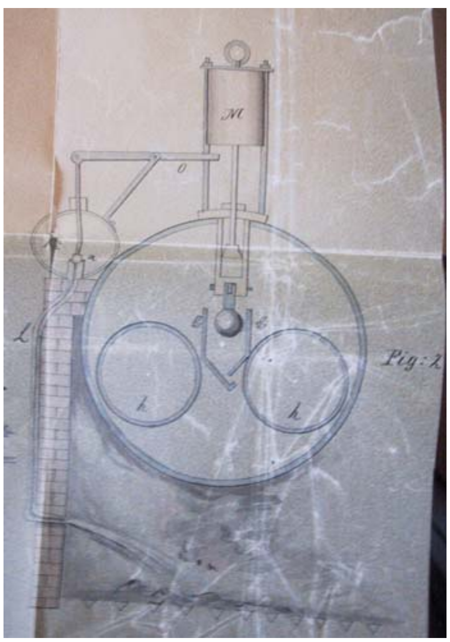
[105] The author of this thesis discovered the four missing figures for Patent 1,122 (shown here) in the NARA records. They had been lost for 153 years. The author remitted computer images of these figures to the U.S. Patent Office in the fall of 2005; to date the patent has not been updated. How did the figures originally go missing? In the patent filing there is a note from a Mr. Finis D. Morris of the Patent Office dated June 1, 1915, stating that he could not locate the figures. The original patent was dated April 15, 1839; it was reissued on November 23, 1852. It is surmised that the original drawings were lifted out of the applicant Evans's patent papers and inserted in his reissue application 13 years later (presumably to save the cost of redrawing). The patent filing was summoned by the Treasury Department soon thereafter due to the question of Bache's possible infringement of Evans's patent. The original figures are located at present in Evans's 1852 patent reissue request bound in the Treasury Department's Steamboat Inspection Service records (NARA RG 41). The reason Mr. Morris could not locate the drawings, therefore, was because they were contained in the Treasury Department, not the Patent Office, records. Reference author's IMG 1403 (Fig. 1); IMG 1404 (Fig. 2); IMG 1405 (Fig. 3); and IMG 1406 (Fig. 4).



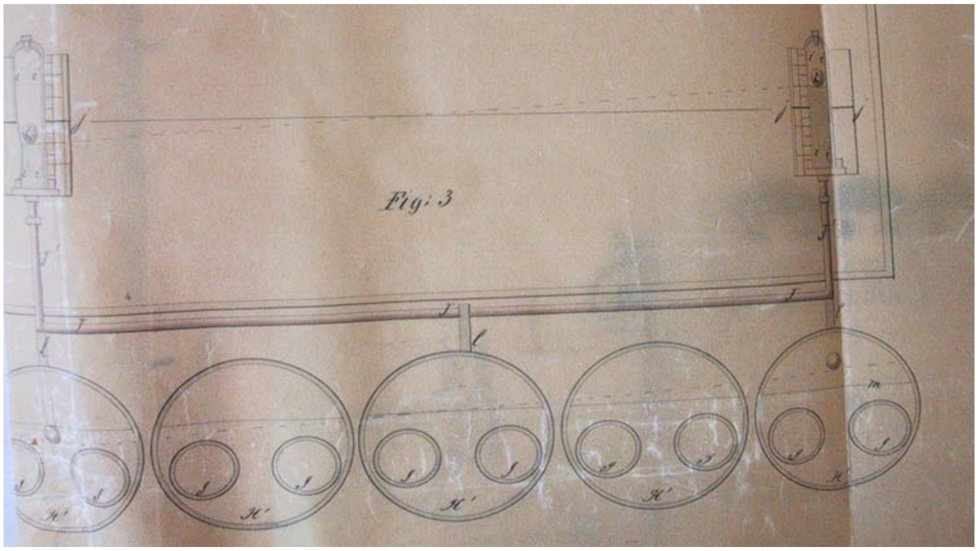
(a) Elevation View



(b) Side View

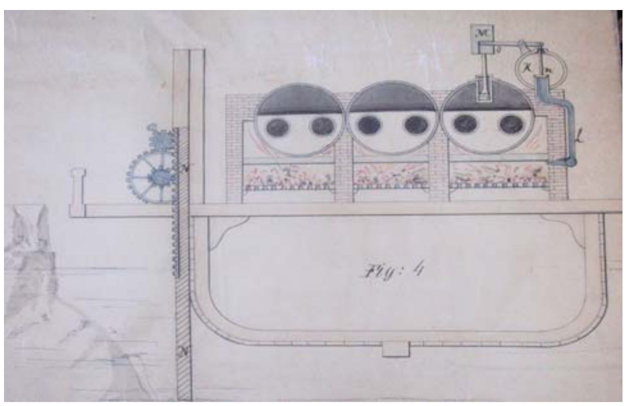
Figure 22. Evans's 1839 Patent No. 1,122. Fusible alloy safety guard, combined with float for detecting low water, and firebox deluge system. The engineer was still to be held accountable by passengers: "To render the fact of the absolute or relative deficiency of water in the boilers known not only to the engineer but to the passengers on board of a steamboat, and to lead to the immediate correction of the evil, I employ an alarm apparatus, which by giving two different and distinctive sounds, will communicate the desired information." Note the firebox water deluge system in (b), at bottom left.

(Figure continued next page) . . .



(c) Water Level for Passengers

Figure 22 (cont). Water gauge in the salons of steamboats: ". . . a water level, which is to be placed within the cabins of steamboats, and which will, upon inspection, point out to the passengers, at all times, the exact trim of the boat, and will cooperate with the indications of the horn and whistle in the last described apparatus, in making known the quantity of water in the boilers, and the deviation thereof from the proper level." Passengers were instructed to move to the other side of the boat if the boat tipped. The water level scales can be seen at the upper left and right portions of the figure.



(d) Anti-careening Fixture

Figure 22 (concl). Evans described his wharf apparatus for preventing careening ". . . a strong upright piece of timber . . . is made to slide up and down by means of a rack and pinion, operated by suitable gearing. The sliding timber is retained in its proper position by passing through mortises, or guide pieces, and may be readily forced down when the boat is at a landing, so that its lower end bearing upon the bottom of the river will effectually prevent the careening of the boat, and thus disastrous consequences resulting therefrom." Note the fusible alloy safety guard connected to a water tank (right) to supply the firebox deluge system.

choice of extending the tube (cup) to the flues. Thus, protection was limited to generalized heat built up in the steam chamber and was not provided for the low-water condition. Further, Evans claimed that the other non-heat detection mechanisms in the patent were needed for “perfect safety.” He wrote, “A part of [several distinct devices] may be omitted on board of certain steamboats, but in such as are used in our great western waters, it is believed that the whole of them will be required to insure safety.”

Evans *had* absorbed the lesson of Bache’s that the safety valve was too slow-acting: “I use the ordinary safety valve on my boilers, but I combine therewith an apparatus intended to open the said valve when the temperature of the interior of the boiler is greater than is deemed compatible with perfect safety; and this I accomplish by a new mode of using the mixture of metals known as the fusible alloy, the fusion of which will cause the safety valve to open although the pressure of the steam may not be such as to produce that effect.”

Rejection and the Great Fire of 1845

With patents in hand, in the early 1840s Evans began marketing his safety guards at Pittsburgh’s local wharves, trying to convince steamboat owners and engineers of the guards’ benefits. In this endeavor, however, he noted much prejudice by the engineers, many of whom considered his safety guard “an intolerable nuisance” and who sparred with him over the reliability of the fusible alloy after repeated use. It seems the oxidation problem had not been solved after all. Meeting frustration at the wharves, he moved the debate over reliability into the newspapers. Later patent documents describe Evans' “excessive zeal” in trying the issue in the press and in “forcing” the safety guards upon the boating community, which resulted in “all the difficulties and obstacles against which he has had to contend.” Others noted a lack of demand for Evans’s guards based on the fact that he charged too high a price to install them.[106] [107]

Evans produced several different models in a range of prices. For owners of steamboats, the safety guards’ high cost was a major obstacle to their purchase; it was an expensive fixture by the standards of the day. If owners balked a few years later at paying five dollars for an inspector’s certification of their steamboats, Evans’s charging fifteen times as much for his safety guard in the 1840s was prohibitive. His

[106] Evans began selling his safety guards about 1840, see his 1850 Treatise, p. 51; prejudice noted, see 1853 12-15 and many instances mentioned in Evans’s 1850 Treatise. On the lack of demand for the invention, see 1855 4-10. Oliver and son George Evans’s Pittsburgh engine-building shop served as a base of operations in the western country around which Cadwallader set up his safety guard shop and “laboratory,” probably around 1838-1839. His shop was located at No. 10 Water Street. The particulars of Cadwallader’s relationship to his father Oliver and brother George, and to any business arrangements in setting up Cadwallader’s new business, are not known. We do know that Evans employed a man in his shop whom he tried to teach accounting and mathematics; this was Morrison Foster, a brother of composer Stephen Foster (Stephen was born in Pittsburgh). Library sources note that Cadwallader was a cousin of Eliza Clayland Tomlinson Foster, who was Stephen Foster’s mother and niece of Oliver Evans’ wife Sarah Tomlinson. This means Cadwallader and Stephen Foster were first cousins once removed. Cadwallader also had family connections to President James Buchanan through Stephen Foster’s sister, who was married to Rev. Edward Buchanan, James’s brother, of Lancaster, Pennsylvania. Cadwallader was married to a Jane Mahon. (See O’Connell, Joanne: *Understanding Stephen Collins Foster, His World and Music*, PhD Dissertation, University of Pittsburgh, 2007, pp. 68, 95; and the Wikipedia entry for Stephen Foster.)

[107] The “nuisance factor” was key to the rejection by engineers of Evans’s safety guard. Supporters of the safety guard believed “bad engineers” refused to accept self-acting control, and this choice had consequences. When the Steamboat *West Wind* departed from St. Louis heading up the Mississippi River in 1842, the safety guard activated four or five times. The engineer reset the guard each time but grew weary of this and finally fastened down the guard’s lever. The boiler suffered a flue collapse. See 1852 5-1. Date of the accident from *Way’s Packet Dir.*, Ohio Univ. Press, rev. ed., 1994, p. 484.

most advanced model cost seventy-five dollars; a cheaper twenty-dollar version was the one most often sold to boatmen because, as Evans noted, “they usually opt for the cheapest… this cheap version works an alarm only, and does not relieve the safety valve.”[108]

Whatever Evans’s problems in introducing his safety guard into the boating community, these were overshadowed by a catastrophic natural event. His workshop and all of his papers burned to destruction during Pittsburgh’s Great Fire on April 10, 1845 (Fig. 23). “This flourishing adjunct of the city is well nigh annihilated,” an eyewitness recorded after he saw the fire, fanned by high winds, destroy the city’s entire central business district. Other witnesses were astounded to see the Monongahela Bridge consumed in a matter of minutes: “The bridge took fire at the North [...] next to Pittsburgh, and the flames [ran] roaring and crackling through [with] railroad speed, and from the time the fire commenced, until it was prostrate [in the] river, only ten minutes elapsed!” Nearly all the businesses in the Water Street district where Evans had his shops were destroyed, including Fulton’s bell and brass foundry and other industrial concerns, small businesses, and residences. “The appearances of things is awful--nothing but an immense forest of walls and chimneys is visible, and desolate heaps of brick and mortar,” a local newspaper recorded.[109]

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108 Evans noted also that the improved version did not sell well because it was not required by law. See Evans’ letter dated 1854 6-9.

109 Evans’s papers destroyed: “Ever since the great fire in 1845, in which perished his office, his manuscripts, with the results of his manifold chemical and mechanical tests and experiments…” Evans, 1850 Treatise, from a third party testimonial, p. 64, IMG 1059. Details of the fire, see The Mystery newspaper, Wednesday, April 16, 1845. Source: http://www.clpgh.org (Carnegie Library of Pittsburgh).

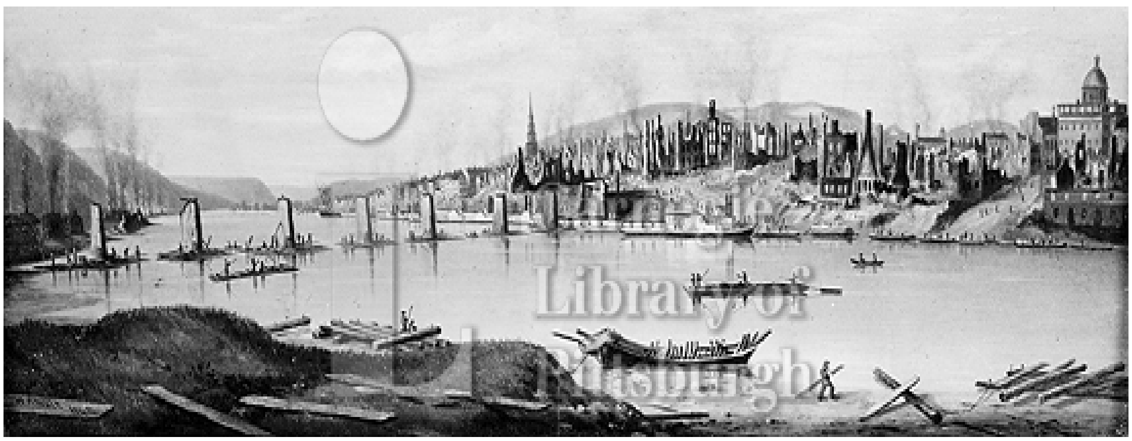

Figure 23. Aftermath of the Great Fire, 1845, Pittsburgh. Source: Library of Pittsburgh.

After the fire, Evans relocated his office and laboratory to the second floor of a warehouse owned by an I.S. Waterman and Sons, located some distance away at No. 81 Water Street "between Market and Ferry," and from there he worked to "regain and replace" what he had lost.[110]

Details of Evans's life during the interval between the Great Fire of 1845 and early 1854 are sketchy. We do know that in those years Evans published, or was working on, three tomes on steam science: (1) a treatise on steam boiler explosions and his improved 1850 safety guard; (2) a general 300-page volume on steam science; and (3) a report of experiments he made on the effects of pressure on fusible alloy plugs. Bache had left Philadelphia for Washington, D.C., in 1843 to run the U.S. Coast Survey and so his direct influence, if any, in Evans's writing of these texts is doubtful. However, Evans had requested funds in 1839 for conducting his experiments. It is possible he was funded and commissioned to report his results and the basis of his studies in these three publications. Bache's -- or at least the Franklin Institute's -- influence on the ideas in Evans's treatise is obvious, for from 1850 onward Evans concentrated on nothing but heat theory and the effect of pressure on the alloy. There were no more discussions of floats, water gauges, or other non-heat-related apparatus in his writings.

We do not know if Evans was able to complete his 300-page volume on steam science before he died; apparently he did not because no copies survive. In describing the work, Evans upheld the shop tradition of the practical engineers in which technical information was to be freely exchanged in the interest of the common good: “I have written a good deal on matters connected with my profession, and have now nearly ready for publication a large work on Steam, Steam Engines, Steamboats, and Explosions in detail, expressly designed for the use of Engineers on steamboats, and other practical men. All this has been done with a view to impart to them whatever knowledge my opportunities and years may have enabled me to acquire. If this displays hostility, then must sentence of condemnation be prosecuted upon me.”[111]

Of greater significance for our story is Evans’s 1850 booklet, *A Treatise on the Causes of Explosions of Steam Boilers*, which did survive and was distributed to steamboat engineers at the wharves by Evans himself. Because the document enlightens us more than any other source material about Evans and the safety guard, it will be useful here to explore this document in some detail (Fig. 24).[112]

2.3 Evans’s Important 1850 Treatise on Steam Boiler Explosions

Taken in isolation and without the backdrop of its scientific development, Evans’s 1850 *Treatise* tells us little more than how the safety guard worked and Evans’s attempts to gain acceptance for it among the steamboat community (targeting

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[110] Evans’s 1850 Treatise, p. 64, and back cover.

[111] Evans’s 1850 Treatise, p. 15.

[112] Full title: A Treatise on the Causes of Explosions of Steam Boilers with Practical Suggestions for their Prevention to Which is Added a Description of Evans’ Improved Safety Guard, or Engineers’ Assistant. In NARA RG 46, Commerce Records, Tray 26, folder 1 of 2. This was the same booklet described by T. J. Haldeman as being circulated aboard steamboats, see Introduction, Chapter I.

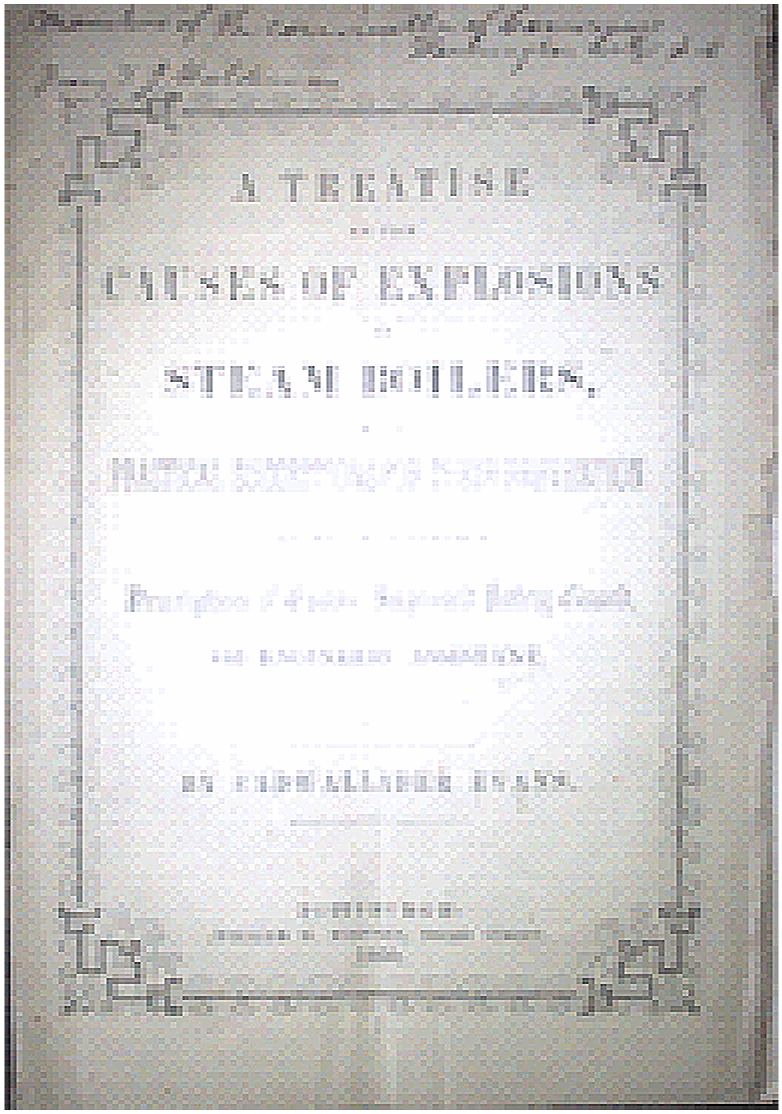

Figure 24. Cover of Evans's 1850 *Treatise on the Causes of Explosions in Steam Boilers.*

specifically steamboat engineers); it also appears to be the sales brochure of a zealous inventor. However, when evaluated in the context of Bache's work on heat theory (and how this would play out with the engineers), the meaning of the document takes on a larger dimension. The clarity and lofty rhetorical style of the *Treatise* is a vast improvement in communicating Bache's theoretical concepts over the Franklin Institute's obscurant, esoteric 1832 and 1836 reports of their experiments ("… the writers make this subject appear most vague, unaccountable, and mysterious to us…".[113] The *Treatise* makes all of the same scientific claims - - point for point - - that the Franklin Institute scientists had been making in the pages of the *JFI* over the previous 20 years. It emphasizes heat as the sole quantity to be measured; highlights the deficiency of the common safety valve and the superiority of fusible alloy; and introduces the pressure principle. Significantly, it veers away from Evan's familiar nuts-and-bolts patent descriptions in favor of an emphasis on salient scientific principles and their experimental verification. As such, the text succeeds in skillfully blending science and the technical arts, a significant achievement for its day, and one suited to Evans's primary audience: "scientific" practical engineers.

Thus, Evans's *Treatise* appears to be scientific propaganda aimed at the leading engineers of the day in the western districts. Evans's likely goal was to use the document as a key part in a campaign to roll out the safety guard in coordination with the industry-reforming Steamboat Act of 1852. The timing of publication in this regard (1850) is significant and provides some circumstantial support for the

[113] Engineers commenting on the works of scientists, *H. Ex. Doc.* 145, ibid., p. 5, February 1843.

conjecture that the *Treatise* may have been commissioned by Congress. This was the year in which Congress was busily drafting the new Steamboat Act of 1852. A few years hence, the Act would contain a provision effectively mandating the safety guard on the basis of Bache's pressure principle.

The *Treatise* describes Evans's difficulties in obtaining the acceptance of steamboat engineers for his safety guard, his struggle to overcome defects in the device, and his reorientation to Bache's focus on heat as a scientific concept (for purposes of highlighting for engineers the scientific virtues of the invention). Featured is Evans's final "improved" version of the safety guard, pictured in a handsome illustration on the frontispiece (Fig. 25). The key innovation of the device was a clever rotating stem to get around the oxidizing/congealing alloy problem at the bottom of the tube. This particular device was the culmination of all of Evans's work for the past 20 years; he claimed it made all of his previous float and gauge mechanisms obsolete.

With a skillful blend of science and salesmanship, Evans's purpose was to persuade river men of the merits of Evans's invention and to defuse criticisms of it, which as we have seen had been frequent in the 1840s leading up to publication of the *Treatise*. The *Treatise* included as support for its ideas the endorsements of prominent scientists, steamboat practical engineers, and captains. In fending off criticisms that the fusible alloy used in the safety guard was defective (comments such as "humbug," "worse than useless," and "a danger" were common), Evans resorted to the rhetoric of

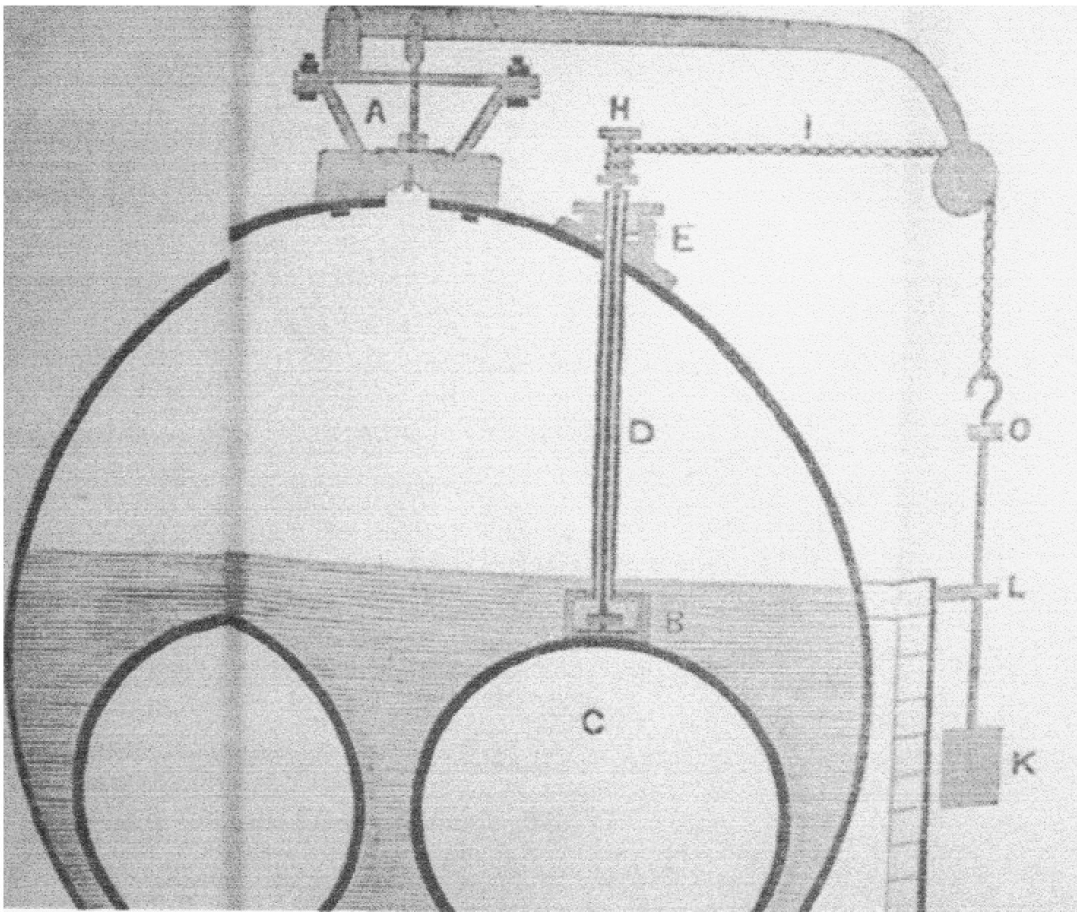

Figure 25. Evans's 1850 Safety Guard. The impeller was seated within a cup upon the right flue. The cup was filled with fusible alloy. When the alloy melted, the impeller was released and rotated, turning the stem D. This in turn released weight K, which activated the relief valve A.

science as well as appeals to scientific authority to convince engineers that his improved model was now made "perfect" by the rotating stem feature.[114]

A synopsis of the document's text illustrates these points. Evans notes that steam is the means of fulfillment of the country's "commercial destiny":

> "The unparalleled increase in trade and travel of late years, keeping pace with the development of our resources and the march of our population, and giving rich promise of a still more wonderful augmentation in the future, calls loudly for the adoption of every improvement, and all reasonable measures, calculated to advance or attain the objects proposed. The commerce and wealth of the world will soon pour into our lap, to be conveyed on our railways and borne on our steam vessels from the Pacific to the Atlantic, and thence to the most distant climes, bringing back in return the richest and rarest commodities of the earth. The great agent by which all this is to be accomplished,--by which we have advanced, and must continue to advance towards the realization of our glorious manufacturing and commercial destiny, is steam." (p. 67)

[114] Evans gives a history of his invention's development, first treating the dead-end inventions: floats, alarms, a doctor pump, and mercurial gauge "consisting of an artificial fountain often seen in the east, in the hands of venders of lemonade, only reversing its pressures, and using mercury in place of water … a mere indicator of pressure… I never proposed this as a preventive against explosions." Expanding rods were not effective because they would have required the boiler temperature to reach 1,157 degrees Fahrenheit before they reacted. He moves on to difficulties he encountered in harnessing fusible alloys; there were problems with successive operations of the plunging stem that caused the alloy to congeal at the bottom of the tube, preventing the stem from plunging far enough to

He sees that this vision is threatened by the poor strength of contemporary boilers: "The evil lies in the radical defect of the machine, and can only be met by an improvement upon it, and that improvement must possess principles the same as the Safety Guard, viz: the power of relieving the boiler of all its steam before it arrives at a dangerous temperature." (pp. 16-17) Even the perfection of engineers and the encouragement by the government of associations of engineers, he writes, can not eliminate accidents under these circumstances (he compares engineers to doctors who are "not equally skilful and competent, although each one [carries] a regular diploma in his pocket.") Because it reacts to high temperatures and is self-acting, the safety guard is the only effective safety device. To make the invention palatable to the engineers, Evans personifies it as a "faithful sentinel" and an "untiring friend and assistant to the engineer." (pp. 31-32) The safety guard's self-acting feature serves a dual purpose: it not only protects against the negligence of the "bad engineer" but it corrects for the oversights or ill-providence of the good engineer[115]:

> The Guard is put on as much for [the good engineer's] benefit as for that of any one else. It was intended to be his friend and assistant in

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operate the mechanism. For this problem, he devised the rotating impeller and spindle. With this innovation, his invention "became perfect." (p.28)

[115] Evans on the good engineer: "A good engineer should be a man of sobriety and temperance in all things. He should have a proper sense of the moral relations in which he stands to society. He should possess firmness, courage and self-possession. Neither obstinacy nor rashness should form an element in his disposition. He ought never, under any circumstances, to yield to excitement, no matter what the temptation or what the reward. Coolness and calmness should be daily practiced, until they become fixed habits. A just respect for the opinions and for the feelings of others, should accompany him in his intercourse with all men. Together with this, the most amicable relations should subsist between himself and all those connected with the ownership and management of the boat. Finally, when on duty, the engineer should have his whole mind bent upon his duties. Nothing should distract him from his business, or lull his vigilance into supineness or indifference. It makes no difference what Safety-Valve or Safety-Guard may be placed upon his boilers, his duty is plain; namely, to attend to every thing as though no such contrivance were attached to the boat." (1850 *Treatise,* ibid., page 19).

> moments of danger, and under circumstances in which all ordinary care and skill would be utterly powerless to save." (p. 19)

With this passage, in conjunction with Evans's view that the "radical defect" in the machine exonerates the good engineer from blame for explosions, he cleverly implies that *to not accept the safety guard as a friend* would be irresponsible and immoral. He writes, "…notwithstanding the exercise of the highest skill and watchfulness, there is still room enough for accidents; and in this respect the Guard becomes the best friend of the engineer." (p.20) Clearly, the good engineer (i.e., the scientific engineer, or conscientious aspirant to the name) is the party Evans most wishes to influence in his argument.

In this, Evans feels a kinship toward practical engineers like himself. He feels discomfort in justifying his invention on purely scientific grounds; he makes clear that he wishes to strike a bargain with his fellow engineers in not abandoning them for a "merely scientific" approach. "Government should not always employ in its experiments and offices the merely scientific professor, to the exclusion of men of enlarged practice and experience. The statistics of the Treasury Department abundantly show that in point of economy, if nothing else, a reform in this respect is loudly called for." (p. 18)

Part of Evans's reservations about relying too heavily on scientists had to do with the stifling of the engineers' freedom to innovate. He does not wish a government mandate to enforce the safety guard's use. Rather, he wants his invention to stand on

its own merit: "I have not asked, nor do I now solicit the enactment of any law to COMPEL the introduction and application of the Safety-Guards. Others may do this, if they see proper..... For myself, I have an abiding confidence in the intrinsic merits and acknowledged worth of the invention; and if its good qualities and practical operations are not sufficient to win its way to public confidence and general adoption, then so far as I am concerned, let it fall. My determination is never to invoke any legal measures to force its application or use." (p. 65) (Emphasis his).[116]
Embracing government research while at the same time making room for the views of practical engineers, Evans is walking a tightrope between science and practical engineering. His balancing act reveals an internal conflict concerning two realms of expertise that hitherto have been separate and, below the level of the scientific engineer, antagonistic. As such, he gives us a glimpse into an inflection point or seam between antebellum science and engineering.

Evans is clearly moving his safety guard into the domain of the scientists, however. In sympathy with the scientific point of view, Evans's rhetorical appeals in the *Treatise* to scientific practical engineers dovetails perfectly with Bache's observations and conclusions - - although Bache is not credited. In fact, Evans's points agree so well with those of Bache that we are tempted to infer that there was some sort of direct communication between members of the Committee and Evans. Evans does quote several times from the *Journal of the Franklin Institute*'s 1836 final report and other

[116] However, contradicting himself, Evans included several endorsements in the same document that urged the government to mandate his safety guard. Four years later, he petitioned the Treasury Department to enforce the pressure principle. This would have had the effect of making his device the exclusive safety guard.

subsequent articles--on the pressure principle, for example. Evans gives the usual laundry list of factors that are thought to cause explosions (low water, flash theory, heat buildup, etc); he criticizes defective devices such as the common safety valve and devices using fusible alloy that are exposed to the pressure of steam (he notes how pressure renders fusible alloy ineffective); he lists the defects in fusible plates and plugs; and he disavows the hydrogen gas explosion theory. Most importantly, like Bache, he focuses on heat. "I came to the conclusion that HEAT is the only effective, practicable and sure principle to be adopted as the means of preventing explosions; FOR HEAT IS THE CAUSE OF EVERY EXPLOSION… consequently, the plan is to use the heat so as to prevent itself from ever exceeding a safe temperature..... A machine based upon this principle, becomes a corrector or guard against all the defects of all other kinds of contrivances applied to boilers, intended to effect the same object..." (p. 26, emphasis in the original)

A substantial portion of the *Treatise* treats various criticisms of the safety guard then in circulation among the engineers. Here, Evans appeals to scientific authority and uses a scientific rhetorical style to defend against the attacks of his critics. His appeals to scientific authority are profuse, even to the point of renaming his mechanism an "apparatus," as if to elevate its status to that of a laboratory instrument. He writes that practical engineers and scientists have successfully tested the guard's alloy fusing points on twelve steamers at Pittsburgh (on pages 37-40 he cites the report of the test committee, which is composed of "scientific and practical gentlemen" of the city and whose results have been verified by Cincinnati doctor, polymath, and founder of the

Ohio Mechanics' Institute John Locke). He also notes that the Navy Board of Examiners has tested and validated the safety guard and the fusible alloy in it, and that Professor Henry of Princeton has conducted further successful independent experiments:

> "Many of the names arrayed in favor of the invention, are illustrious in the departments of science, and associated in the annals of the country, with the progress of the arts. These men cannot be deceived—cannot easily be mistaken. With splendid reputations at stake, they would not give hasty opinions, founded upon half-tried experiments. It is idle, then, to talk of a 'chemical change' affecting the certitude of its operations, after the apparatus has passed through such hands." (p. 37)

A final endorsement connects Evans's name to that of his father, an acknowledged authority on the science of steam, as well as the inventor of the high-pressure engine and the first practical steam boiler used in Western steamboats.

Using scientific rhetorical technique, Evans provides several proofs of the mechanism's effectiveness through experiment (appending tables as proof) and defends against his critics' charge that the alloy hardens upon reuse (i.e., a casualty of the oxidizing/chemical change theory).[117]

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[117] "How absurd this objection, raised by cavilers, becomes under truthful experiment." P. 32.

He states the objection (A), and then refutes it (B):

> (A) "…the fallacy of a certain objection advanced against the apparatus, namely, that 'the alloy is liable to be oxydized, and that, as the oxyde is a bad conductor of heat, it requires a higher temperature to fuse the alloy each time it is melted';
>
> (B) "…if it were possible to convert the whole of the alloy into an oxyde, it could not, owing to the peculiar construction of the apparatus, resist or prevent the spindle from turning, and consequently no steam whatever could be kept in the boilers." (p. 32)

Here Evans is referring to the rotating spindle, which presumably would have functioned in spite of the oxidation of the alloy.

A large portion of the treatise is devoted to a lengthy endorsement section (pp. 42-69), which includes favorable reviews of the guard by some practical engineers who later rejected the invention. One such endorsement is signed by forty-three engineers. Evans notes that many engineers are not listening to him because they have been guinea pigs for "so many fanciful plans and inventions for the… prevention of explosions… that they have become rather indisposed to listen even to the suggestions of practical men laboring for the best interests of the profession." Evans urges engineers to "cast aside prejudice" and approach the invention with open minds. He advises the wisdom of "accepting all viewpoints, from scientists as well as practical men," and notes that "the collision of thought, like the clashing of steel, frequently produces sparks of light, which spreading, illuminate the minds of millions."

Professor Locke's observations reinforce the notion that Evans has been persecuted by prejudiced engineers. He states that Evans has suffered bitter malignity at the hands of the critics; Evans has been attacked in a "tempest of passion," and been forced to quit his occupation. "His enemies promised a better substitute for his invention, they have not developed one." There is much circumstantial evidence that engineers had been sabotaging the safety guards. For example, many endorsements state that the guard will work if left free to act. An endorsement from the *Pittsburgh Daily Chronicle* on May 31, 1850 opined: "The best remedy ever invented to prevent explosions is Mr. Evans' 'safety-guard.' We do not mean the 'safety-guard' when chained down, or plugged up, but as its inventor made it, when left free to act."

Captain James Atkinson urges "all SENSIBLE men" to receive the invention (emphasis in the original). "People are… beginning to get their eyes opened about the matter, especially since the many explosions which have occurred within a very short time, and which have been attended with the loss of so many valuable lives." William H. Young, an engineer with the Allegheny City Water Works, acknowledged on page 60 that he was one of these: "I was engineer on the iron steamer *Valley Forge*, about one of the first boats on which the Guard was placed, and at that time partaking, to some extent, of the prejudice of the profession against it, I was, from that very circumstance, led to mark with caution, its operation, and the result was a complete dissipation of all doubt as to its value." Another wrote that "When Mr. Evans first gave his discovery to the public, it was assailed by the strongest prejudices, and even he himself was subjected to the ungenerous contumely of the very men who should have hailed him as a benefactor. But it is cheering to observe that the storm is beginning to subside, and the merits of his invention becoming universally recognized."

In the final analysis, Evans's 1850 *Treatise* stands as a testimony to Evan's life work of trial and error with mechanisms, especially in the context of his developing intellect for the scientific point of view. His pains at exposition were spottily rewarded; evidence indicates that the *Treatise* was warmly received by so-called scientific engineers like T. J. Haldeman, but the document produced little effect on run-of-the-mill engineers of steamboats. Nevertheless, Evans moved on to pursue a new research project intended to justify his safety guard as superior to existing safety devices.

2.4 Evan's Last Years and General Comments on the Development of the Bache-Evans Safety Guard

In 1854 Evans published his last work before his death. This was the result of his experiments on fusible alloy plugs placed within a test boiler (Fig. 26).[118] Evans's alloy experiments may have been funded in part by Congress.[119] The main intent of this work was to prove Bache's pressure principle, i.e., that fusible alloy not isolated from the pressure of steam would fail to function properly.[120] In a series of experiments, Evans placed fusible alloy plugs in two configurations interior to the boiler: one configuration in which the plug was exposed to steam pressure and another configuration in which the plug was protected from pressure. Plugs exposed to pressure showed blockages caused by the separating out of constituent parts of the alloy; those that were protected from pressure fused and evacuated the plug housing perfectly. The experiments successfully validated the pressure principle. Evans illustrated his report liberally with engravings to demonstrate the experimental results.

In late January 1854, Evans wrote the government requesting a modification to the Act of 1852 to require that any device employing fusible alloy be isolated from the

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[118] Evans, Cadwallader: *A Statement of Experiments upon the Temperature of Steam, the Operations of the Common Safety Valve, and upon Government Alloys: with a Description of Newly Invented Safety Valves, &c. Pamphlet.* 1854. NARA RG 46, Commerce Records, Tray 26, folder 1 of 2, found with his 1850 Treatise.

[119] See memorial of Cadwallader Evans for "an appropriation to enable him to test his invention to prevent the explosion of Steam Boilers &c," *House Ex. Doc*. 88, 25 Cong., 3 Sess., January 7, 1839. Referred to the Select Committee on Steam Engines. Author's GD 26; Source: The Hagley Museum.

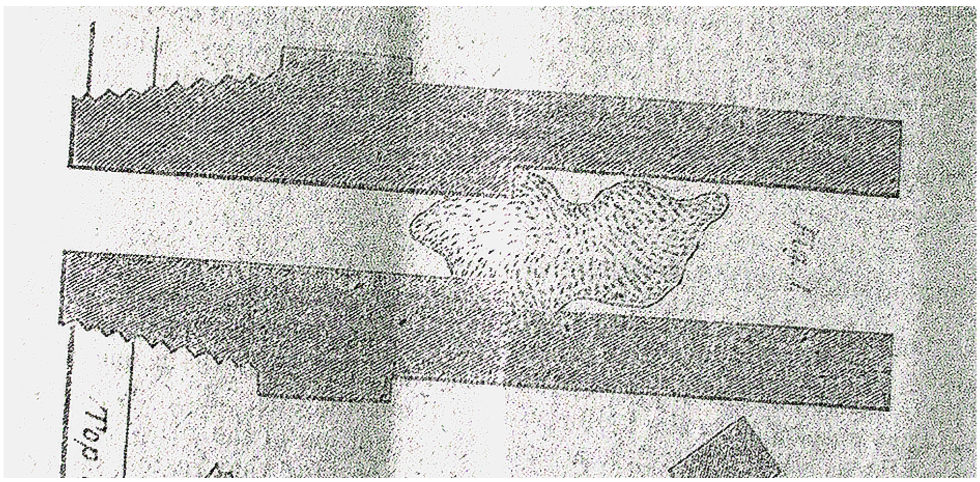


Figure 26. Evans's fusible alloy experiments – blocked plug. The fusible plug deteriorated when exposed directly to the pressure of steam but would not clear the plug housing. This was due to the different melting properties of the tin and lead components when exposed to pressure.

[120] A brief discussion of Bache's discovery of the pressure principle can be found in Sinclair (1974), pp. 180-181.

pressure of steam. It appears that Evans was seriously ill and that this move might have been to protect his business from competition in preparation for his widow taking over his factory. In the next several months, there was much activity by the government surrounding Evans's fusible alloy formulation. The Treasury Department's energetic actions during this period can best be explained as a reaction to Evans's illness and the need to secure the formulation of Evans's fusible alloy before he died.

Evans died in September or October 1854, leaving his widow Jane Evans to continue his safety guard business. Jane Evans knew the business, was technically skilled, and continued to supervise the workmen in the manufacture of the safety guards and fusible alloy after Evans's death.[121]

There are several conclusions we can reach in illuminating the subject of expertise during the period of the development of the safety guard. First, we can see in this story that the development process mirrors Sinclair's remark that science and practical engineering were merging during this period. Scientific investigation was empirical in nature while being guided by Bache's heat theory; invention and engineering were moving from practical mechanisms for their own sake toward an

[121] Memorial of Jane Evans to the U.S. House of Representatives dated February 21, 1860: "Memorial of Jane B. Evans, widow and executrix of Cadwallader Evans, deceased, praying the renewal of a patent granted to her late husband . . . referred to Committee on Patents, Patent Office."

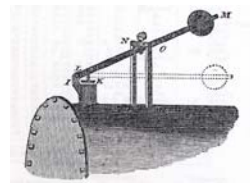
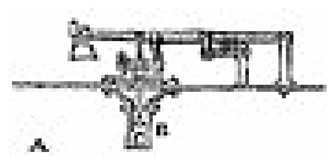
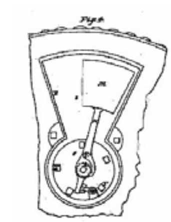
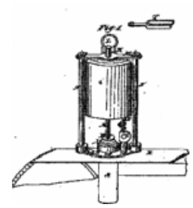
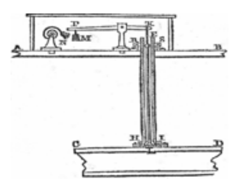
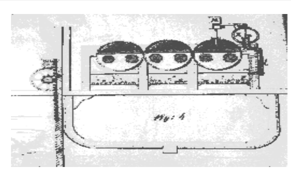
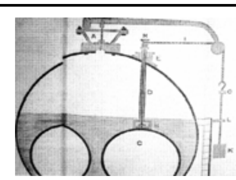
alignment with the scientific elites' theoretical principles. Second, we can see that development of a safety strategy was consciously guided by scientists at the Franklin Institute, and that this strategy was supported by the funding and authority of a powerful group, the Treasury Department. Third, from the government's overall development program, a practical safety device - - the safety guard - - emerged as a precise means of regulating temperature in the boiler. The self-acting safety guard promised to control the "bad" engineer and assist the "good" engineer and was a replacement for the common safety valve, which operated on pressure.

The self-acting feature of the safety guard depended on its "perfection" in accurately detecting heat and then activating at the right time. With fusible alloy, this proved difficult as Evans's hyperbole about the safety guard became tested through experience. As engineers would express later, the safety guard habitually activated at too low a temperature. We will go into more detail about the engineers' rejection of the safety guard in a later chapter, when we discuss the implementation of Act of 1852 on the western rivers. At that time, the safety guard became a test of the legal aspects of safety and expertise as the Treasury Department moved away from the practical engineers' strictly technical approach to safety.

We turn now to the practical engineers, who would find themselves central actors in the development of a new inspection service and steamboat law (the Act of 1852). Led by a handful of so-called scientific engineers, they sought to overturn the "lame" act of 1838. In the process, they became the first true boiler inspectors. This was a class of experts who had little to do with the development of the safety guard, but whose influence in shaping the outcome of its use became crucial over time. (Table 1)

Table 1. Evolution of Evans's Safety Guard (second page continues table).

Idea or Invention	Problem/Description	Solution	Action
1831 Bache JFI	Problems: Safety valve "ceases to deserve the name" – due to flash theory. Even opening the valve is thought to be dangerous (per Renwick).	Lock safety valve open, and combine valve with fusible alloy plate, separated by a cylinder. A modified safety valve design.	Valve normally locked open (the reverse of usual). Capt must close safety valve after alloy fuses, to get boat underway for repair. Alloy is lost, must be replaced at repair station.
1832 Evans JFI	Alloy in Bache's invention is not reusable.	Improvement is to extend the cylinder and close the tube, which prevents the metal from being lost. Always ready for a new operation. The first safety guard in conceptual form.	Plunger DOWN upon melting of alloy. SG serves as an alarm (rapid release of steam) on a lever. Alarm cock "gives notice."
1834 Evans (Patent) "Steam Safety Valve"	Further refinement to recover alloy.	Rotating shaft using "mallet" weight.	Mallet ROTATES about horizontal axis upon melting of alloy. Activates alarm. "Considerable noise" from small valve. Two SGs recommended [much expense!].
	Further refinement to recover alloy.	Vertical stem. Weight depresses stem upon melting of fusible alloy.	Plunger DOWN upon melting of alloy; heavy weight used. Fork needed to hold up weight as alloy resolidifies. Opens small alarm valve, "engineers receive notice."
1836 Bache JFI	Another basic SG idea to recover alloy. Alloy acts as an accurate thermometer because it is in contact with the flue.	Vertical stem, weight on lever pulls up stem, rings bell.	Plunger UP upon melting of alloy. Activates bell alarm. Used as fixture to do experiments on melting points/general behavior of fusible alloy.
1839 Evans (Patent) Safety Guard	Further refinement to Evans's other safety guard ideas.	Floats, plunger safety guard; anti-careening jig; passenger salon water gauge (tube)	Combination float, plunger type safety guard. Option for tube to descend to flue.
1850 Evans "Improved Safety Guard"	Final version. Safety guard now made "perfect."	Vertical, rotating stem with impeller.	Stem ROTATES about vertical axis upon melting of alloy. Chain-wound reset. Eliminates fork. Activates alarm, or puts out the fire.

Principle	Source	Illustration
Alloy is not isolated from steam. Alloy is with safety valve, nowhere near flue (a later development).	Bache's article, JFI April 1831	
Isolated from steam, but not in contact with the flue.	Evans's article to Committee on Boiler Explosions, JFI, 1832	
Isolated from steam but not in contact with the flue.	Evans's Patent 8185X, 5/1832.	
Isolated from steam but not in contact with the flue.	Evans's Patent 8185X, 5/1832.	
Isolated from steam, AND in contact with the flue.	Doc 162 (3/1/1836) and Committee's 1836 report in JFI (10/1836).	
Isolated from steam, contact with the flue is secondary consideration..	Evans Patent 1122, dtd 4-15-1839m, reissued 11-23-1852. (See 1855 4-10 and 1853 1) Drawings lost, found during research.	
Isolated from steam, AND in contact with the flue.	Evans's 1850 *Treatise.*	

CHAPTER 3. THE TRANSITION PERIOD 1838-1852: PRELUDE TO THE STEAMBOAT ACT OF 1852

3.1 Introduction

The Practical Engineers React to the Act of 1838

We have discussed the government's approach to safety through its scientific and practical experts - - Bache and his Franklin Institute Committee on explosions, and Evans with his prototype "improved" safety guard. Now we turn to another important group of experts, the practical engineers aboard steamboats, from whose ranks came the first bona fide steamboat boiler inspectors after passage of the Steamboat Safety Act of 1852. This chapter will cover the crucial 1838-1852 period, a formative period for the practical engineers as they coalesced into labor associations and began to shape the character of the soon-to-emerge Steam Boat Inspection Service. It was during this period that the "lame" Steamboat Safety Act of 1838 came under attack by the practical engineers, exposing its administrative and legal defects. The practical engineers exploited these defects to remake their industry in the image of their own trade associations by (1) serving as technical consultants in revising the Act, (2) promoting the best technical experts among their ranks to serve as future steamboat boiler inspectors, (3) pushing for the examination and licensing of engineers in accordance with the technical and moral standards of the associations, and (4) the culmination of all of this effort, the expelling of unqualified "engine-drivers." All of this was done under the auspices of a powerful government-scientist-industry alliance to set up a better administrative organization than the decentralized and ineffectual inspection service of 1838.[122]

Historians have underestimated the depth of feeling of the western practical engineers in their struggle to overturn the 1838 Act. These feelings arose as inferior engineers began to infiltrate the steamboat trade by the late twenties, taking jobs away from qualified men. More significant for the final makeup of the associations, even some of the newcomers aspired to professionalism and joined with senior engineers to keep out new entrants to the profession. The fact that this amalgamated bloc of practical engineers successfully maneuvered into position by 1852 to displace inferior engineers and inspectors operating under that act by 1838 indicates that the practical engineers were not a group to be trifled with—they had ambition, organization, power, and numbers. As early as the mid-1840s, influential members within their ranks had formed a powerful alliance with steamboat owners, Whigs in Congress, the Treasury Department, and the Franklin Institute. Each of these groups perceived the accidents as stemming from a crisis in qualified engineering manpower and a dysfunctional inspectorate.[123]

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[122] Congress invited the participation of steamboatmen in influencing steamboat regulation. See Hunter, SBOTWR (1949), p. 525. Inclusion of the steamboat industry in the alliance pushing for a radical revision to the Act must be qualified. Atlantic seaboard steamboat interests actively opposed the initiative, citing fewer accidents there, whereas western cities' boards of trade, in concert with much exertion by the engineers' associations, led the way to reform. See Hunter, ibid., pp. 529-530.

[123] Two men who carried the engineers' message to reform the act of 1838 to Congress were T. J. Haldeman and W. W. Guthrie. Both were accomplished practical engineers who had ties with the Franklin Institute for decades before 1852, served as inspectors under the Treasury Department after 1852, and initially supported the safety guard. Their influence will be detailed later in this chapter.

In light of new information on the engineers' motives and power on the western rivers, therefore, Burke's theme that the government regulation of steamboats was brought about by a general technological innovation (steam technology) requires revision. From the practical engineers' point of view, it was the flooding into the labor market of ill-trained men to run steamboats that motivated the reinvention of the inspectorate by 1852. Victorian religious attitudes toward improving the moral qualities of workmen were another powerful motivation for regulation, and this societal movement is intimately associated with the notion of the "good" engineer. Burke's steam technology aside, it was the engineers' movement that shaped the true character of regulatory reform of the steamboat community. Thus, notwithstanding the form of technology, it is highly likely that the push of the artisanal classes toward professionalization of the mechanical arts would have occurred during the period of the 1840s-1850s at any rate.[124]

This chapter will provide background information concerning the steamboat practical engineers' professional motivations, their scope of expertise, and their relationship to scientific and government institutions during this period. These facts will set the stage for understanding the engineers' later rejection of Evans's safety guard and the

[124] President Van Buren wrote in 1839: "There is a power of public opinion in this country…which will not tolerate an incompetent or unworthy man to hold in his weak or wicked hands the lives and fortunes of his fellow-citizens." President Van Buren's Message to Congress, January 19, 1839, in *Sen. Doc. 66*, 25 Cong., 3 Sess. Similarly, the moral weakness of the dissipated or incompetent engineer was seen by industry reformers as the underlying reason for steamboat accidents and hence the main reason reform was necessary. Calvert noted that in the 1840s, "Temperance, morality, and cleanliness were advocated as means of raising the mechanic's lot, indicating a possible relationship with the reform movements abroad in society." From Calvert, Monte A.: *The Mechanical Engineer in America, 1830-1910*. The Johns Hopkins Press, Baltimore, 1967, p. 30.

turmoil that disrupted relations between inspectors and high government officials in the Treasury Department.

Placement of Western Steamboat Engineers within Steam Society; the “Lame” Act of 1838

Through Calvert (1967), we can trace modern mechanical engineers to the practical engineers of the antebellum period. These “gentlemen engineers” worked in industrial machine shops situated in the eastern United States. The shops had their origins in the establishments that made weaving machinery for the textile mills of New England. The shop engineers were skilled craftsmen and designers of the privileged class who built steam machinery for mills, steamboats, steamships, and locomotives. In addition to mechanical skill with sophisticated machine tools and factory processes, their expertise included familiarity with theoretical subjects such as mathematics, chemistry (including heat theory), metallurgy, natural philosophy (physics), and the latest textbooks and journals of American and European scientists.

Between the years 1803-1813, the earliest steamboat owners on the western rivers ordered their engines and boilers from these eastern machine shops, the equipment being shipped overland or by sea to the ports of the western rivers. Soon, the practical engineers from these shops migrated to the near-western and far-western frontiers bisected by the Mississippi and Ohio Rivers to serve the burgeoning steamboat trade. By the early 1810s, they established engine-building shops and factories in three main steamboat construction centers: Pittsburgh, Cincinnati, and Louisville. It was from these shops, and other minor ones, that the practical engineer emerged to install and run boilers and engines on the hundreds of steamboats that were beginning to ply the western rivers.[125]

Within steam society, steamboat engineers belonged to "shop culture," defined by Calvert as "the orientation, institutions, and traditions of the nineteenth-century machine shop." Calvert describes the shops as "experimental laboratories in which mechanics developed and perfected industrial and mechanical processes and equipment." Wealthy and connected industrialists placed their sons in these establishments, where they could partake of an intellectual challenge without becoming entrapped in mass manufacturing. Thus, the machine shops provided "a gentleman's occupation within an ungentlemanly industrial world." The practical engineer's inclination to improve his mind put him in stark contrast to the capricious and itinerant "engine-drivers" who began to infiltrate the steamboat industry in the 1820s from land establishments such as cotton, sugar, and lumber mills. These men had no connection to shop culture. As Calvert stated, "All were involved with the more or less isolated job of tending one engine, which precluded their coming into contact with a large variety of mechanical problems." They had little inclination to improve their skills and knowledge and thus were little more than engine tenders who underappreciated the dangers of the trade.[126]

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[125] Hunter, SBOTWR (1949), Ch. 3.

[126] Calvert (1967), p. 12. The nature of the shops as innovative centers is covered in pp. 6-8. Both theoretical and practical learning were important aspects of engineering practice at these centers.

As we have seen in Cadwallader Evans's definition of the "good engineer," shop culture also embraced certain Whiggish personality traits. The gentlemanly qualities of temperance, morality, and a calm and steady demeanor were esteemed in the steamboat engineer, and like his shop counterpart, such qualities were expected to accompany the engineer's technical mastery of his machinery. The gentlemen-engineers observed that few engine-drivers possessed these qualities. Selecting for all of these traits two decades later would be the main task of the practical engineers in the role of local inspectors.[127]

A Case of Mistaken Identity: The "Good" Engineer versus the Quack

The good engineer considered the bad engineer a danger to himself, his colleagues, and the public. Worse still - - according to practical engineers - - the bad engineer had become predominant in the engine rooms of steamboats, invading the industry to such

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Some of the "shop aristocracy" valued a good education for their sons to such a degree that they eschewed American shops in favor of European ones, which they thought superior. Local Inspector Thomas J. Haldeman and others habitually noted that not one in ten or twenty engine-drivers knew how to make a calculation of a safety valve.

[127] "Many of them are of dissolute habits, with no application, nor inclination to improve their minds, being satisfied with the name of Engineer, and in putting in the time ..... moral culture has been thrown aside; when one of them is asked if he has read anything on the subject of steam he will reply "No! That he has not time," when he spends at least 3 months in the year unemployed, and ¼ of his time while on the boat in idleness; and it is not uncommon to hear them say, that they "are not afraid to carry 200 lb pressure in the boilers." (See 1853 12-15). The writer, W.W. Guthrie, had been "engaged in the manufacture of steam engines and in the capacity of engineer of steam boats for the past 20 years." At the time of writing, he was a local inspector of steamboats. Supervising Inspector and Whig Benjamin Crawford informed the press in 1853 that the purpose of the Act of 1852 was to reform "intemperate and dissipated" individuals, see 1853 6-6.

a degree that no distinctions were being made as to the quality of personnel. Practical engineer W.W. Guthrie wrote in 1853 that he had witnessed “good careful steady men, with long experience as engineers, hurried into eternity” by explosions caused by incompetent colleagues. He provided the details of how technological changes in steamboat design had brought this about:

> “The introduction of double engine boats on our western Rivers created a demand for Engineers which did not exist before; this demand was supplied by taking young men, mostly from that class without education or mechanical skill, who in a few months or years took the place of their tutors, having no other recommendation than that of going for less wages, and assuming the skill in running the boat faster than others, which they no doubt accomplished through their ignorance & recklessness. They have finally succeeded in controlling this important business, many of them are not able to write, not one in 20 can weigh steam by the common safety valve & lever, and but few of them understands the principle upon which the lever is governed.[128]

In a case of Gresham’s law as applied to expertise, these inferior engineers had driven out the good engineers:

[128] See W.W. Guthrie, 1853 12-15 (ibid).

> "This is the class of men, who has for the last 20 years, gradually superceded [sic] others better qualified, in the management of our Engines and Boilers. . . Large numbers of the regular mechanics retired to the workshops, and to other employment in preference to remaining in a business that was no longer profitable, nor at all worthy; others remained in the business but were compelled to pursue a course contrary to their best judgment in order to keep their employment." [Ibid.]

The tendency to blame *all* engineers, good as well as bad, for steam boiler accidents, served as the primary impetus for involvement of engineers in the reform of the Act of 1838. The bad engineer impugned the practical engineer's technical skills and character, and he poignantly felt the rejection of the public, government officials, scientists, and the press, many of whom did not understand that there were varying degrees of expertise among engineers. Marginalized practical engineers lamented that "the existing state of affairs is causing a prejudice to exist in the minds of the public against the whole community of engineers."[129] Customs Collector G. J. Floyd testified to Congress in 1838, for example, that "to the engineer may be traced all the accidents I have ever known." Another noted that engineers of land boilers were sober men whereas steamboat engineers generally were not, hence the increased incidence of accidents. Even scientist James Renwick indicated that in his

[129] *House Ex. Doc.* 145, 27 Cong., 3 Sess. (1842), p. 7.

investigations, “all have been caused by ignorance, culpable negligence, or foolhardiness” on the part of the engineer in charge.[130]

Captain Haldeman stated a more favorable view toward engineers in general but one that nevertheless revealed existing popular views of engineers, “…many persons not acquainted on our rivers, would suppose that our engineers are generally a dairing [sic], worthless, wreckless [sic] and intemperate set of men who would scarcely place more value on the life of a man than that of a spider, and that they are gathered up by taking <u>halfway blacksmiths</u>, <u>runaway apprentices</u> and <u>handy carpenters</u> and that engineers are made daily in this way.”[131]

Identification of the “six-month” engineer with the “quack” doctor was common among practical engineers in the 1830s-1840s, and this comparison carried forth into inventor Cadwallader Evans’s later thinking and writings. Engineers with the Cincinnati Association of Steamboat Engineers wrote that “the public will be compelled to intrust their lives in the hands of young and inexperienced practitioners, unless the intervention of Government soon puts an end to this system of frauds and quackery, now so extensively practised in the Western country..... the quack doctor can only destroy one life at a time, whilst the quack engineer may destroy, perhaps, hundreds at a blow, and that too without a moment’s warning; and yet the physician is compelled to go through a regular course of collegiate exercises before he is permitted to practise, while any man may practise as an engineer with no more

[130] Floyd: *H. Ex. Doc.* 21, beginning on p. 291; steamboat engineers not sober, beginning on p. 221; Renwick, beginning on p. 389. Renwick’s son later became a local inspector of boilers.

knowledge of the business than may be acquired in six months' time. This state of affairs causes a prejudice to exist in the minds of the public against the whole community of engineers." Haldeman echoed the same sentiment in making a case for the examination of engineers: "…many physicians and lawyers may carry a diploma in their pockets and never be able scarcely to make a living at the practice, owing to their want of practical knowledge, which they are not susceptible of receiving, and just so with engineers—there is no law in any country that requires the examination of engineers, yet I would not oppose such a course here as I think it would be a kind of stimulant to young men to seek for information in the science of Engineering, about which so many know but little at present."[132]

The economic and hierarchical labor structure of the trade favored the employment of the quacks. The practical engineers criticized newly commissioned steamboat captains for sustaining inept engineers in their positions and attempting to instruct them in the art of engineering. It was claimed that such captains had obtained their positions by buying them for the price of a few hundred dollars, and that usually in such instances their skills in managing a steamboat were poor. They taught the inexperienced engineers to keep the water level low in their boilers; as a result, when the safety valve blew, the captains urged the engineers to weigh it down so as not to waste the steam, but rather to work it through the engine, "and the engineer, not being any wiser than the captain on the subject, (and neither of them knowing the amount of

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[131] See Haldeman to Senator John Davis, 1852 5-1.

[132] Quack engineers: from *A supplement to the petition of the practical steam engineers and others of the City of Cincinnati, to the Congress of the United States*, *H. Ex. Doc.* 145, February 13, 1843, p. 7; see also Haldeman letter dated 1852 4-24.

steam they carry in the boilers,) suffers the captain thus to direct him, until, between the captain and the other ‘engineer,’ they blow the boiler out of the boat, and perhaps hundreds of persons into eternity.” When an experienced practical engineer took employment under such a captain, he had to suffer the guidance of the “directing engineer” (the captain), or find a more suitable job ashore.[133]

Expertise akin to that of a doctor required a good grounding in practice as well as extensive training. In addition, some persons had been born with the needed analytical skills for such trades and others had not. The former provided a high degree of flexibility of thought and the ability to adapt to new conditions through understanding and experience. But with the advent of high-pressure steam engines and their refinements, an engine-driver could put on a good show, but would fail when his superficial knowledge confronted real-world problems on the rivers. Engine design had been simplified so that any man of common sense could learn to start and stop an engine in a remarkably short time, and to pass a supply of water from the pumps to the boilers. Everything would go according to plan so long as the engine and pumps remained in perfectly good order, which they did not. The engineer must be “capable and ready, in every exigency, to counteract all difficulties that may unexpectedly occur on the trip from port to port.” Engine-drivers “had perhaps been underassistants to a principal engineer on a large boat, or had gained limited experience running an ordinary grist or saw mill engine, or occupied a position as a tanner, grinding bark by means of a steam engine that he had started and stopped a

[133] *H. Ex. Doc.* 145, 1843, p. 7.

few times." They could gain employment on a boat by exaggerating these instances of superficial expertise: "By telling a fine story… the most incompetent men are often found in the most responsible situations." The self-styled engineers were also a direct economic threat: "Such men are very often found in full charge of a steamboat engine for the only reason that their services may be had for a trifling sum less per month than men of well known experience would require." Such complaints testified to the nexus of frustration the qualified engineers felt toward the engine-drivers, and this frustration motivated them to mobilize their trade associations to reform the steamboat law.[134]

The Engineers' Antipathy toward the Steamboat Safety Act of 1838; the Formation of the Engineers' Associations

The practical engineers had suffered from competition by inferior engineers since the early 1820s. By the early 1840s, they believed insult had been added to injury when the confusion between the two classes of engineers was made official and codified in the Steamboat Safety Act of 1838. The Act was a stopgap law that lumped all steamboat mechanics into one class and held all engineers legally responsible for boiler explosions. For the engineers, the main objections to the 1838 law were that (1) it did not provide for the licensing and grading of engineers (to establish a distinction between skill levels), and (2) it unfairly singled out engineers as the

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[134] *H. Ex. Doc.* 145, 1843, pp. 6-14.

legally responsible party in cases of steam boiler accidents (i.e., accidents as prima facie evidence of neglect, carrying a penalty of up to ten years at hard labor).[135] The prima facie guilt clause within the Act can be found in Sections 12 and 13:

> "Every captain, engineer, pilot, or other person employed on board of any steamboat or vessel propelled in whole or in part by steam, by whose misconduct, negligence, or inattention to his or their respective duties, the life or lives of any person or persons on board said vessel may be destroyed, shall be deemed guilty of manslaughter, and, upon conviction thereof before any circuit court in the United States, shall be sentenced to confinement at hard labor for a period not more than ten years."[136]

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135 The grading scheme eventually decided upon consisted of first, second, and at the low end, third-class engineers or "Strykers" (engine tenders and oilers). Strykers were usually young assistants (boys) or negroes who were not given much responsibility under the new scheme, but who previously had been employed by Captains, before the Act of 1852 (and to some extent afterward, to the protests of the practical engineers), as the sole engine-drivers because their wages were low. The formal grading scheme of engineers evolved out of the types that were differentiated before the Act was passed. This is murky, but with Calvert and Hunter as sources, as well as a note from Haldeman and other NARA letters, we can infer an educated guess as to the various gradations of engineers. These consisted of (1) experienced and educated practical engineers from the shop tradition; (2) ambitious engine drivers who showed intelligence and conscientiousness to apprentice under the experienced men, and whom Haldeman acknowledged could be allowed to attain the rank of practical engineer; (3) rank and file engineers who joined the engineers' associations but who had little inclination to read the works of science or advance in knowledge; (4) other rank and file engine-drivers and strykers of dubious quality and experience. How the above classes correlated to the later grades is unclear, but we may surmise that the experienced practical engineers and aspiring apprentices (once qualified) made up the First Engineers. These were supervisory engineers in charge aboard steamboats, and were the persons usually considered responsible in cases of accidents. Second Engineers actually monitored the operation and safety of the boilers under supervision of the First Engineers. These were rank-and-file engineers. Third engineers and strykers performed routine maintenance and lesser tasks. It is inferred that opposition to the safety guard was strongest among the less educated engineers, but eventually it appears that most if not all grades of engineers engaged in sabotage, or acquiesced in it with the collusion of some local inspectors. Further research is needed, but because sabotage was unlawful, only circumstantial evidence is available. Some of this evidence will be presented in the next chapter.

136 Section 12, "An act to provide for the better security of the lives of passengers on board of vessels propelled in whole or in part by steam," 25th Congress, Sess. II, Ch 191, p. 306, July 1838.

> "And be it further enacted, That in all suits and actions against proprietors of steamboats, for injuries arising to person or property from the bursting of the boiler of any steamboat, or the collapse of a flue, or other injurious escape of steam, the fact of such bursting, collapse, or injurious escape of steam, shall be taken as full prima facie evidence, sufficient to charge the defendant or those in his employment, with negligence, until he shall show that no negligence has been committed by him or those in his employment."[137]

The practical engineers vociferously objected to the prima facie provision because they believed it violated fundamental rights due any citizen. These rights were enumerated in the fifth and sixth amendments to the U.S. Constitution, "which articles guaranty to all persons under criminal prosecution the right of a speedy and impartial trial by jury, to be informed of the accusation, and be confronted with the witnesses against him or them, to have compulsory process for obtaining witnesses in his favor, and to have the assistance of counsel for his defence." These were educated men from shop culture who possessed a sort of nationalistic pride based on Constitutional precepts. For them, the startling implication of the flawed provision was that it in effect preclassified the engineers as criminals. In this sense, the clause struck at the core political values of the engineers. They wrote: "Why so large a class of industrious and enterprising citizens should be denied a privilege granted to the

[137] Section 13, loc. cit.

greatest criminal—via, that of being deemed innocent until proved guilty—we are at a loss to conjecture."[138]

The Act suffered in reputation also because the men installed as the first steamboat boiler inspectors were considered incompetent and venal. Professor of Chemistry B. Silliman at Yale College wrote in 1838 that the compensation of the inspectors was too low, and that such trivial compensation would lead to inspectors "being bought" by powerful steamboat companies. This outcome is verified by later commentators, who noted that the old inspectors "never gave [steamboat owners] any trouble," and that the steamboat companies had succeeded in removing the good inspectors.[139]

Administratively, these early inspectors were semiautonomous, appointed by federal District Court judges, and not supervised by a board of inspectors. As a result, the Customs Service, focused as it was on its traditional role of collecting tariffs and regulating smuggling, seemed ambivalent as to results. Inspections were poorly performed and were not adequately monitored. Although the more conscientious inspectors actually stepped inside boilers to do their inspections, most did a cursory and inadequate job. Some stayed away from the wharves entirely and collected their fees. The hydrostatic test, an important strength of materials test borrowed from France and advocated strongly by the engineers' associations, was uniformly ignored. Denault (1999) wrote, "By 1848, it was clear that the [safety act of 1838] created an

[138] The engineers' concerns are contained in *H. Ex. Doc.* 145 (1843), p.13.

environment where unqualified inspectors obtained their positions through political favoritism and patronage. These inspectors regarded the position as a lifetime office and failed even to inspect boilers. This was pervasive enough for one writer to suggest that boiler inspections be conducted in the presence of two witnesses."[140]

By the early 1840s, finding themselves driven from their boats by unqualified men and in the clutches of a punitive law, the practical engineers began forming trade associations (steamboat engineers' associations) as a means of banding together to show the public and Congress the "true character of western engineers." A cross between labor unions and artisanal guilds (e.g., mechanics' institutes and lyceums), the associations' main political function was to begin pushing licensing laws. The character ideal of the good engineer was in keeping with that of the engineers' own associations; when performing their duties aboard steamboats, members were expected to exhibit a sober disposition, calm demeanor, high moral character, and knowledge and skill in the properties of steam.[141]

The details of the formation of the engineers' associations shed light on how the association engineers viewed themselves. According to Cincinnati practical

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[139] Venal inspectors, Hunter, SBOTWR (1949), p. 534; B. Silliman, *H. Ex. Doc. 21*, April 1838, p. 386; old inspectors gave no trouble, 1852 11-19; removal of good inspectors, 1852 9-18, "we hope the inspectors appointed under the new [1852] law will be as sacred men."

[140] The hydrostatic test was a borrowing from the French used in the proof testing of cannon. In the test, the inspector pumped water under pressure into the boiler to about a third over the rated pressure to detect weaknesses in the joints of plates or to reveal other structural weaknesses in boiler shell or flue. After 1852, we see frequent records noting inspectors carrying portable hydrostatic test pumps about with them at the wharves while performing their inspection duties. See 1852 5-3, 1852 11-1, 1853 4-12, 1853 6-3, 1853 7-8. also see Denault, 1993, pp. 162-163.

[141] True character of western engineers, *H. Ex. Doc.* 145, 1843, p. 8.

engineers, their own members formed the first such association (Fig. 27 and 28). Engineers followed this example in other large western cities "having the same object in view," which was to resurrect the tarnished image of western practical engineers. To achieve this, the associations aspired to conduct experimental scientific research of their own, putting them more on a par with scientists. They also wished to procure their own scientific apparatus so that young engineers could make their own experiments and gain a hands-on education that they would not ordinarily acquire. The association engineers admitted, however, that they did not have sufficient resources to finance such initiatives, and so they solicited funds from the federal government. Further, they admitted that their members were not sufficiently educated to understand the higher aspects of the science of steam. This was not because they did not have access to science books, but because the texts they did possess were "written in such unintelligible language as to require of the reader a more than ordinary education to enable him to comprehend the meaning of the terms used by the authors." They attempted to bridge this gap by holding regular lectures and discussions in the engine-building shops where expertise was congregated. In the larger cities, they joined lyceums so they could be exposed to lectures provided by scientists.[142]

[142] *H. Ex. Doc.* 145, 1843, ibid., p. 8.

Figure 27. Cincinnati Mechanics' Institute (a practical engineers' association).

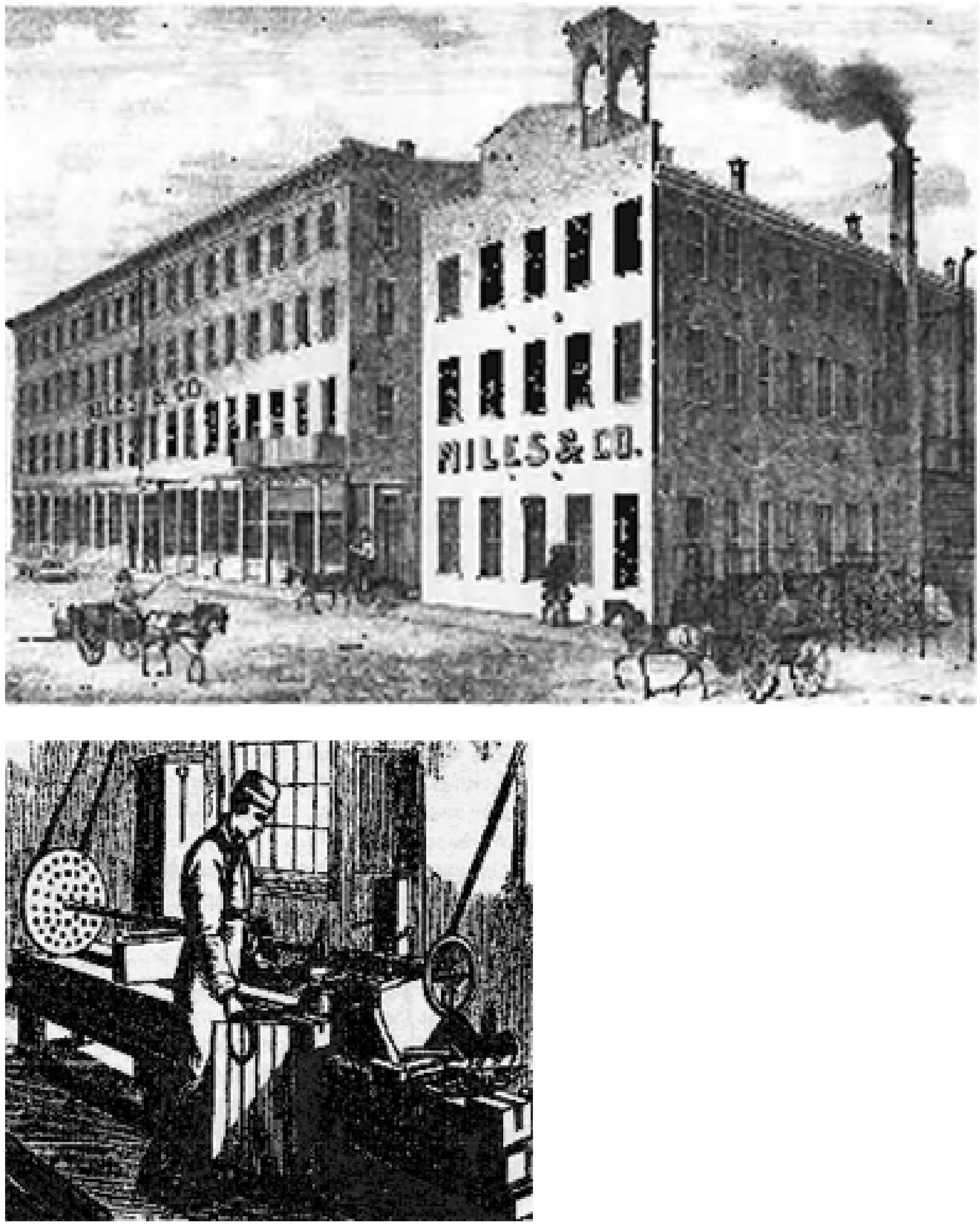

Figure 28. An engine-building shop in Western country. The workman from Calvert (1967).

3.2 Improving the Steamboat Law

Reforming the Act of 1838

How did the members of the associations plan to overturn the Act of 1838? The move to modify the Act should be viewed as an action to restore the profession of practical engineering to its former high status before the influx of the untrained men. Thus, the examination and licensing of engineers was the first order of business. The inspection of machinery and the incorporation of safety devices, while important, were of secondary strategic importance in the lobbying effort. This was because trained engineers and qualified inspectors, unlike the engine-drivers, would presumably maintain all the mechanical components in proper working order. As far as safety devices went - - beyond the more traditional methods such as water gauge, steam gauge, and safety valve - - only the hydrostatic proof test of boilers was deemed useful and desirable. All other inventions (labeled “gimcrack” and “humbug” by most practical engineers) were condemned as superfluous or even dangerous (Fig. 29).[143]

Formal examination and licensing were to be done in accordance with the engineers' associations' own standards and personal codes of conduct. For example, the

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[143] Technical inertia is the best explanation for the practical engineers' preference for traditional monitoring devices. According to Denault (1999), steamboat technology, generally, had frozen by about 1850. Practical engineer T.J. Haldeman was an exception to most engineers in this regard. He cited the efficacy of several new inventions such as Evans's safety guard, Borden's mercurial gauge, and Faber's Magnetic water gauge. See Haldeman's letter to Senator John Davis, 1852 5-1, IMG 1088.

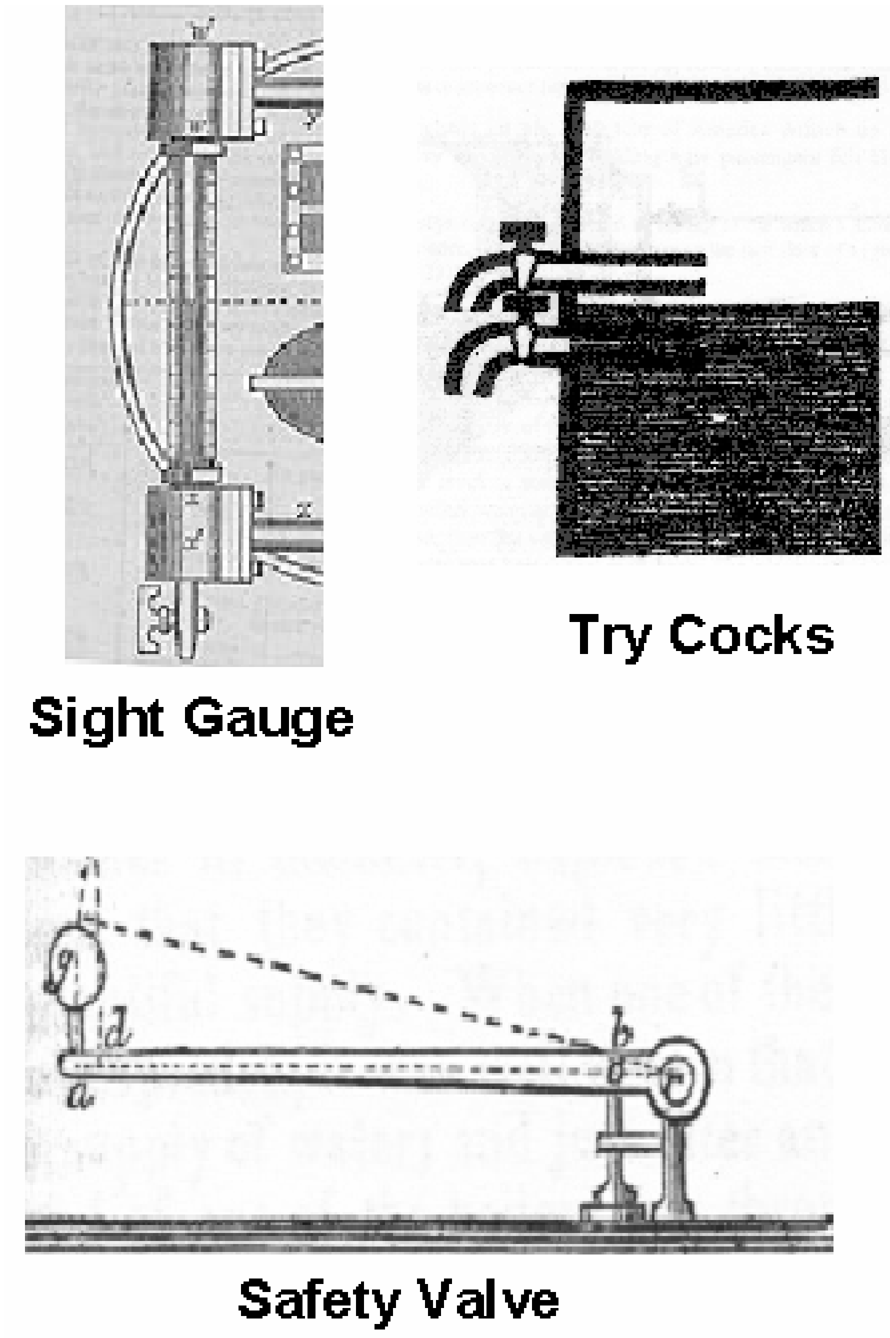

Figure 29. Engineers’ standard suite of boiler safety apparatus and techniques. First, a qualified, sober engineer, water gauges, trycocks, mercury nanometers for measuring steam pressure, safety valve and calculations, doctor pump, hydrostatic test.

Cincinnati engineers noted that national law should base qualifications of engineers on the form specified by their association. The form consisted of a written set of rules published by the association, which were provided to Congress. Examinations embraced moral qualities of the applicant, as well as basic technical and scientific knowledge and the subject's familiarity with the operation of traditional safety equipment. There must be a complete understanding of the workings and calculations of the safety valve, the ability to design a hydrostatic test based on the calculated strength of the boiler shell, and a thorough knowledge of boiler construction. Mathematics and geometry would constitute necessary skills in all calculations. Licensing of engineers would be performed by an acting board of engineers governed by a constitution or bylaws of a recognized practical engineers' association in each port of entry in the Union. In remote places, a chief engineer in residence would be chosen; he would have at least six years of practical experience as an engineer, and would be required to "give satisfactory evidence that he possesses sufficient energy of character, good morals, and proper attention to his duties."[144]

The engineers emphasized the reform or removal of "dissipate," unskilled, or uncaring engineers in upgrading the Act. Material aspects of safety such as those emphasized by Bache, Evans, and the government's research establishment, while important to a select few practical engineers, were seen as secondary to personnel

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[144] *H. Ex. Doc.* 145, 1843, pp. 18-20. Examinations were a matter of paramount importance to the practical engineers. The Cincinnati engineers wrote, "so long as Government refuses to interfere and enforce the qualifications of engineers, just so long must the public trust their lives in the hands of quack engineers, possessing no more knowledge of the business than any schoolboy may be taught in a few lessons." *H. Ex. Doc.* 145, ibid., p. 14. The Cincinnati rules for engineers' qualifications were provided to Congress but do not survive. The NARA correspondence shows that after 1852 the engineers exerted much pressure on at least one supervising inspector (Embree, Fifth Inspection

examination and licensing. As one practical engineer wrote Congress in 1838, "Engineers are the inventions that your committee should test… the fault is not in the boilers, but in men calling themselves engineers."[145] This emphasis on licensing is confirmed by Calvert: "The associations and organizations created by these groups sought to get license laws with such vigor that no other type of professional activity was pursued." (Table 2).

Thus, from the engineers' perspective, the failure of the Act of 1838 was not a failure of regulation of an entire industry so much as a failure to regulate a single profession. Historians have tended to portray the act in the former light. For instance, Hunter noted that "by all evidence the law failed and failed badly," and by this he meant the failure of the government to reform safety practices (Hunter, pp. 533-535). Burke wrote of the disappointment in the law by the "informed public" (i.e., chambers of commerce, boards of trade, bodies of engineers, and other interested persons), citing the need for corrective legislation and agreeing with Hunter that "experience proved that the 1838 law was not preventing explosions or loss of life."[146] Although these portrayals are true in a "macro" sense, the accident rate was to a large extent a

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District) to follow the law and conduct proper examinations of engineers. See 1853 1-1, 1854 5-1, and 1854 5-24.

[145] *H. Ex. Doc.* 21, p. 398.

[146] Burke (1966), p. 17. Denault's relatively recent statistical study of steamboat explosions (1999) shows that there was a gradual and steady improvement in the accident rate over a long period due to government-guided boiler design and construction improvements (refer to Figure 8). Nevertheless, there has been an erroneous impression created by contemporaries and historians alike that the act of 1838 did not alleviate explosions as expected, and that this ineffectual government regulation was corrected by the Act of 1852. This view continues to be propagated. See, for example, Jonathan Rees's article in the journal *Technology & Culture*, in which he concludes, "Finally, in 1852, Congress passed the nation's first substantive regulation of a technological practice. The death toll on the nation's rivers dropped precipitously." T&C, Vol. 46, No. 3, July 2005, p. 548.

Table 2. Partial list of questions proposed in the inspection of engineers, estimated to be from around 1853.

- Can you find the area of a circle, a cylinder, or of a safety valve, the diameter being given?
- By what process do you determine the pressure in a boiler?
- What do you understand by the pressure of the atmosphere? What height of a column of mercury will equal the atmosphere? What of water? Does this ever vary?
- What do you understand by a horse power? How do you determine it, the dimensions of an engine and diameter being given?
- What do you understand by using steam expansively? What gain would there be in using steam cut off at half of the stroke, over using it through the whole stroke? By what rule?
- How do you find the cubical contents of a globe or ball?
- What do you understand by the term latent heat? What by specific, and what by special?
- What is the temperature of water at the boiling point in the open atmosphere? Does pressure have any influence upon the boiling point? Can the height of a mountain be determined by the point at which water boils? Why is it?
- What general views have you in explanation of the causes of explosions of steam boilers?
- What would you do first on discovering that water was low in the boilers, and a probability that the interior had become greatly heated? What would be your first step on discovering that water was getting low in the boilers?
- What measures should be adopted to insure perfect safety on making a landing and leaving it? Is one time more common than another for boilers to explode? What is the probable cause?
- What is the probable condition of the surface of the water in a boiler while steam is generating, but before any escape or surcharge has taken place? What is the effect, upon a discharge?
- What are the component parts of water? Of air? What is the explanation of combustion? Why is air necessary?
- What is the principal cause of foaming?
- Have you any general ideas of the truth or falsity of explosions through the agency of gas? What are they? What is the gas? How is it exploded? What is produced as a result of it?
- Have you any general ideas of the course you should pursue if exposed to a violent storm upon the lakes? Suppose a derangement of your pumps, crank pin or other machinery, or in case of fire? In such peril, how far should the officers of the boat control your actions?
- At what temperature has iron its greatest tenacity? What will a bar of iron one inch square sustain before being pulled asunder? What will copper?
- What temperature is a red heat by twilight? What by daylight?
- How do you estimate the strength of a boiler? Suppose, for example, a boiler perfectly cylindrical 42 inches in diameter with two sixteen inch flues: show the mode of calculating.
- What is the weight of a cubic foot of water? Of wood? Oak, pine, and of cork? What is the ratio of the weight of mercury compared with water? What is that of air?
- What are your habits in reference to the use of intoxicating liquors?

subsidiary concern of practical engineers. They believed that by emphasizing reform of the engineering corps, a reduction of the accident rate would naturally occur. But even had the steamboating community perceived a decline in accidents after 1838, the engineers still would have found certain provisions of the law odious and would have worked strenuously to overturn them. This is primarily because the act as written could never have imposed the type of organizational framework that affixed the engineers within the topmost sphere of power and decision-making, *as final technical arbiters of the technology within the industry*—a position they believed they deserved by virtue of their expertise as applied scientists. These men saw themselves as the inventors of the steamboat power plant, and as the innovators who brought it to perfection. Out of their shops arose the technology—and out of their shops also would come the practical expertise that would provide the solutions to its dangers. This professional pride goes far to explain how conflict could arise when the Treasury Department later tried to move the findings of theoretical science into the engine rooms of boats. It also provides the sharp demarcation perceived by the engineers between theoretical scientists and applied scientists. Each to his own realm; the two professions could participate in a sort of symbiosis of expertise, but science in practical application was the exclusive province of the practical engineers. Interference by scientists, inventors, and bureaucrats in the area of actual practical use of machinery on the rivers was not justified and was not wanted.

The Commerce Committee Drafts the Replacement Steamboat Safety Act of 1852

As the Act of 1838 revealed itself as an unpopular failure, the engineers' associations began to lobby Congress in Washington for passage of their major points: the licensing of engineers, the removal of the prima facie "blame" clause, and the replacement of political appointees or local favorites with inspectors who were experts appointed from the engineers' own ranks. As Hunter wrote, "Western steamboat engineers were particularly active in criticism of the act of 1838 and in demanding a more thoroughgoing law. When the bill of 1852 was under consideration steamboatmen met in the various river cities for discussion of its provisions, made criticisms, proposed modifications, and sent not only memorials but delegates to Washington to confer with those in charge of the bill.[147] Delegates to Washington included two future supervising inspectors whom we shall meet in the next chapter. These were engineer-inventors Alfred Guthrie (1805-1882) of Chicago, and Benjamin Crawford (1809?-1873) of Pittsburgh. Both were presidents of their respective steamboat engineers' associations. Guthrie had spent decades investigating boiler accidents at his own expense; he frequently went aboard steamboats disguised as a common traveler, making inquiries of the engineer about his practices. Crawford was a foundryman and inventor of steam and farm machinery in Allegheny County, Pennsylvania. Crawford's particular gift was his administrative talent for organization. He would go on to write most of the safety rules for

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[147] Hunter, SBOTWR (1949), p. 530.

steamboats via his membership on various committees of the Board of Supervising Inspectors. Another influential practical engineer who corresponded with the steam safety committee was practical engineer and steamboat captain Thomas J. Haldeman. Like Guthrie, Haldeman spent decades investigating boiler accidents on his own, and was a contributor to the *Journal of the Franklin Institute* on steamboat safety practices in the 1830s. He would go on to serve as a local inspector of boilers and machinery. He was particularly anxious to overhaul the Act of 1838, writing to Senator John Davis in May 1852, "We are all here in the West, take much interest in this Bill of yours, as we do not want to have saddled upon us such another useless law as passed in 1838, which has been a constant tax without the first particle of benefit, and we have been trying for years to get it repealed."[148]

When it was finished, the act of 1852 would turn out to be a long and elaborate document of 43 sections.[149] Its emergence coincided with an unusual convergence of disasters during the years 1847-1852 - - explosions, fires, and collisions.[150] Being a government enterprise attempting to merge political and legal contending interests,

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[148] T.J. Haldeman to Senator John Davis (1787-1854), chairman of the Steam Safety Committee, U.S. Congress, 1852 5-1. The practical experts did not always agree amongst themselves. Guthrie had developed his own invention—a device with floats and alarms connected to indicators that displayed "water getting low," "dangerous steam," and other warnings when attention was needed to fix a problem. Haldeman disliked this invention, and noted that Guthrie had ignored the three most important inventions just coming into vogue: Evans's safety guard, Borden's steam gauge, and Faber's magnetic water gauge. The Safety Committee was left to sort out the provisions of the bill based on these and other inputs.

[149] "An act to amend an act entitled, 'An act to provide for the better security of the lives of passengers on board of vessels propelled in whole or in part by steam,' and for other purposes." (32nd Congress, Sess. I, Ch. 105, 106, p. 61, August 30, 1852). The reference in the title to "an act to amend" referred to the overhaul of the old act of 1838. In the same year, Harriet Beecher Stowe published Uncle Tom's Cabin, signaling the beginning of the abolitionist activism of that era and the looming split between North and South.

[150] Hunter, SBOTWR (1949), p. 537.

the Act was an amalgam of the reforming ideas of several groups: scientists, practical engineers, owners and captains, and government officials. The framing of the Act of 1852 coincided with the development of sectional political strife and the Compromise of 1850 that would lead to the Civil War a decade later. At that time, the federal government would in effect nationalize the steamboat service in the Western country to provide troop transports for the Union Army, and safety would then take a back seat to military expediency.

We have seen how the plan of the practical engineers was to overhaul the personnel in their industry. However, events took another course after 1852 once the Customs Service imposed its own system of expertise—a bureaucratic expertise that engendered many more aspects than the practical engineers' narrower technical and moral ideas of regulation. These included political, legal, and bureaucratic traditions that were alien to the practical engineers, as well as institutional scientific and technical perspectives that came from a long accumulation of military engineering expertise in navy yards and armories. There were also the important 1836 findings of the Franklin Institute's investigation in 1836, compiled as a "pull out" section for insertion in the steamboat act. These findings had been around for a long time, but despite wide distribution in 1848, they were not comprehensible to most engineers.[151]

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[151] "It quickly became apparent that those most directly concerned with steamboat power did not understand the General Report [of the Franklin Institute]" See Brockmann, *Exploding Steamboats, Senate Debates, and Technical Reports: The Convergence of Technology, Politics and Rhetoric in the Steamboat Bill of 1838*, Baywood Publishing Co., Amityville, New York, 2002, p. 81. The printing history of the General Report was as follows: In 1836, 500 copies; in 1848, 10,000 copies, see p. 84. In his book, Brockmann provides extensive background material on the reasons for the failure of the 1838 Act.

Parallel with evolution of the act of 1852, inventor Cadwallader Evans was beginning to gain official government acceptance for his safety guard as the single “catch all” invention that was meant to act as an insurance policy to prevent steam boiler explosions. The official acceptance of the safety guard by the Treasury Department (via a Navy Commission) coincided with the mass distribution in 1848 of the earlier *General Report on the Causes of Boiler Explosions* issued by the Franklin Institute (1836); timing of its acceptance coincided as well with the initiative of Congress in 1850 to redraft the steamboat law. To the engineers, the inclusion of a fusible alloy safety device in the contemplated new federal boiler code took safety beyond the issue of personnel reform, but this was not realized at the time. After enactment of the Act of 1852, the fusible alloy requirement would be seen by the engineers as a point of fundamental distrust of the engineer and a denial of his self-appointed role as autonomous applied scientist.

In the next few years, from 1852 to 1859, there would take place a convergence of the various actors to create the first government agency to extend its technological expertise to the western waters of the U.S. This convergence, and the reaction of the engineers to the key technological actor, the safety guard, is the subject of the next chapter.

CHAPTER 4. THE INSPECTION SERVICE MOBILIZES FOLLOWING PASSAGE OF THE ACT OF 1852; RESISTANCE TO THE SAFETY GUARDS

4.1 Introduction and Background

The New Inspectors Descend on the Western Rivers

In January 1853, newly appointed Supervising Inspector of Steamboats Davis Embree of Steamboat Inspection District Five, St. Louis, published a notice in the local newspapers that he would be arriving at several ports on the Mississippi River to examine and certify steamboats, and to license steamboat officers and engineers. “The provisions of [the act of 1852] are very rigid,” he warned, “and subject all who disregard them to heavy penalties… ignorance of the act will be no excuse for its violation.” The steamboat act itself had been made to run the gauntlet of critics and experts for the past two decades, and it now captured the best scientific research of the academy in combination with the best practical experience of the engineers. The phenomenon of the supervising inspector, who brought with him a small host of field inspectors (trained practical engineers and carpenters called local inspectors organized into nine district “local boards”), was completely new to the steamboat community. Power was now concentrated in this centralized body of men who understood the importance of action and had the will to strictly carry out the new steamboat act.[152]

The new inspectors made rapid strides in screening personnel and checking the safety of steamboats. In one district, for example, in their first three months in office the local inspectors at Louisville certified 72 steam vessels, licensed 176 pilots and 263 engineers and their assistants, and inspected 19,175 gross tons of shipping.[153]

The new organization and the high level of activity signaled a sea change in the way inspections were to be conducted; the Congress and the Federal government had launched a radical program of reform and there was no going back. For the practical engineers in the associations, the most important consequence of the change was a professional one--the opportunity to reclaim the lost status and reputations of better days. Those had been days in which expert mechanics developed the first high-pressure engines that conquered the western rivers, before the engine-drivers had arrived on the scene to command low wages and spoil the profession. It would now

[152] Steamboat Act of 1852: "An act to amend an act entitled, 'An act to provide for the better security of the lives of passengers on board of vessels propelled in whole or in part by steam,'" Thirty-second Congress, I Sess., Ch. 105-106, August 30, 1852, pp. 61-75.

[153] The Steamboat Act of 1852 was passed in August 1852 but was not put into effect on the western waters until early 1853 - - steamboat owners were not ready. Embree announcing his arrival on the river, see newspaper article 1853 1-1, D13. News source and date of publication clipped, but by proximity to other source materials, date is presumed to be January 1853. Rapid strides of inspections, see U.S. Coast Guard site, Steamboat Inspection Service (Discussion), from: http://www.uscg.mil/hq/gcp/history/h_Westernrivers.html.

be possible to expel those operators who were not worthy to bear the name “practical engineer.”[154]

Overnight, the Act raised the top class of old-guard practical engineers into positions of near absolute authority on the rivers as local inspectors of hulls, boilers and machinery. The promotion of top engineers to the rank of U.S. inspector raised the power and prestige of the best-qualified rank-and-file engineers as well. These engineers would now have a say as to who would be permitted to hold engineers’ licenses and who would be denied them. Furthermore, the Act empowered engineers to overrule their captains in operational safety matters. This grant of power was unheard of at the time, and was quite controversial with captains and owners. We shall see later in our story, for example, how a powerful steamboat captain and owner of a fleet of steamboats, Captain William J. Kountz, engaged in a virtual war with a supervising inspector, Charles Ross, over a licensing matter. It is an indication of the upset to the power structure on the rivers generated by the Act of 1852 that Ross was sufficiently provoked by Kountz to remark, “The only way he can get rid of us is to kill us.” With this challenge, Ross summed up the conviction and pluck of the new

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[154] Scholars have underestimated the impact of the steamboat act on the western steamboating community. The history of regulation was a considerably messier affair than what has been conveyed by the standard histories, which tend to merely recount the legislative aspects. At the microhistory level, there was much reluctance to obey certain provisions of the 1852 Act due to economic costs, social traditions, and (in the case of owners) feelings of property ownership. In some cases, provisions simply could not be enforced or were open to a degree of interpretation, such as the provisions on the grading of engineers.

inspector-engineers: the power structure on the rivers had changed and this time the change would be substantial and permanent.[155]

Organization

The Act of 1852 created nine inspection districts, each under the control of a supervising inspector and two local inspectors—one of boilers and machinery and one of hulls (Fig. 30 and Table 3). The supervising inspectors formed the Board of Supervising Inspectors, a quasi-independent executive board under the Treasury Secretary. In rank, the supervising inspectors were roughly on a par with the powerful Customs collectors.[156]

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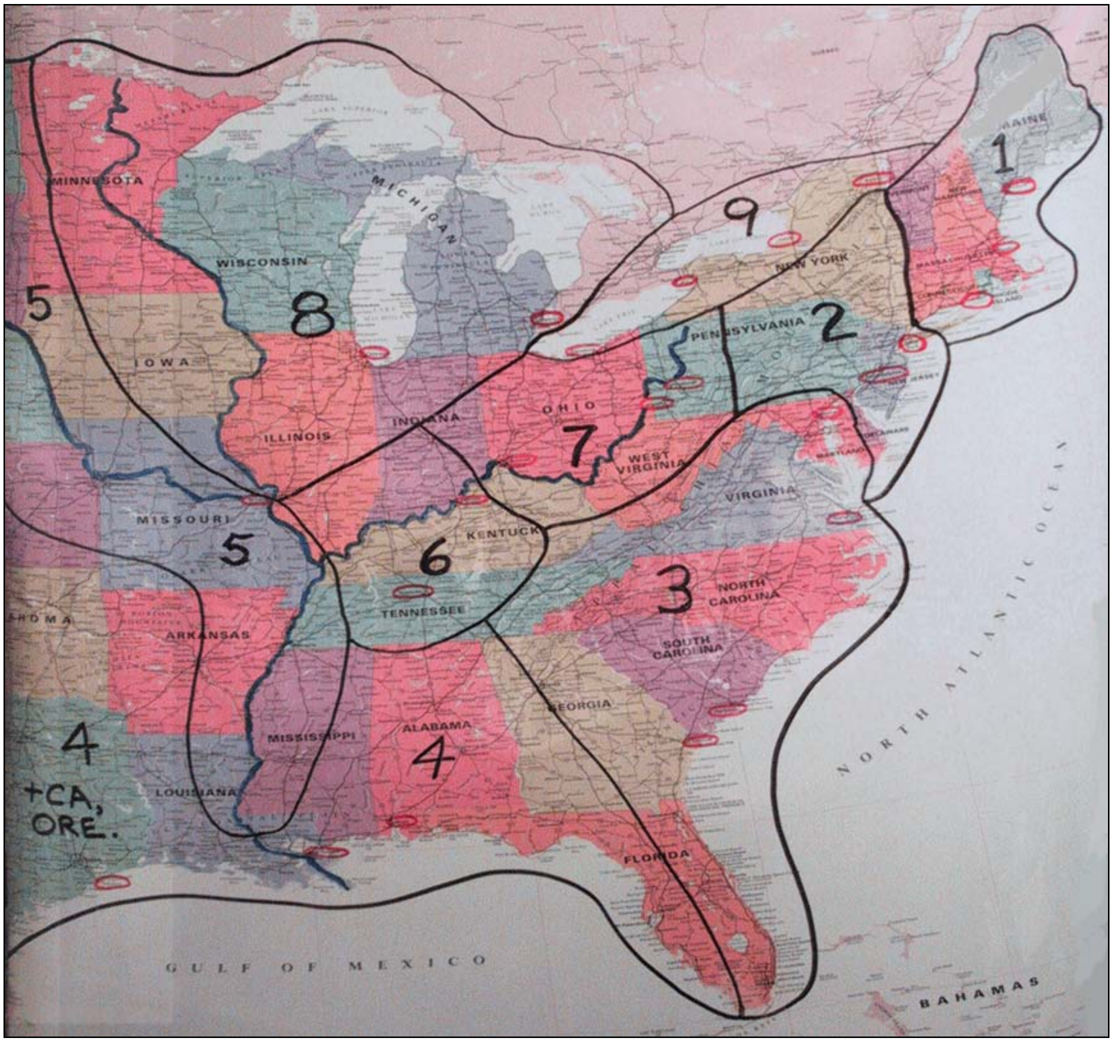
[155] For purposes of discussion, the name "steamboat inspection service" or "inspection service" is used in this chapter in place of the formal "Steam Boat Inspection Service," a designation arising sometime late in the nineteenth century. In its formative decades, the inspection service remained undifferentiated from the Customs Service and had no official name.

[156] There were important differences, however. The supervisors were less broadly political than the collectors because their activities were restricted to the regulation of a narrow industry (steamboats). Further, their activities were specialized and did not generate appreciable revenue for the Federal government, whereas customs officials presided over entire political districts in the regulation of maritime commerce and the collection of government-sustaining tariffs. These tariffs constituted the main source of income for the Federal government. In addition, the supervising inspectors were latecomers to the Customs organization; because they had to fit into the administrative structure of Customs, for many years they were answerable to some extent to the collectors. For example, although there was no formal "pecking order" or authority of customs officials over inspectors, local inspectors did sometimes complain or express concern to collectors over the actions of supervising inspectors, see 1858 5-10; and collectors sometimes became involved in disputes between local and supervising inspectors, see 1859 1-11. Ultimately, steamboat inspectors and customs officials were jointly responsible for carrying out the administrative and financial directives of the Secretary of the Treasury with regard to the Steamboat Act. In one instance, for example, Customs surveyors complained that they were shouldering the extra load of preparing steamboat certificates and other documents for the inspection service, and they lobbied for more pay, see Proc, 4-8-1856, p. 11. It should be pointed out that the specialized, technical, nature of the inspection service did not stop attempts to politicize the position of steamboat supervising inspector. The traditions of political patronage in the Customs Service were already in place and ready for exploitation for political advantage. Details provided in the "politics" section of this chapter.



Steamboat Inspection Districts, 1852

No. 1: Upper New England
No. 2: NY, NJ, DE
No. 3: Mid-Atlantic
No. 4: Gulf Coast, New Orleans
No. 5: Lower Mississippi River, Missouri River
No. 6: Lower Ohio River
No. 7: Upper Ohio River
No. 8: Great Lakes and Upper Mississippi River
No. 9: Eastern Great Lakes, Oswego
(Red circles indicate local inspectors' offices)

Figure 30. The Supervising Inspectors divided the country into major river systems, lakes, and coastal bodies of water for purposes of administering the Act of 1852. Map prepared by the author.

Table 3. List of steamboat inspectors attending the annual meetings of supervising inspectors. Italics indicate a change in personnel from the previous year.

District	Supervising Inspector	Location
Proceedings **10-29-1852**		
1	Samuel Hall	Boston MA
2	Chas. W. Copeland	New York NY
3	James Murray	Baltimore MD
4	P.H. Skipwith	New Orleans LA
5	Davis Embree	St. Louis MO
6	John Shallcross	Louisville KY
7	Benjamin Crawford	Pittsburg PA
8	Alfred Guthrie	Chicago IL
9	William A. Bird	Black Rock NY
Proceedings **8-1-1853**		
1	*Wm. Burnett*	Boston MA
2	Chas. W. Copeland	New York NY
3	*John S. Brown*	Baltimore MD
4	(not present)	New Orleans LA
5	Davis Embree	St. Louis MO
6	John Shallcross	Louisville KY
7	Benjamin Crawford	Pittsburg PA
8	Alfred Guthrie (not present)	Chicago IL
9	*John A. Campbell*	Black Rock NY
Proceedings **10-6-1854**		
1	Wm. Burnett	Boston MA
2	Chas. W. Copeland	New York NY
3	John S. Brown	Baltimore MD
4	*William E. Muir*	New Orleans LA
5	Davis Embree	St. Louis MO
6	John Shallcross	Louisville KY
7	Benjamin Crawford	Pittsburg PA
8	*Isaac Lewis*	Chicago IL
9	*Augustus Walker*	Black Rock NY
Proceedings **10-10-1855**		
	(NO CHANGES)	
Proceedings **4-1-1856**		
1	(not present)	Boston MA
2	Chas. W. Copeland	New York NY
3	John S. Brown	Baltimore MD
4	(not present)	New Orleans LA
5	Davis Embree	St. Louis MO
6	John Shallcross	Louisville KY
7	Benjamin Crawford	Pittsburg PA
8	(not present)	Chicago IL
9	(not present)	Black Rock NY

Table 3 (concl).

***Proceedings* 10-15-1857**				
District	Supervising Inspector	Location	Local Inspectors, Hulls	Local Inspectors, Machinery & Boilers
1	Wm. Burnett	Boston MA	Andrew Burnham, Joseph W. Dyer, Calvin Lester	Increase S. Hill, John Sparrow, Charles M. Daboll
2	Chas. W. Copeland	New York NY	John W. Weeks, Samuel Vaughn	Henry B. Renwick, Thomas Murphy
3	John S. Brown	Balto MD	John T. Farlow, Wm. H. Hunter, C. Candler, John Christee	James Curran, G. B. Davids, E. E. Hewes, Wm. Kine
4	*O.A. Pitfield*	New Orleans LA	J.O. McLean, H.F. Towlmin, H. Wilson, John C. Hoyt	John C. Barsh, J.M. Cumberland, George W. Coffee (California)
5	Davis Embree	St. Louis MO	Henry Singleton	James H. McCord
6	John Shallcross	Louisville KY	Joseph Sweegar, H.H. Harrison	Reuben Dawson, John Wilson
7	Benjamin Crawford	Pittsburg PA	John S. Dickey, Clark Haynes, Thos. J. Halderman	Andrew Watson, A.M. Philips, W.W. Guthrie
8	*Isaac Lewis*	Munroe MI	R. Prindiville, George W. Strong	Thomas C. James, Wm. F. Chittendon
9	Augustus Walker	Buffalo NY	Charles Reeves, B.A. Stanard, J. White, J.E. Lee	Thomas Truman, T.R. De Forrest, E. Root, Wm. T. Barnes

Note: Local inspectors began to be listed in the Proceedings beginning in 1857.

The Board met two months after passage of the Act to decide the exact boundaries for the nine districts. Each district would contain between one and four ports. In the East, many of these same ports were long-established centers of operations in which Customs officials handled the usual tariff-collection and anti-smuggling duties. No such Federal presence existed on the Western waters. This is important for illustrating why many western river men were hostile toward the exercise of Federal power during the time of the introduction of Evans safety guard.[157] For example, in the year Evans's safety guard was introduced - - 1854 - - Eastern Districts 1 through 4, along with District 9 in the north (part of the eastern Great Lake system) held by far the greater numbers of customs officials, totaling some 2,621 persons.[158] By contrast, western Districts 5, 6, 7, and 8 held only 85 personnel. Of these 85 persons, Detroit and Chicago, whose vessels plied the Great Lakes and so were not part of the western river systems, accounted for almost half. Thus, Eastern customs officials outnumbered Western officials by a ratio of 2,621 to 45, or about fifty-eight to one.[159]

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[157] The old established centers were the ports of Boston, New York, Philadelphia, Baltimore, Charleston, etc (classifying New Orleans as an Eastern seaboard port because that city connected the Mississippi River with steamship routes from the Atlantic coast).

[158] District 4 also contained California and Oregon, but these states contained no western river ports (Mississippi and Ohio Rivers) and so are not included in the analysis.

[159] The table below shows the number of customs officials in the nine inspection districts, excluding the Far West, in 1854 and 1858 (compiled by the author from a U.S. Treasury report to Congress; Source: U.S. Customs House Data, 1854-59, http://eh.net/databases/customs.) The ratio for 1858 remained virtually unchanged from that of 1854. The two years' worth of data were selected from a spreadsheet giving the total number of personnel employed at each of 152 customs houses in the United States in the years 1854 through 1859.

Geographically, the western districts were vast, making the Federal presence even more diffuse. District 5 contained most of the Mississippi River, extending some 1,400 miles and passing through eleven states. Districts 6 and 7 covered the Ohio River and its tributaries from the Mississippi to Pittsburgh in northern Pennsylvania. These two districts spanned approximately 1,000 miles of river in eight states and together with District 5 held the greatest concentration of steamboats in the country. Thus, six inspection offices served more than 2,400 miles of river (to put this distance in perspective, 2,400 miles is roughly the distance spanned by the coastline of the entire Atlantic Coast, from New Brunswick, Canada, to the tip of Florida). Districts 5, 6, 7, and 8 were located in the heart of the western river country, and these districts caused Treasury Department officials the most trouble over the safety guard. The Northern Districts 8 and 9 consisted mainly of the Great Lakes (the "Northern Lakes" district referred to in the annual reports) and the upper reaches of the Mississippi River.[160]

Inspection District	**1854***	**1858***
1	557	544
2	1256	1414
3	302	316
4	323	325
5	9	7
6	8	9
7	7	9
8	61	72
9	183	157

*Fiscal year ending on June 30.

Summary Table	**1854**	**1858**
"Eastern" Districts (1-4, 9)	2,621	2,756
Western Districts (5-8)	85**	97

**Forty of these were from Detroit and Chicago.

[160] The centers having the greatest number of steamboats in the U.S. at that time (1839) were Pittsburgh (District 7), Cincinnati (District 7), and Louisville (District 6). See *House. Ex. Doc* 21,

The supervisors' function was to supervise the local boards, execute the administrative aspects of the law, systematize rules and make modifications to the act as needed, and supervise the introduction and evaluation of new safety inventions; this latter function was part of the supervisors' responsibility in executing Treasury Department technological policy. The steamboat law required that the supervising inspectors meet as a board each year to report on progress and summarize developments. The annual reports that historians have relied so heavily upon, called *Proceedings of the Annual Meeting of the Board of Supervising Inspectors of Steamboats*, captured the highlights of these meetings.[161]

The local boards, whose inspectors reported to the Supervising Inspectors, were made up of practical engineers from the engineers' associations and mechanics' institutes of

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25 Cong., 3 Sess. (1838), p. 11. The geographic expanse encompassed by district boundaries made inspection trips long and lonely. In District Eight, covering the Great Lakes during a series of inspections in 1855, the local inspector of boilers at Oswego logged 1,500 miles on his circuit in just forty days. These forays consisted of one round trip from Oswego to Ogdensburg, New York (on the St. Lawrence River high above Lake Ontario), and four round trips to Lewiston (Niagara subdistrict) on the isthmus between Lake Ontario and Lake Erie, 1855 9-10. Another inspector (Third District) had as his territory "all of the waters of North Carolina and Virginia that flowed into the Atlantic Ocean." He wrote, "The office [required] much of my time and absence from home." (1859 1-26).

[161] The conduit of power for the Department's technological policy is obscure. For the fusible alloy safety guard, direction appears to have been communicated directly to the Board of Supervising Inspectors by the Treasury Secretary and special agent William M. Gouge in consultation with their scientific consultants Professor John L. Smith, Professor John Locke, Professor James Booth, and inventor Cadwallader Evans, among others. See Proc 10-6-1854, 10-18-1855, and the Secretary's instructions to the Supervisors in 1859 12-19. The supervising inspectors came from a variety of backgrounds, most being "persons engaged in business." see 1852 12-1. (See detailed biographies of selected supervising inspectors in the chapter end notes). One was a large industrial manufacturer of naval vessels (Charles W. Copeland, New York), several were owners and captains of steamboats (Davis Embree, St. Louis; John Shallcross, Louisville; and Charles Ross, St. Louis), one was a practical engineer (Alfred Guthrie, Chicago), and one was an inventor and foundryman (Benjamin Crawford, Pittsburgh). The supervising inspectors each were paid an annual salary of between $800 (Wheeling, Virginia) and $1,800 (Cincinnati, Ohio), the amount depending on the size and importance of the port, and the local inspectors were paid $300, see Proc 1856 4-16. At this time, both supervising

their respective cities. These were the technically brightest, most skilled, scientific practical engineers in the industry. Unlike career customs officials and some supervising inspectors, these were technical experts who, on the whole, had little political skill or ambitions. Under the Act of 1852, local inspectors were initially selected jointly by the collector, the supervising inspector, and the federal district judge.[162]

The local inspectors were the actual interface with the river men and were the real power on the rivers. Of this situation, at least one supervising inspector complained of powerlessness. On the subject of pressure carried in steamboat boilers, Supervising Inspector Alfred Guthrie lamented in 1853 that he had "no power over what the local inspectors do." Supervising inspectors who were vulnerable politically also had to defend themselves against public criticisms by engineers and local inspectors vying for their positions. In both of these cases, it was the local inspectors and leading engineers who best understood the current situation on the rivers and tended to operate in sympathy with the rank-and-file practical engineers.[163]

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and local inspectors appear to have worked part time on inspection matters, holding regular jobs or running their businesses for their primary incomes.

[162] After 1853, inspectors and engineers found themselves in the political world of the Customs Service, a nontechnical realm to which they generally were ill-suited. There were exceptions: a few engineers showed political skill in campaigning for inspector's positions when inspectors came under political attack or were vacating their positions. When these engineers began to understand the power the inspectors' civil service position conferred, they were quick to campaign for the open slots. For example, respected practical engineer John S. Dickey, in Crawford's seventh district, built a considerable power base in his campaign for Crawford's position because of his popularity with district steamboat engineers.

[163] Powerlessness of Alfred Guthrie, Supervising Inspector, 8th District, to TS Guthrie. Chicago, 1853 4-12. Local inspectors challenge incumbent supervisor, see local inspector John S. Dickey's campaign to unseat Crawford, 1858 10.

The emphasis of the local inspectors was primarily on personnel reform (removing unqualified engineers) in concert with use of tried-and-true safety practices and a trained eye toward boiler quality. The main duties of the local inspectors consisted of examining, grading, and licensing engineers; inspecting and certifying steamboats; conducting legal investigations of accidents and preparing reports and testimony; and running the inspection office (Fig. 31). Examinations served to place engineers in three grades, a system devised by the supervising inspectors at the behest of the Cincinnati local board. Examinations determined experience level and aptitude of the candidate (as described in a previous chapter). Ratings were generally assigned according to the size of steamboat. Large boats having three or more boilers received the highest grade of engineers, and small boats with less than three boilers received the lower grades. Under the new rules, promotion in grade could only occur with the approval of a local inspector, and only when a case was justified by "special and satisfactory reasons."[164]

[164] Large boats versus small boats, see Proc 10-9-1854, p. 103. Crawford presented a communication from the local board at Cincinnati on the classification of engineers on the Western waters, referred to a committee, see Proc 10-9-1854, p. 101. Promotion criteria, see Proc 1853 8-4. Inspecting steamboats: the procedure consisted of the inspector entering the boiler with a lantern to explore the various internal parts for scale and rust. He checked the number and placement of stays, which were metal straps that supported the internal flues; checked boiler plate for cracks, sufficiency of strength, and quality rating as stamped on the iron; checked for substandard plates patched into the old shell of the boiler, and for riveting flaws; checked the safety valves, water cocks, and gauges; and checked for obstructions in water and steam pipes. A final strength test of the boiler was done using the hydrostatic test, a key test in the French System. Here, the inspector forced water under pressure into the boiler at two or three times the rated strength of the shell using a portable hydrostatic pump. If the boiler failed during test, it would burst without releasing the excessive amounts of energy present in a steam explosion. Boilers tended to fail along seams where rivet holes had been damaged in the manufacturing process, where patched sheets of plate iron had been spliced in during repairs, or around thinning or burnt sections of iron produced by the accumulation of "scale" (scale was a deposit of limestone and mud that hardened and produced local "hot spots" near the fire end of the boiler). By 1852, the hydrostatic test was a proven and accepted technology. To execute the test, one had to know how to calculate the burst pressure of the boiler, a strength of materials exercise that required both practical knowledge and mathematical skill. This precluded most engine-drivers and some supervisors from conducting the test. The test was universally popular with scientific practical engineers and inspectors because it was effective in preventing poorly constructed boilers from circulating in the

Figure 31. An engineer's certificate and a steamboat inspection certificate.

trade. The hydrostatic pumps used were designed, built, and manufactured at the U.S. Navy Yard. These were portable devices that could be placed on wheels. For a detailed list of inspectors' duties, see pp. 64-65 of the 1852 steamboat act (32nd Congress, Sess. I, Ch. 105, 106, August 30, 1852). Once a steamboat passed inspection, the inspector issued a certificate of operation.

In practice, the grading of engineers was not so tidy. Engineer Leonard Harbaugh of Cincinnati complained that industry practice on the Ohio River combined the jobs of carpenter and second engineer. If a steamboat happened to strike an object in the river, the engineer was forced to abandon his post in the engine room to tend to hull damage. In the process, he turned over the running of the engine to an inexperienced "stryker" (third class engineer). In this way, a steamboat being run by a second class engineer suffered an effective downgrading of engineering skill to that of a stryker. Harbaugh believed this a violation of the spirit of the law and was a serious hidden cause of accidents.[165] In another case, engineers complained that the local board in New Orleans refused to prosecute the Ferry Steamer *Trenton* for employing unqualified negro strykers as engineers.[166] In Alabama, labor combines were forming in 1857 by which engineers and pilots were subverting the grade structure by independently bidding up fees for their services.[167] In other cases, skill in grade was evidently not as important as political affiliation. In New Orleans in 1855, an engineer could not find work unless he belonged to the Know-Nothing Party.[168] Another serious problem in which grades became confused arose during some accident investigations where no hard-and-fast rules governed whether the first or

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[165] See 1858 7-27. One also senses Harbaugh's jealousy at suffering a third engineer taking his place while he performed carpentry, a humiliating occupation for an accomplished engineer.

[166] See 1858 5-10. This concern went nowhere. The local board's decision was upheld by Captain Pitfield, the Supervising Inspector at New Orleans.

[167] Pilots, see 1857 9-4; engineers, see 1857 11-3. These actions were condemned by the Department as "unlawful conspiracy."

[168] See 1855 5-19.

second engineer should bear responsibility for negligence. In such cases, grading of engineers became almost meaningless.[169]

Local inspectors operated on a shoestring budget, with the Treasury Secretary micromanaging even the smallest expenditure. Incidental expenses included firewood, floor coverings, and office rents. In one instance Treasury Secretary Howell Cobb instructed his local inspectors to sell forty yards of surplus carpet "without delay," then deposit the proceeds in an account or use it to credit other purchases. In quite a few instances, rooms were not to be had at all because there was no money in the appropriation to pay for them. Supervising Inspector Crawford wrote, "We also want offices for Local Inspectors, for which there is no provision made in the law. I spoke to Mr. Hodge on the subject and he said he would send in an estimate to the Committee of Ways and Means and have it inserted in the Appropriation Bill, as it is a matter of great importance to us." For years, inspectors housed their offices and instruments in Customs warehouses or in basements of Customs offices. Accident investigations were conducted in the salons of steamboats.[170]

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[169] The case of the *Fanny Fern* explosion in January 1858 was a notorious one among engineers, in which the second engineer was blamed for the explosion and the first engineer was exonerated. Local Inspectors Dickey and Watson accused Supervisor Benjamin Crawford of nepotism in protecting the first engineer. See Dickey and Watson's *Vindication* pamphlet, 1858 9-10. (Full title: *A Vindication of the Action of the Late Local Inspectors at Pittsburgh in the Case of the Explosion of the Steamer Fanny Fern; with the Evidence and Correspondence*. By John S. Dickey and Andrew J. Watson, local inspectors at Pittsburgh, 1858).

[170] The Secretary and his small staff, which, until the Civil War, consisted of a high clerk and perhaps a few assistants and copyists, kept the organization's administrative machinery running. The staff were consumed mainly with reimbursing expenses from the local boards and with arbitrating complaints and pleadings from the inspectors and steamboatmen. Small appropriations, 1853 7-15 and 1853 10-15, and many other letters; room rent charge not allowed because it was not pre-authorized, 1853 10-12; non-reimbursed travel expenses, 1853 10-10; unpaid salaries (a local inspector was paid $300 per annum), 1853 4-12; firewood request for coming winter, 1856 12-23; TS Cobb authorizes the

Reactions of Owners, Engineers, and Inspectors of Steamboats to the Steamboat Act

The strongest reaction to the new enforcement regime was by masters and owners of steamboats. This was largely a matter of the additional costs imposed on owners by the new law. These costs included the expensive retrofitting of engines to lower steam pressures so as to permit the boilers to pass the hydrostatic test. Owners on the western waters were accustomed to operating their engines at 200 psi or more. The 1852 law required them to reduce pressure to 110 psi. The only way to achieve this reduction was to retrofit the engine by changing out the cylinder to increase its volume and hence lower the pressure. Owners at Louisville argued that it would take a month to make a trip from New Orleans to Louisville under the 110-pound system. Inspector Alfred Guthrie called this argument "extravagance," arguing that all that was needed was a re-gearing of the paddlewheel so it could turn faster and "do the same amount of labor in a given time." He noted with disgust that owners of older steamboats requiring the modification were content to "let them blow up and when we build them we will do better."[171]

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inspectors to sell carpet, 1857 11-9; no rent money for offices, 1853 2-3 and 1853 10-15; boiler explosion inquiries held aboard boats for want of office space, 1854 1-2.

171 See 1852 5-3. In June 1853, Crawford reported that he was going to go after unlicensed engineers and pilots, as well as boats in the situation stated by Guthrie: these were the boats that had received extensions because they could not meet requirements, but still they had not retrofitted after the allotted time. They thus had not obtained their certificates of hull and boiler inspection. 1853 6-6. The 110 psi limit was for a standard 42-in. boiler, see p. 65 of the Steamboat Act of 1852 (32nd Congress, Sess. I, Ch. 105, 106, August 30, 1852)

Other additional costs were for unconventional safety devices. A rough reception awaited devices such as Borden's steam gauge, Faber's magnetic water gauge, the French manometer, and Evans's Guard, not to mention many other inventions spawned by inventors in an attempt to quell the growing number of boiler explosions (we recall that by 1850 most of the simpler safety equipments on steamboats had settled or "frozen" in their development so far as river men were concerned; novel equipment flooding the profession was most unwelcome). Cost for owners was a cause of concern; novel appliances collectively cost in the several hundred dollar range; Evan's device alone was quoted by Haldeman at $150 (Fig. 32).[172]

Owners reacted as well to the new inspection regime. Supervising Inspector Benjamin Crawford in Pittsburgh reported that there was "a good deal of opposition to [the new law] by the owners and masters of steamboats" and that owners and captains lamented that they wished the old [1838] inspectors back because they "never gave them any trouble." In Cincinnati in March 1853 alone, local inspectors cited fourteen "masters and persons" for employing unlicensed pilots and engineers; these

[172] Although many general safety devices and rules were not yet mandated by the law, a variety was being considered by the supervising inspectors after 1852. Some of these had nothing to do with boilers; they were for general safety such as for the prevention of fire and drowning (e.g., wire steering ropes, life vests, passageway clearances, navigation rules, etc). Supervisor Benjamin Crawford had a hand in all of these. See Appendix A, Index of Annual Reports (Proceedings) of the Supervising Inspectors. Although Evans had a cheaper twenty dollar version of his safety guard available and another at seventy-five, he did not recommend these cheaper versions as the best protection against explosions. Evans's $20 version (the one most popular to owners because of its low cost) was an alarm only; the $75 and $150 versions activated the safety valve to release steam, or opened a valve from a feedwater tank to put out the fires.

“Going downstream, pilots usually held to the channel, keeping to the outside of the many bends, to profit by the depth and swift current. The problem was to locate and make the ‘crossings’ where the channel passed diagonally across the river. When rounding the bends going upstream, pilots held to the shallower but relatively slack water along the inside of the bends. By weaving back and forth in counter-direction to the channel, pilots could avoid the force of the current and save time, fuel, and wear on the machinery.”

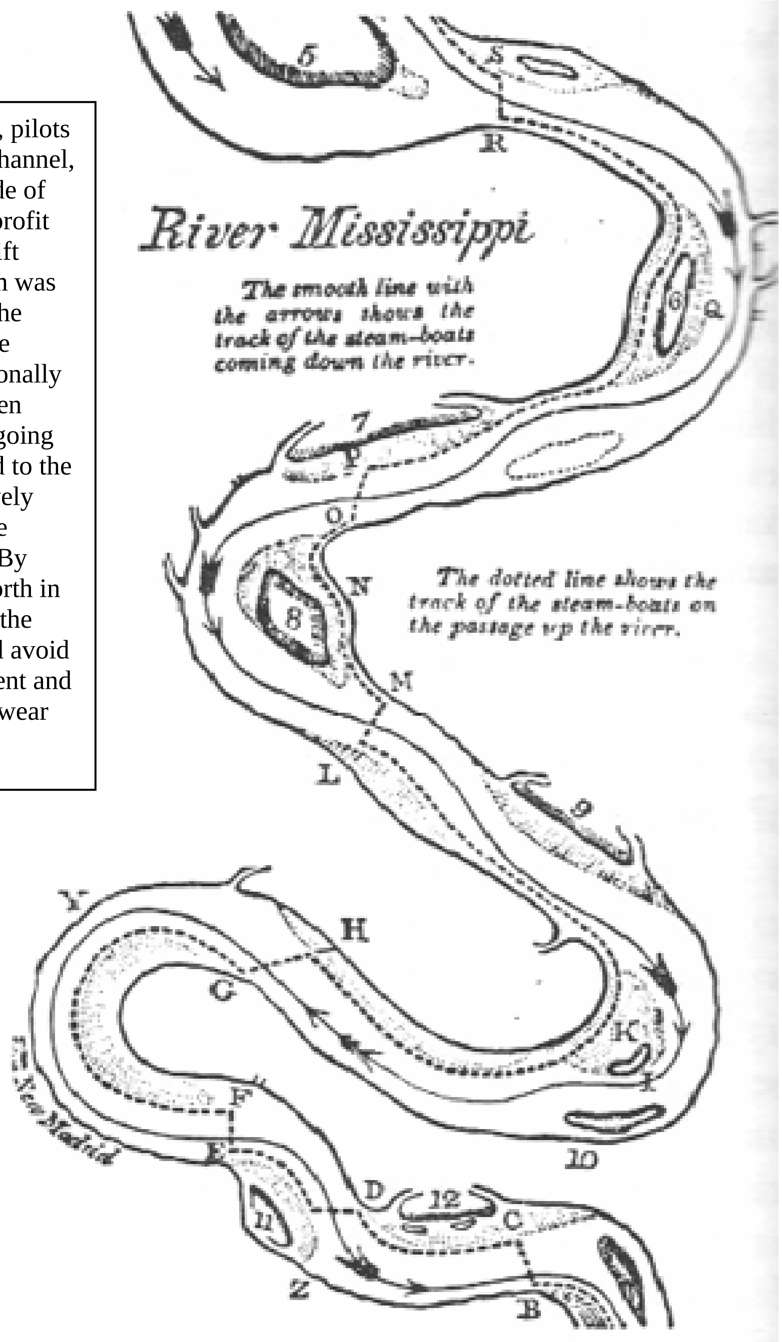

Figure 32. The Steam Boat Inspection Service soon expanded to govern safety in many other areas than boiler safety. Shown are the complexities of river navigation requiring the formulation of special rules and protocols for pilots. (Source: Hunter, SBOTWR, 1949, p. 240).

paid their $100 fines and reclaimed their licenses or were suspended for "neglect of duty."[173]

Owners played cat-and-mouse games with the inspectors, thwarting inspections by painting a unique name on each side of their boats, or by stalling the inspectors by not making ordered repairs between inspection visits.[174] Some captains interfered with the inspectors' operations, as in the example of the aforementioned Captain Kountz, who continued to employ engineers who had had their licenses revoked.[175]

Reaction from the rank-and-file engineers toward the inspection service was mixed. The supervising inspectors noted in 1853 that general trade opposition to the 1852 law had been great in the beginning, but that after several months it had diminished. However, the law did create some major inconveniences which served to make it unpopular. A number of engineers and pilots in Memphis, which had no local inspection board, complained that they had to travel great distances, to either St. Louis (310 miles upstream) or New Orleans (460 miles downstream), to be examined

[173] Opposition to the new law, 1853 3-31; Table of masters violating law, 1853 3-31.

[174] Long times between inspectors' visits, which were few and far between due to distances, allowed owners to put off repairs and apparently still operate, although it is not clear if owners could legally operate their boats in the interim.

[175] Problem of multi-named boats, see Proc 10-10-1854, pp. 113-114. Owners dragging their feet, see 1854 10-5. Local inspector Curran of the Third District answered the Secretary's charges that he had overused the Department's precious travel budget in inspecting the Steamboat *George Page* at Washington. In fact, the inspectors had to make numerous trips back to the steamer to see that remedies to bring the boat into compliance were performed as ordered. "…it is a disagreeable task for me to have to say that this same Mr. Page has given the Board more trouble to carry out the requirements of the law than any other owner of a steamboat in our district. The question may be asked why is he not arraigned for infringment [sic] and [this] is asked frequently. I can only say unfortunately for the laws he has been reported as far back as last July was a year, and still action is stayed. The owners of steamboats in the district know it, and have complained terribly about it."

for licenses. This caused them “unnecessary expense and loss of time… we consider this a great injustice.” Further, after they had traveled “far away from home” to those points, they found they were unknown to the local boards there, could not be given the proper examination, and were turned away.[176]

Some engineers lost their jobs and feared becoming hardship cases when they violated one provision or another of the steamboat act and had their licenses revoked. Often such hardship cases came under appeal with the supervisors. In appealing the local board’s decision, however, engineers could usually count on an unsettling experience with a board of inspectors that held almost unlimited power. In 1855, a New York engineer of the Steamboat *Thomas Hunt*, Edward Barnay, was denied a license and suffered a loss of income for some violation of the act. Upon appealing for a re-examination, he was turned away. His advocate wrote the Treasury Secretary that he accompanied Barnay to the inspectors’ office, “…prepared to show that he is an old, experienced and competent Engineer. I asked that they would examine him, to which request they refused, saying that they would not examine him or give him a license until he settled the complaint they had preferred against him. I represented to them that if they were permitted to exercise such unlimited power they could bring ill founded accusations against the whole Steamboating people within their District, put off the investigation of the charges for an indefinite period, and cause the ruin of all such persons by throwing them out of employment, leaving them no means of redress

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[176] Initial opposition to law, then improvement, see Proc 11-19-1853c. This was likely Supervisor Benjamin Crawford’s optimistic appraisal of progress. In his reports to the press and in the annual reports, Crawford always suggested forward momentum. On the signed petition addressed to the

whatever." The advocate asked the Secretary if steamboat inspectors "are clothed with any such powers, and whether a citizen must be compelled to fold his arms and go to the poor house merely because an Inspector chooses to persecute him."[177]

Engineers could be caught in the middle between the inspectors and recalcitrant steamboat owners as well. After losing his license and being banned from his steamboat, a stryker at St. Louis made it known that he was intent upon reboarding his vessel to resume work. The steamboat was owned by the powerful Captain William J. Kountz. The stryker's contempt for the law raised the ire of the supervising inspector, Charles Ross. Ross chastised the stryker and told him that his immediate re-boarding of Kountz's boat, due to leave in a day or two, was out of the question: "You shall not work on any boat in any capacity whatever and my power is absolute and I will take care to use it." The engineer pleaded with the inspector to hear him out: "Why not examine my case now so as I can earn Bread for my five little children [?]. They are now crying for Bread. They have none as I have no money to buy them any." The inspector was unmoved: "You shall not earn them any in Captain Kountz Boat. He, Captain Kountz, shall not take who he pleases in his Boat as he did around at Pittsburgh. He cannot scare us here [--the only] way he can get rid of us is to kill us."[178]

President of the United States from 20 steamboat pilots and engineers on the inconvenience of traveling to St. Louis to get licenses, 1854 11-1, Vol. 3, IMG 1192-93.

[177] 1855 6-2, IMG 1682.

[178] 1859 9-21 IMG 1291-1293. Emphasis in the original. Captain Kountz later became "Commodore" Kountz. Throughout his career he either owned or held an interest in at least 36 steamboats. He also led the group operating the horse-drawn Pittsburgh, Allegheny & Manchester Passenger Railway. Kountz was a powerful figure during the Civil War, serving as Master of Transportation (U.S. Quartermaster Corps) in Paducah, Kentucky, where he helped organize steamboat transportation for Union troops and war goods. See Hunter, SBOTWR (1949), p. 558n. The steamboat in the story above

The clearest violation of the steamboat act was the engineer's imbibing of intoxicating liquors. In the past, spirits had been liberally served aboard many steamboats, not only for the benefit of passengers but also for the entertainment of the crew (presumably when not on duty). Under the Act of 1852, abstinence of the crew while near a steamboat became a part of the reform program. Abstinence had its origin in Whiggish religious sentiments of the day, but also had obvious safety implications. Supervising Inspector Benjamin Crawford at Pittsburgh reported progress in "making sober men of [pilots and engineers] as no one can get license who is known to be in the habit of drinking to excess." A Whig, Crawford had been instructing his local inspectors to "let us try and get clear of the drunkards in some way or other…" by which he meant denying them licenses. He optimistically reported to the Congress that he thought "we will show an improvement in the character of our River Men in the course of another year."[179]

Crawford's obsession with making sure there was a sober and disciplined "man of character" in charge of the engine room caused friction with a supervising inspector in the adjoining fifth district, Supervising Inspector Davis Embree (St. Louis), in 1854. A pilot in Crawford's district, Hamilton, had gone on a "mere fourth of July

was the *City of Memphis*, of which Mark Twain was a pilot. In the Civil War, it served as a floating hospital. See http://members.tripod.com; and http://pghbridges.com/articles/haer/sisters_HAER_PA490/sisters_HAER490a.htm.

[179] Crawford noted that on a trip to Cincinnati, his local inspectors had "refused licenses to a good many who were intemperate, one of whom took an appeal from their decision, but he did not fare any better with me." 1853 2-3. But Crawford noted in another letter that engineers were generally sober, and that pilots were more bothersome: "As a body the Engineers… are generally sober and trustworthy. The same may be said of a large majority of the Pilots; but it is to be regretted that some of them have shown a different disposition, and have tried hard to repudiate the law and bring it into disrespect." Interestingly, here we see Crawford framing a moral transgression as a lawbreaking

frolic," as Embree put it. This consisted of Hamilton's stopping at every landing for a drink of intoxicating liquor, and then reboarding and piloting his boat. Crawford's local inspectors gave the facts of the case: "[Hamilton has been]… known to us personally for 20 years, and whose reputation is that of a reckless and intemperate man—who has been the cause of great loss of life by running into Steam boats—been in more fights, sprees and difficulties, than that of any other man known to us—the result of his reckless and intemperate habits—besides it was only a short time previous to our refusing him a license, that he very deliberately let go the wheel of the boat he was steering, and shot at the pilot of the passing boat, who had not done in accordance with the particular whim of his (Hamilton's) fancy."[180]

Hamilton complained to Embree of his treatment at the local inspectors' hands, and in turn Embree charged that Crawford's inspectors had acted with too extreme zeal. Because of this, Embree believed, the community would "revolt at the law." Changes brought about by the Act had come too suddenly, and the powers of the Federal government (in particular the Board of Supervisors) were revealing themselves as "monstrous." Embree wrote that Hamilton would become a beggar without his license, and that a description of the proscribed behavior befitting a crewman had not been printed on Hamilton's license. Crawford brushed aside Embree's agitation over the matter, writing that he saw no "monstrous power" being levied, nor did he expect to see the community rise in revolt. Hamilton had had his chance to appeal the local

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activity, a legal emphasis that became commonplace in the inspection service after passage of the steamboat act. 1853 6-6.

[180] See 1854 4-17.

board's decision, Crawford argued, but had done nothing and so had acquiesced in their decision. Now Hamilton was suing the local inspectors for $5,000 in damages, which disturbed the peace and harmony of Crawford's own district. Hamilton's suit later failed when the local board was exonerated.[181]

While these disputes were occurring at the operating level of the new inspection service, and as painful adjustments were being made there to the new way of life on the rivers, political winds almost immediately began to drive personnel changes at the higher levels of the inspectorate.

Politics and the Inspection Service

The Customs Service was highly affected by politics, and this carried over into the inspection service. Political attacks against high inspection officials were usually supported by complaints and petitions of engineers, who had some axe to grind because they believed the officials were not properly carrying out provisions of the

[181] Hamilton case, see 1853 11-16. To put this topic of drinking in historical perspective, Hunter described this "Mike Fink age" and the steamboat occupation as one of machismo, violence, and hard times. Brawls, thefts, and fighting abounded on trips up and down the rivers. Although inexcusable as a safety hazard, the excessive drinking to be found in the industry can perhaps in part be attributed to the roughness of the steamboating life. On the correspondence of Crawford to Embree, "Even if his case was precisely as you state, and he was deprived of his license by extraordinary power, or even illegally if you choose, he had his remedy by appeal, and when he neglected to avail himself of it, he voluntarily cut himself off from all recourse by law, and acquiesced in the decision of the local board." 1853 12-2, C10. Crawford had by now written his local inspectors Haldeman and W.W. Guthrie to get evidence against Hamilton: "I wrote you yesterday in regard to Thos. Hamilton. You had better make enquiries of the Captain and officers of the Steam boat I. M. Harris in Regard to the matter, perhaps you will be able to obtain sufficient evidence there without going further. I had heard on my way up, that Hamilton was employed on that boat, at the time he took the spree. This would certainly be sufficient to revoke his license, as no plea could be made, that he was not on duty, he might as well say that he had a right to get drunk every time he came off watch, whilst the boat is underway. I hope you

law. Local inspectors were generally immune to attacks by engineers; most of the local inspectors' duties, if carried out according to the law (at least as interpreted according to the guidelines of the engineering associations), posed no problems. This was most likely because the reforming engineers and the local inspectors arose from the same professional body and were of a similar mind regarding safety reforms. The supervising inspectors, however, were political appointees who did not always have the requisite experience and were often not engineers. Adding to the Supervisors' difficulties in this situation was the collusion of owners and captains against them, usually over the expense of meeting regulations or over issues of licensing. Disillusionment with the supervising inspectors tended to fester until a political need arose that provided an opportunity for the engineers to strike on the street with handbill campaigns against the inspector in question, or in the press.[182]

Unfortunately for the practical engineers, who were generally apolitical, the timing of the creation of the inspection service itself coincided with political upheaval in the national government. With the collapse of the national Whig Party in 1852, it was necessary (and followed customary practice) to replace Whigs with Democrats wholesale in all important government positions. The inspection service, initially manned by Whig inspectors for the most part, was a prominent new target. The

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will investigate that and every similar case that comes to your knowledge. Let us try and get clear of the drunkards in some way or other…" 1853 9-16.

[182] On the subject of political needs arising, on a turnover in the national party, there could be severe political pressure to replace a supervising inspector with one from the newly voted-in party. On the relative immunity of local inspectors to replacement for political reasons, there were several cases in the NARA record of engineers criticizing the supervising inspectors, but no attacks by engineers against the local inspectors. On the subject of supervising inspectors criticized for laxity, see 1853 1-1, 1853 6-3, 1854 5-1, 1854 5-24, 1855 7-29, 1858 1-13, 1858 5-10, and others; details from these sources are interspersed throughout this chapter.

Treasury Department began its purge before the new supervising inspectors could even settle in; this continued at least until 1858. Changes made to the supervisors' roster in 1853-1854 included the replacement of supervisors in five of the nine inspection districts (the two Great Lakes districts, New England, Mid-Atlantic, and New Orleans). Another attempt was made to replace the inspector at Pittsburgh (Crawford) but this was beaten back by supporters.

Eighth District Supervising Inspector and practical engineer Alfred Guthrie was the first appointee to fall. A key founding inspector who had worked with Senator Davis of the Commerce Committee to shape the 1852 Act, Guthrie's influence and experience counted for little in the face of the purge. He wrote Treasury Secretary James Guthrie (no relation) in the spring of 1853 complaining that he was being removed on political grounds. Apparently receiving no help from the Secretary, Guthrie went over the Secretary's head and wrote two letters to President Franklin Pierce in September. Guthrie's pleadings are quoted here:

> "We have had over 2,600 people killed by explosions in this country. I ask if the person who voluntarily and successfully undertook to correct this great evil would not be entitled to some little consideration. Would Your Excellency think a selection of the proper person to check this great evil would be the person who knew nothing in the world of the causes of explosions or the principles of steam?

"And yet Mr. Lewis who had never thought ever of the causes and was profoundly ignorant of the subject is selected for this purpose.

"Mr. Lewis will be frank enough I have no doubt to say that when he was appointed he did not know anything whatever about the subject. And Sir he cannot today go on board the U.S. Steamer Michigan and stop the engine if it should be running to save his life nor can he stop and start any other engine upon these lakes. I have no doubt but your Excellency has been deceived in regard to his qualifications. I do not expect a reappointment but I do think I have been wronged for the years of labor and study I had devoted to this subject to be superceded [sic] by one so… disqualified.[183]

[Second letter]: "In my last letter I thought I would not again annoy Your Excellency with letters upon the subject of Steam Boat Inspectors but I feel so confident that you have been misdirected not only in my removal but in the appointment of Mr. Lewis that I feel constrained to ask if Your Excellency to [sic] grant me an interview upon this matter by my calling upon him in Washington in the early part of October. I shall not require but a few minutes to make my explanations and will feel thankful for the opportunity."[184]

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[183] First letter to President Franklin Pierce. dated 1853 9-4.

[184] Second letter to President Franklin Pierce, dated 1853 9-11. There is no record that Pierce ever replied to Guthrie's letters or met with him. We recall that it was Alfred Guthrie who argued against high pressures of steam carried by engineers on the western waters (in collusion with the local

Despite his appeals, which apparently were ignored, Guthrie was dismissed. The practical engineers reacted angrily to Guthrie's removal. A printed flyer signed "an engineer" appeared in June, urging engineers and pilots to protest Isaac Lewis's (Guthrie's replacement) continued appointment as the replacement supervising inspector. The flyer attacked Lewis's ignorance of basic practical engineering knowledge, noting that the owner of a steamer had complained that Lewis had refused to make a hydrostatic test of his vessel. "I believe he declined to undertake such inspection from ignorance and not knowing how to do it." It seems also that Lewis was traveling around the district receiving a crash course in the basics of steamboat engineering.

The flyer pointed out that the Act of 1852 required inspectors to be competent, and Lewis was not. By the act of Lewis's appointment, the local Board of Inspectors had been "broken up," steamers were now "running without inspections and without licensed pilots or engineers," steamboats were exploding and collisions occurring, "all for want of competent individuals to inspect and control them." The flyer then complained that Lewis's lack of credentials put the engineers in an awkward situation:

inspectors), commenting that "the whole system of inspection seems to be deranged," 1853 9-4. It is clear from the record that the practical engineers (in positions as both inspectors and engineers) became increasingly uncomfortable with the overlay of the Treasury Department's political and legalistic structure on their technically oriented community. The practical engineers were ill-equipped to deal with the new and powerful bureaucracy and the political pressures that came with it. Guthrie wrote in 1853, "I am the fartherist [sic] removed from being in any manner a politician possible, my studies and occupation being in an entire different channel." See NARA letter, Item 256, Vol. 2, spring 1853.

> “We who have paid our inspection fees and have been deemed competent by competent inspectors are now suffering for these wrongs …We are compelled to submit to the humiliating farce of an inspection by [Lewis]… Did the law ever contemplate this, or does a decent respect for the laws of the country require of us such acquiescence?”

For the engineers, reverence for the law was paramount, but a paradox was arising: the flyer noted that as good citizens the engineers should submit, but that no obligation could require them to give Lewis their respect, whose capacities were so feeble. "Apply the test fearlessly, for I feel certain that [Lewis can not] stop or start any one of your engines, or guide your vessel a single mile, however great the necessity.”[185]

A similar attempt to replace Whig inspector Benjamin Crawford of the seventh district (the virtual creator of the inspection service) failed. Crawford had been able to fend off the attempt on his seat because of his value in parsing and updating the steamboat law.[186] A political chameleon, Crawford had been faking his Democracy,

[185] Printed flyer of engineers, 1853 6-3. Lewis had evidently taken the sole hydrostatic pump in the district with him on his training junket, leaving steamboats at the main ports untestable. On the incompetence of some inspectors, see 1858 1-13 in which Haldeman noted that recommendations for supervising inspectors were often made by personal friends, “but this tells us nothing of qualifications.” He noted that some were good pilots or masters, but not engineers, and that Supervising inspectors were required to be knowledgeable because they had to inspect steamboats in some reaches of their districts where there were no local boards. The supervisor had to carry a hydrostatic pump, solve steam pressure calculations, and act in all respects in the capacity of a local inspector.

[186] According to one who admired Crawford, a Charles Thaler, Crawford was the law’s “virtual author.” See 1858 7-22.

but the attack prompted him to enlist advocates who testified as to his loyalty to the party in power. Seven local inspectors wrote Treasury Secretary Guthrie to support him, stating that Crawford "has been consistent and reliable in [the Democratic] cause" and the "carrying out of democratic principles." Crawford had made steam the study of his life, the inspectors wrote, and "he is, and always has been, a thorough Democrat--clinging to his party in all fortunes."[187]

Crawford not only had to fight for his own position as supervisor, he also had to struggle to keep his newly appointed local inspectors. "Certain persons" in Pittsburgh had sent the Treasury "remonstrances praying that these men may not be appointed," Crawford successfully defended his inspectors, writing the Secretary:

> "I am at a great loss to know what manner of objections can be raised to the appointment of Mr. Watson as boiler inspector. He is a man of large experience as an Engineer, having regularly learned the business of engine building, and been a practical engineer on the Western Waters for some sixteen years, and is considered by all who know him, as one of the best practical as well as the most learned in the Science of Steam, and Steam Machinery, of any in this district. He is a man of great firmness and integrity of purpose; he knows what is right, and is

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[187] The 1853 letter of support for Crawford had been signed, among others, by Captain David Lynch, John S. Hamilton, A.J. Dallas, and John S. Dickey, and included a column from *The Pittsburgh Commercial Journal* dated September 7, 1852, in which Crawford was named as the inventor of "two or three improvements on the Steam Engine." 1853 3-11. Captain Lynch exposed Crawford's pretense when, in 1858, he accused Crawford of pretending to be a Democrat but in fact remaining a Whig. See 1858 1-3.

> not afraid to do it; further than that he will not go. In regard to the politics of those gentlemen, it so happens that one of them votes the Democratic ticket, the other the Whig ticket. But neither of them are politicians. I am aware, however, that the political opinions of those who are appointed to these offices will have no weight with the Department, one way nor the other, as they [certainly?] have not with me."[188]

Crawford managed to hold off the Democrats for five more years, but then succumbed. Criticisms by engineers were instrumental in his removal, and these were likely motivated by retribution against Crawford's prosecution of an innocent engineer in an accident case. Crawford had acted in the matter over the objections of his local inspectors (one of whom was the same Andrew Watson that Crawford had defended in 1853).[189] It appears that the Treasury Department used the case to

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[188] 1852 11-19. Watson was able to hold onto his position as local inspector of boilers at least through 1857.

[189] This was the aforementioned case of the explosion of the steamboat *Fanny Fern* in January 1858. The ensuing dispute between Crawford and his inspectors Dickey and Watson eventually precipitated the local inspectors' removal. Dickey and Watson had accused Crawford of nepotism in protecting the guilty engineer King, whom the inspectors believed was clearly responsible for the accident. The backlash for Crawford was that one group of thirty-five engineers, and another of forty-eight engine builders and engineers, urged President James Buchanan to remove Crawford. They argued that Crawford "never had any experience whatever on board steamboats," and thus was unfit to fill the office of supervising inspector. A steamboat captain noted that Crawford was accomplished at making wood patterns for sand castings but knew nothing of the technology of steam, 1858 1-3. He further accused Crawford of pretending to be a Democrat when in reality he was a Whig; Crawford had not even voted, he wrote, "unless after 1856, at which time he began supporting the Democrat position." In the attacks, Crawford was accused of using a Whig printer for steamboat blanks when Democrat printers were available, see 1858 1-3. Local Inspector Haldeman wrote that "Efforts are being made to remove Crawford as Supervising Inspector," 1858 1-13. A petition is circulating to replace Crawford, 1858 6-27. Scheme concocted by enemies of Crawford to support other candidates for Supervising Inspector, 1858 6-29. Group of thirty-five engineers urging removal of Crawford, one of whom was Andrew Watson. See 1858 10. Engine builders and engineers write President Buchanan complaining that Crawford is "neither a practical man or a mechanic, and is totally incompetent," 1858 10.

leverage Crawford out. The Department compiled a list of Crawford's deficiencies as set forth in lengthy self-published pamphlet by Crawford's local inspectors after the flawed investigation of the explosion of the steamboat *Fanny Fern* in January 1858.[190] The list was entitled, "Shortcomings of Benjamin Crawford, Esq.," and named thirty-five charges under "violations of law, evasion of duty, ignorance, etc." In addition, other material was collected on Crawford; these bore more directly on his character. The letters were of a personal nature, concentrating mainly on Crawford's chronic habit of skipping out on his creditors in former times.

With this onslaught, the remarkable architect of the Act of 1852 eventually was drummed out of his post of Supervising Inspector. He thereafter fulfilled auxiliary roles in the inspection service as a substitute local inspector and then special agent. (See Crawford's biography in the end notes of this chapter).

[190] The pamphlet was entitled, *A Vindication of the Action of the Late Local Inspectors at Pittsburgh in the Case of the Explosion of the Steamer Fanny Fern; with the Evidence and Correspondence*. By John S. Dickey and Andrew J. Watson, local inspectors at Pittsburgh, 1858. Dickey and Watson were dismissed before they could file their report on the accident. They were later exonerated by the Supervising Inspectors in October 1858, but their reputations had already been damaged. See 1858 1-20, as well as the 1858 *Proceedings of the Supervising Inspectors*, dated 10-1858.

4.2 The Treasury Department Pushes the Safety Guard; Significance of the Safety Guard in Defining Expertise

Unbeknownst to the practical engineers on the rivers, built into the enactment of the Act of 1852 was the ability of Treasury Department officials to devise and control a single definition of expertise; this definition hearkened back to the scientific research on fusible alloys conducted by Professors Bache and Johnson in the 1830s. We have already discussed personnel reforms meant to bolster the quality of the engineering corps. Both the Department and the practical engineers were in harmony on this issue. However, the Department wished extra insurance against the mistakes or incompetence of engineers, and here they deviated from the engineer's program. In this instance, the Evans guard became the tangible manifestation of the Department's distrust of the practical engineers over the issue of the safe operation of boilers.

The Department began promoting the Evans safety guard on the western waters in 1854. This posed a legal problem for government officials: whereas it had been relatively easy to use the good engineers to keep bad engineers off the steamboats, it was a more difficult problem to convince engineers that a monopolistic invention that intruded into their everyday affairs could provide a scientifically enlightened improvement in safety. The safety guard had never been popular with rank-and-file engineers. Early rejection was based on several factors: (1) the bad reputation of the safety guard's early 1840s prototypes, which had reliability problems; (2) the "nuisance factor" of the safety guard going off constantly, or the danger of its not activating at all; (3) satisfaction with existing, traditional, safety technologies such as the safety valve, water gauge, and steam gauge; (4) the strong influence of owners, who resented the expense of the safety guard (especially in St. Louis and Louisville); (5) fear of the inventor's monopoly of the technology; and (6) fear of losing wages because the safety guard lowered the qualifications needed to run steamboat machinery.[191]

Further, the scientific justification for the safety guards apparently never reached the rank and file engineers, or never overcame their prejudices. The Department's view that the safety guards were a last defense against explosions hardly penetrated beyond Washington and a handful of practical engineers in the Districts. Thus, the matter very quickly turned from a technical issue of safety to a legal one. Once the guards began to be pushed, inspector-engineers who balked at the use of the safety guard were not only considered "prejudiced" and unscientific, but also lawbreakers who risked anarchy. To the chagrin of the engineers and most inspectors, Evans's device was destined to become the key test used by the Treasury Department to define expertise. But more importantly, it became the key test of obedience to the broader principle of law and order.

The growth in the number of Evans's Safety Guards deployed coincides with the assertion of federal power on the rivers. Before the act of 1852, Evans only managed

[191] Addressing Senator John Davis, Haldeman claimed that many practical engineers had endorsed the safety guard. He cited the names of "many, in whose opinions you will have confidence," in the pages of Evans's self-promotional 1850 Treatise. ". . . you will see a mass of evidence from practical and Scientific engineers, which it seams [sic] to me, is sufficient to prove to every unprejudiced [sic] man, the great necessity of using Evan's Safety Gard [sic] and I hope you will read this pamphlet with great

to sell and install 125 of his safety guards to masters of steamboats. Even in those early years, as we have observed in Evans's 1850 *Treatise*, rank-and-file engineers had begun disabling the guards, perceiving them as "humbug" and "hostile to the body of the profession." On the eve of passage of the Act of 1852, the number of boats having safety guards had grown modestly to 135. But by 1856, it is estimated that about 300-400 steamboats had safety guards, amounting to about half of all western boats.[192] The safety guard required more than physical presence, however; it needed the mantle of legal authority, which soon would be provided by the Department.

William M. Gouge Clears Legal Hurdles Associated with the Evans Guard

It had been known for years that the effectiveness of the safety guards depended on a fusible alloy having thermometer-like accuracy. The job of developing and defending this product for the federal government fell to a powerful government official in our story, William M. Gouge (1796-1863). Formerly an economic historian, Gouge joined the Treasury Department in 1854 as a high clerk and special agent serving Treasury Secretary James Guthrie. After reading Cadwallader Evans's 1850 *Treatise*

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care and attention . . ." 1852 4-24. As time went on and the reliability problems of government-manufactured alloys used in the safety guard surfaced, however, the engineers withdrew their support.

[192] The quantity of 125 is from Evans's 1850 Treatise, page 51, and the quantity of 135 is from Haldeman 1852 5-1; Hunter missed the significance of the safety guard because he had not accessed the NARA records. His footnote on page 72 of SBOTWR (1949) notes that a "small proportion" of boats had safety guards, but his source for this information was from a government reported dated 1847. The NARA letter collection shows that most of the western safety guards were installed after 1850. The quantity of 300-400 is based on a conservative estimate of the quantity of pieces of government alloy (one piece of alloy per safety guard) distributed by metallurgist James Booth of the U.S. Mint to the districts on behalf of the Treasury Department (see 1855 10-1). These estimates are supported by express receipts and Booth's own reports. On page 33 of SBOTWR, Hunter lists 727

on the causes of explosions, Gouge became convinced that the Evans guard was the only safety appliance that would provide protection of steam boilers in accordance with established scientific principles. The scientific rhetoric of Evans's *Treatise* persuaded Gouge that only fusible alloy applied in a particular way (i.e., to exclude pressure effects) could be used to monitor heat in the boiler.[193]

Gouge had what he needed in the ninth section of the new steamboat act to begin pushing the safety guards, but there were two problems: the provision on the alloys was vague, and the alloys were not yet ready. The provision was vague because it required that fusible alloy be applied in a "suitable manner" but it failed to specify a particular device for this purpose:

> "…in or upon the outside flue of each outside high pressure boiler, there is placed *in a suitable manner* alloyed metals, fusible by the heat of the boiler when raised to the highest working pressure allowed, and that in or upon the top of the flues of all other high pressure boilers in the steamer such alloyed metals are placed, as aforesaid, fusing at ten pounds greater pressure than said metals on the outside boilers, thereby, in each case letting "steam escape."[194]

At the time, there were three ways of applying the fusible alloy: (1) in plates inserted in the top of boilers; (2) in an open tube, in which the alloy was

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boats on the western rivers by 1855, so, using the alloy shipment figures, we can assume that roughly half of the 727 steamboats had safety guards within 3 years of passage of the 1852 act.

[193] William M. Gouge's detailed biography can be found in the chapter end notes.

exposed to both the heat and the pressure of the steam; and (3) in a cup, by which the pressure of the steam was excluded, and only the heat operated on the mixed metals. Gouge remarked that only the third method answered the intended purpose as set forth by the law and was thus the only "suitable manner" of application.[195]

At their first annual meeting in October 1852, the supervising inspectors had left the choice of the three modes of application to the local boards. Gouge argued that this in effect permitted owners of steamboats to choose the mode of application. This was a mistake because "the result was that in many cases the fusible alloy was applied in open tubes instead of cups, though there was most abundant evidence in books of science… that fusible alloy applied in open tubes was worse than useless."

This was a critical problem for Gouge and the Department's idea of a single scientific technology that could be used once and for all to thwart explosions. The entire

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[194] Gouge's emphasis. See Gouge notes dated 2-21-1855.

[195] Gouge got the idea of the three methods from practical engineer and supervising inspector Alfred Guthrie, see 1853 12-15. The first mode had the drawback of stopping a boat after fusing ("This method was long in use by the French, but has, I believe, been abandoned by them. It was rejected by the Supervising Inspectors as not at all adapted to the state of things in this country"). The second mode caused the separation of constituent metals ("The objection to this is, that alloy thus employed, is deprived of its tin and bismuth by the simple pressure of the steam, even before the pressure is as great as is allowed by law, leaving only the lead, which as it does not fuse under 600 degrees of temperature is useless for the purpose intended.) Gouge buttressed the legitimacy of the third mode by stating that advocates of that choice included Professors Henry (Smithsonian Institute), Renwick (New York), Lilliman (New Haven), Locke (Cincinnati), Colonel Long (U.S. Topographical Engineers), and Dr. William P. James, (Commissioner of the Patent Office). Confirming their testimony is that of C. H. Haswell (Engineer in Chief, United States Navy), William M. Ellis, (Chief Engineer, U.S. Navy Yard, Washington), and "two having engaged in steam engine building in Providence, R.I.," three in Boston, nine in New York, eleven in Philadelphia, fifteen in Pittsburg, two in Wheeling, seven in Cincinnati, and seven in Louisville. To these he added testimony of some "forty or fifty practical Engineers and that of numerous steam boat captains."

steamboat act was mere window dressing if the single most important provision for guaranteeing safety went unheeded. Gouge believed that leaving a back door open with regard to this scientific requirement in effect neutralized all other provisions of the law--each was not in itself sufficient for the prevention of explosions; all provisions together were.[196]

Highlighting Gouge's legal problem was the fact that the local inspectors, and hence the supervising inspectors, were not showing much enthusiasm for the safety guards. The supervisors had been dragging their feet, reacting to the fears of engineers in their districts that Evans's device, if mandated by the government, would constitute a monopoly; such a monopoly would restrict the innovation of the engineers. Gouge believed this was little reason to hold up the safety guards; he thought it imperative to deploy the guards as quickly as possible even if the alloy was not yet fully ready. They were especially needed in light of a recent rash of accidents. On February 16, 1854, the steamboat *Kate Kearney* in Embree's district (District Five) exploded, killing 15 persons. The only action the local board could take after the fact was to revoke the engineer's license. A month later, the steamer *Reindeer* in District Six suffered a flue collapse, killing thirty-eight persons. The inspectors blamed that accident also on the negligence and carelessness of the engineer. They revoked his license, but "he died before he could be prosecuted." There were collisions as well, which, though not directly related to the boiler problem, contributed generally to the

[196] In his notes, Gouge justified the Department's attention to the procurement of fusible alloy metal by citing the usefulness of Evans's guard: "The Evans safety guard is a most useful contrivance. No fair experiment could be made of the law of 1852 unless they be generally adopted." 1855 2-21.

Department's sense of urgency in pushing safety procedures and technology. In March, the steamboats *Fanny Fern* and *Thomas Swan* collided. The *Swan* sank, boat and cargo suffering a total loss, and the *Fanny Fern* was wrecked and left for salvage. Two months later, the steamer *Cuba* ran upon the wreck of the *Fanny Fern*, sinking the *Cuba*.[197]

From a legal standpoint, there was not much the Department could do about the supervisors' lack of cooperation. The Department had no power over the decisions of the supervising inspectors; it could only pass judgment on the appointment of board members.[198] However, at this point Treasury Secretary James Guthrie could intervene, and he did. He and Gouge urged the Supervising Inspectors to convene a special meeting to act on the true intent of the "suitable manner" provision of the ninth section, i.e., to draft a rule that disallowed the use of plates, plugs, and open tubes in attempting to meet the requirements of the provision.

In April, the Supervisors convened a special session in Washington to pass such a rule. Asked to join in the meetings was chemistry professor John Lawrence Smith

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197 On the equivocation of the Board, Gouge wrote, "The Board of Supervising Inspectors held meetings at New York in December 1852, and at Pittsburg in August 1853, but do not appear from their minutes to have taken any new action in regard to fusible alloys....At their meeting in Cincinnati in November 1853 (the first that I attended) the subject came up for discussion, but no new decision was made. 1855 2-21.

198 "The powers granted to the Secretary of the Treasury and the responsibilities imposed on him by the law are strictly enumerated the power to make rules and regulations is confided solely to the Board of Supervising Inspectors, and if they err therein, they alone are responsible. Neither has the Treasury Department power to take [responsibility] for carrying into effect those rules and regulations, nor power to punish the Local Boards for not attending to such directions, except by removing them from office." Gouge notes, 1855 2-21.

(1818-1883) of Louisville, Secretary Guthrie's son-in-law. Smith drafted the resolution, which read as follows:

> "Resolved, that hereafter in all inspections of passenger steamers, which are by law required to have a suitable application of fusible alloyed metals, in or upon the flues of the boilers for greater security, the Local Inspectors be and are hereby directed not to permit of such application by any method which shall not exclude all pressure from the alloy which shall tend to separate its components, by enclosing the same in a case, or tube, or some equivalent device. Further, that in the preparation of the alloys, the temperature at which the same are to be considered as fused for the purpose of the law, shall be that temperature at which it is semi-fluid, or at which a solid is readily moveable within it."[199]

Gouge noted that there had been two main stumbling blocks in adopting the guards, and these turned out to be related to the same old concerns by owners and engineers over monopoly rights and cost. First, the patented aspect of the invention caused a

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[199] Special meeting held in Washington in April 1854. Professor Smith worked with the Department as a technical consultant on the fusible alloy issue and was related to Secretary James Guthrie by marriage. He began his career as a civil engineer; studied chemistry in France; developed an expertise in medicine, metallurgy, meteorology, and a host of other sciences; and eventually ran the Louisville Gas Works before his death in 1883. Resolution excerpted from Gouge's notes dated 2-21-1855. The reason for the requirement that the alloy fusing point be defined as that corresponding to the state at which the alloy was "semi-fluid" was so that it would be calibrated to correspond with the temperature at which Evans's impeller (or Bache's upward plunger) would be able to turn freely and activate the alarm mechanism. The resolution carefully avoided the specification of a specific device (such as Evans's guard) for employing the fusible alloy. This got around the discomfort the Supervisors felt over the monopoly issue, but this ambiguity would cause problems later, as we shall see. The new rule did enshrine the pressure principle, however, and so in theory the Department found itself in a position to direct that Evans's guards be installed on all steamboats in the western country.

"delicacy" to be felt in the Supervisors (the Board of Supervisors could not be seen to promote a particular invention). Second, owners opposed the additional expense. With assurances by Evans that costs would be kept under control, the Board passed the resolution.[200]

Reluctant Local Boards

Despite Smith's resolution, the local boards failed to act. It was reported that the local boards at Wheeling, Louisville, St. Louis, "and other places," were especially reluctant to support the resolution. Of the western ports, only Pittsburgh and Cincinnati had begun to apply the resolution "according to its true intent."[201]

The greatest hotbed of opposition was St. Louis. The Supervising Inspector there, Davis Embree, came under considerable pressure from his local board to nullify the resolution. Embree had received the inspectors' protest and forwarded it to the Treasury Secretary. The protest was "against what they look upon as [an] improper <u>legislative</u> act of the Board of Supervising Inspectors; and they appeal to you [the

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200 "The mode of applying the alloy in a cup, had been patented by Mr. C. Evans and to adopt a resolution requiring that this mode should alone be used, would be, in effect, to give the patentee a [grant] of monopoly. The Supervisors felt the delicacy of their situation, but after receiving assurances from C. Evans that he would not raise the price of his Guards, and also that he would keep a sufficient supply in hand at the points where they were wanted, they adopted the… resolution… that all appliances known to this Board, which are so arranged as to expose the alloy to the temperature and direct pressure of the steam, are unsuitable, and do not accomplish the object of the provisions of the law with regard to such alloys, and must therefore be rejected by Inspectors in all inspections hereafter made of high pressure boilers…" See Gouge notes, 1855 2-21.

201 Western districts failing to apply the resolution, Gouge 1855 2-21. At Louisville, Gouge thought that the supervising inspector there, John Shallcross, "not having been present at the board at their meeting in Washington and thus not having before him a full view of the reasons that induced his

Secretary] to correct the mistake into which that Board has fallen, by not knowing the effect the measure directed will have… on the Boating interest of this Port." Embree agreed with his local inspectors that if the safety guard were adopted and required on all steamboats, the objects of the law would not be accomplished due to the inferior nature of the alloy on hand and the "inferior instruments" furnished by Evans (Evans could multiply his profits several fold by selling inferior devices, and when they malfunctioned, by replacing the defective units at twenty dollars each.) There was also concern over the exclusiveness of the patent: "While the patent is held by others, steam boat officers can not make, or have made, real good instruments in thier [sic] port." Embree feared that if Congress did not act to limit the price of the safety guard (presumably through the government purchase of Evans's patent), "the commerce, of at least this section of the country, will be placed in the power of one man, in a way that never was intended by Congress."[202]

Gouge, receiving the protest, summed it up for the Secretary: "At St. Louis, the Local Board have presented a remonstrance against [the resolution], because it requires the use of a patented invention, and because it will put the owners of steam boats to additional expenses." (See Fig. 33). The inspectors requested instructions from the Secretary on how to proceed in the matter.[203] On the concern about patents, Gouge countered that "most of the appliances used on steam boats to prevent accidents are protected" and that therefore the safety guard was no different. On the

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fellow members to adopt the resolution," had acquiesced to the opposition to the resolution in his district.

[202] See 1854 5-23. Emphasis in the original.

Figure 33. Saint Louis waterfront in 1852, a major seat of opposition to the Evans guard. Supervisor Crawford complained that lax enforcement here spread dissent to his district (upper Ohio River, Pittsburgh). Note the bustling warehouse district with stevedores.

[203] See 1854 5-23 ibid.

subject of expense, Gouge believed steamboat owners were behind the opposition. A Judge Wells of Missouri had observed that both the Supervising Inspectors and the local inspectors at St. Louis were “not deficient in intelligence but… wanting in courage to stand up before the Steam Boat interests, and enforce the law according to its true intent.”[204]

Throughout April and May, general alarm spread in the steamboat community from Pittsburgh to Cincinnati and St. Louis concerning a possible Evans monopoly. In April, local inspectors, engine builders, and “other citizens” of Pittsburgh submitted a petition to Congress urging the invention be purchased and made available free of charge to the public. Less than two weeks later, steamboat officers, steamboat practical engineers, and citizens at Cincinnati (District Seven) placed no fewer than three similar petitions before Congress “praying that measures may be taken to make Evans safety guard free to the public, by the purchase of his patent right or otherwise.”[205]

The Department was beginning to understand that inventions had political overtones for the engineers. Opposition to the safety guard was chiefly a protest against “officially sanctioned” innovation. Evans’s invention was facing what others before them, such as Raub’s safety valve, had faced in the 1830s; government sanction

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[204] Gouge notes, 2-21-1855.

[205] The petitions apparently were never granted. See Pittsburg petition (*Journal of the Senate of the U.S.A., April 19*, 1854), and Cincinnati petition (*Journal of the Senate of the U.S.A., Vol. 45*, May 1, 1854, p. 353). A Mr. Cooper and Senator Chase presented the petitions, which were referred to the Committee on Commerce.

threatened the innovation of the shops.[206] But there were other issues for the engineers as well, namely the consistency and quality of the fusible alloy used in the guards, and the fact that some individuals ("the inventor and his friends") were suspected of whipping up aspersions against the engineers for their own profit. We shall examine two reports by engineers' associations covering these charges in a later section, but let us first discuss the attempt by the Department to engage a government chemist in attempting to develop a reliable fusible alloy upon which the fate of the safety guard ultimately rested.

The Treasury Department Attempts to Develop a Reliable Alloy

From early 1854, while the legal aspects of the resolution on the pressure principle were being hashed out, the Supervisors tried to develop a suitable fusible alloy. They requested the Secretary to instruct the commandant of the Washington Navy Yard to begin developing an accurate alloy so it could eventually be distributed to the local boards. This turned out to be a more difficult undertaking than anyone imagined, consuming nearly a year and a half and ending in failure. Navy Yard scientists and

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[206] Ironically, some engineers favored a government monopoly for Evans's Safety Guard over Raub's device at the time. Raub's device consisted of a flotation device that opened a valve via a lever, see *House Ex. Doc.* 51, 25 Cong., 2 Sess. It received a French endorsement, but was opposed by Pittsburgh engineers, who protested in memorials to Congress against "any law compelling the use of a particular plan of security as inexpedient, inasmuch as ingenious mechanics would thereby be discouraged from prosecuting their experiments with a view to perfecting the safety of steam-boilers." They also asked for the appointment of a board of commissioners to test the relative merits of such inventions. See *Sen. Doc* 188, 26 Cong., 2 Sess., February 15, 1841. Practical engineer and later local inspector of boilers Andrew Watson's, and Captain Thomas Rogers's, names appear on the petition. Another memorial against the device, see Gov Doc 71, January 25, 1841. A description of Raub's device and Renwick's criticism of it to the Navy, see *House Ex. Docs.* 170 and 171, 25 Cong., 3 Sess. (1839). Renwick had recently been appointed to head a board of commissioners investigating inventions. Review of Raub's device was prompted by the Act of 1838. See *House Ex. Doc.* 99, 25 Cong., 3 Sess., (1839).

engineers noted the tedious nature of the experiments, noting the fact that determining the fusing points required many trials. Technical problems abounded owing to impurities in the metals used. The result was an unsatisfactorily wide range of fusing temperatures; these correlated to pressure differences as high as 40 psi. Clearly this would not do for a "perfect thermometer." The Treasury Department canceled the assignment in the spring of 1854 because of "unnecessary expense, delay in the preparation of the alloy, and after all, alloy of a bad quality."[207]

As Gouge began to see that the Navy Yard initiative was going nowhere, he approached Evans with an offer to purchase the alloy directly from him, offering him one dollar a pound. But Evans drove what Gouge thought an unreasonable bargain; he insisted on an annual salary of $1,500, plus expenses, because he had "spent much time and much energy in bringing the art to perfection, and he was not willing that the public should have the benefit of his labors, without paying for them." It was later reported that Evans's friends believed that Evans had in this case acted against his own interests and those of the public. Gouge later regretted his refusal to deal with Evans, who would soon be dead. Gouge wrote in 1855, "Not unfrequently success in an art or manufacture depends on a contrivance so simple that any one can apply it when he knows how, but which no one can apply who knows nothing about it. Since

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[207] Tedious experiments, internal letter, Navy Yard's H. Hunt to Commodore H. Paulding, 1853 12-28; Gouge on unnecessary expense and delay, assignment canceled in spring of 1854, see 1855 2-21; Navy Yard not making alloys quickly enough, see 1854 8-7. Although not known at the time, eutectic alloys made with large proportions of lead are exceedingly difficult to make accurate; the lead component is highly reactive to oxygen and this adversely affects its melting point.

Columbus set the world the example of making an egg stand on one end, nobody has had any difficulty in performing that feat."[208]

In February, Gouge found another source for the development of the alloy: he began to inquire into the transferring of the project to metallurgist and chemist James Booth of the U.S. Mint in Philadelphia. Booth accepted (Fig. 34).

The argument for pushing development of the fusible alloy forward sooner rather than later was echoed by Booth when he took up Gouge's assignment. Booth, aware of Gouge's conundrum and experiences with the Navy Yard failure, admitted that previously he had reached a hasty conclusion that the Department "should not sacrifice the care of an engineer for fusible alloy that was not entirely reliable." But he had experienced a change of mind. He now believed that the Department could not employ too many precautions to prevent "the dreadful loss of life by explosions." This was a compromise for the perfectionist Booth, but it highlights the attitude of the scientific community and of the government hierarchy at that time--that a self-acting mechanism must be employed as an ultimate safety check or insurance policy against the frailties of human operators.[209]

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[208] Gouge approached Evans in late 1853 or very early 1854: "On my western journey [to Pittsburgh], I had three interviews with Mr. Evans. I intimated to him, informally and unofficially, that if he would consent to supply the alloys at the price Government furnished it to the steam boats, namely one dollar a pound, perhaps the Department might be disposed to transfer the business to him. But he declined having anything to do with it, unless he were allowed 1500 dollars per annum, some 400 or 500 dollars for fitting up his machinery, and the [illegible] price of the tin, lead and bismuth that form the alloy. The demand of a salary of 1500 a year appeared to me unreasonable, for, as the same alloy will serve for ten years or more, after the boats are once fully supplied, only a few hundred pounds additional per annum would be required. Mr. Evans, however, intended that he had spent much time and much energy in bringing the art to perfection, and he was not willing that the public should have the benefit

Figure 34. Chemistry Professors James Booth (left) and John Lawrence Smith. Booth (1810-1888) was a U.S. Mint metallurgist affiliated with the Franklin Institute. He attempted to replicate Evans's alloy formula, with mixed success. After conducting his own trials, Booth conveyed his doubts that Evans had ever accomplished the accuracy of melting points claimed. Smith (1818-1883) worked to convince the Supervising Inspectors that Evans's Safety Guard was the best mechanism for employing fusible alloy.

of his labors, without paying for them." 1855 2-21. Professor Locke remarked on Evans acting against his own interests, see 1854 10-21. Gouge notes on making an egg stand on end, 1855 2-21.

[209] See 1854 2-15.

Meanwhile, The Department hoped it could get around the delicate situation of Evans's patent by clearing Bache's nearly identical plunging-impeller safety guard for use by the local boards. Thus, in August 1854, Secretary Guthrie wrote Booth asking if he thought Evans's patent necessary. Booth suggested that the Attorney General should make a study of the Evans patent, and in May 1855 a letter was received acknowledging that there was no interference between the patents. The Attorney General's office wrote that Evans's language was "too general and sweeping to make his patent exclusive.....Bache's device may be manufactured without infringement." This paved the way--in theory at least--for the notion of a government-manufactured safety guard combined with government-manufactured alloys. Since the fusible alloy was the soul of the safety guard, these would need to be made perfectly reliable, and this was what the government next set out to do.[210]

4.3 Making an Egg Stand on End: James Booth's First Experiments with Fusible Alloy (1854)

Having no access to Evans's fusible alloy formula, in February 1854 the Department moved research and manufacturing efforts to James Booth (1810-1888) at the United States Mint in Philadelphia.[211] Booth was a metallurgist and former University of Pennsylvania and Franklin Institute chemistry professor. Secretary Guthrie charged him with the importance of the work he was about to embark upon: "many lives depend on quality alloy." Booth accepted the Secretary's challenge "cheerfully,"

[210] Guthrie to Booth, query, 1854 8-7; Attorney General's reply, 1855 5-1.

[211] The only establishment in the government that had "the requisite chemical skill." 1854 2-7. James Booth (1810-1888), professor of chemistry at the University of Pennsylvania, later, metallurgist at the U.S. Mint in Philadelphia. See end notes in this chapter for full biography.

stating that he was willing to superintend the manufacture of the alloy Guthrie mentioned. He promised that there was ample space in the Mint Building in which to experiment on the proportions of metals.

Booth's subsequent correspondence with the Treasury Department is voluminous. It gives much detail about the difficulty of trying to design and manufacture alloys that could live up to Bache's and the Department's theoretical expectations of the perfect mechanical thermometer. The correspondence also provides a good deal of insight into the entire working relationship from the Treasury Department down to the local boards in conveying Booth's scientific expertise to the engineers.

Booth began by examining the report of the Franklin Institute experiments from 1836, as well as those of a Swedish metallurgist, an "F. Rudberg." [212] In both cases, he found there were no alloy formulations provided for the necessary temperature increments (every ten degrees); he would have to conduct many sets of tedious experiments to determine these. There was also the problem with "absolute reliability" of the alloys issuing from the Franklin Institute's discovery that the molten alloy's components too readily separated. Booth was not sure how this could be overcome. Another technical problem was that the engineers' remelting of the alloys to fit them in the safety guard could upset the delicate fusing point of the alloy; the solution here might be to send out the alloy in a shape that fit the guards. Eventually, this is what was done. Booth would prepare alloy in approximately one-pound ingots or disks and ship them out in boxes to the inspection districts, where engineers would pour them into the safety guards with special ladles.[213]

In March, Booth ordered and received quantities of lead, tin, and bismuth for his experiments. He also ordered a small test furnace for melting the alloys. He noted that the special meeting to be held by the Supervising Inspectors in Washington in April would include a discussion on how the alloy would be required to be used aboard steamboats. "They [the Supervisors] are of the opinion that if the alloy is not used in a form that excludes the pressure of steam, it is worse than useless. Since their decisions will be important as to the form of use, I await the results of their deliberations [before starting manufacturing]." In the mean time, he wrote, he had conducted some preliminary experiments in which he had measured the melting points of the alloy. The results were not promising. Some of the alloys had fused at their proper points; others had not, and this meant that many more experiments would be required in order to establish a reliable range of formulations.[214]

Uncertainties in the individual formulations were due to the response of the alloys to heat depending on which phase the metal was in (solid, soft solid, thick fluid, or thin fluid). The transitional states made measurement difficult, he noted; a range of fusing

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[212] Rudberg (dates unknown) was a Swedish physicist who worked with heat theory, expansion coefficients of gases, thermometers, and fusible alloys (particularly bismuth, used in the safety guard), and was a contemporary of Dalton and Gay-Lussac.

[213] Booth's boxed shipments consisted of 55 or 56 pounds of alloy, see 1856 11-19. The ladles supplied were later discovered to be defective, leading to erroneous melting points and casting further doubt on the overall efficacy of the safety guards, see 1859 7-7.

temperatures from a few degrees to 30 degrees and more was possible depending on how fusion was defined. Unfortunately, this range would express too great differences in pressure for the higher pressure alloys (these higher pressure alloys were for use in the more dangerous high-pressure boilers.) Further, the pressure tables Booth needed simply did not agree with each other. "I have examined several sets of tables showing the correspondence between temperature and pressure, and found them quite variable. The difference is so great that while one table gives a certain pressure for a certain temperature, another table gives a difference of 10 and even 20 pounds for the same temperature." He wanted to obtain from the Supervisors a table showing the correspondence between pressure and temperature for the pressures they wished to measure "because of the discrepancies between different writers and experimenters on this subject." The information never came; the Supervisors wrote that they had no knowledge of such a table.[215]

Within a month, with the assistance of a Mr. Morfit, Booth managed to conduct a more thorough program of experiments. For these, he used a thermometer enclosed in a metal tube (a French method) and measured the point at which the tube could be withdrawn from the softening alloy. He was satisfied after this latest series that he would be able to prepare a full range of fusible alloys rated to fuse at pressures less than 130 psi. Above this, there were problems: "I am not at all satisfied with any

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[214] See 1854 4-6.

[215] Discrepancies in the fusing point were due to the different purities of metals of the various experimenters, as well as the different laboratory and manufacturing techniques of the investigators. See St. Louis engineers' report, 1854 10-2. Booth: "If Evans or analogous method be adopted (and I can conceive of no others applicable), assume that the practical fusing point be that at which iron

proportion of metals composing alloys, which are designed to express pressures above 130 pounds, it being difficult to determine their melting point, or point of moderate fluidity, within 10 to 30 degrees of temperature." This was a serious stumbling block for Gouge and Booth because it was precisely the more dangerous higher pressure boilers operating in the 130-160-psi range that the Department wished to protect against. Booth inquired of the Secretary what the supervisors' views were with regard to the use of alloys with "the apparatus." Secretary Guthrie replied three days later that the alloys must be used "on the principle of Evans's safety guard."[216]

With the instructions of the Secretary in hand, Booth proceeded under the assumption that the alloys would have to be made to work with the Evans Guards. This posed a challenge for Booth. Such a mechanism would have a great effect on the practical fusing points of the alloy. He reported to the Secretary in early May that "The further I progress in my experiments, the more I realize it is essential for me to experiment directly with the Evans apparatus, which the Board of Supervisors has adopted, to determine the practical fusing points of alloys." He had determined that the alloy demonstrating the best reliability (i.e., expressing the narrowest pressure range for a

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passes through alloy, but a limiting range of many pounds pressure should be allowed because of want of exactness even in this fusing point." 1854 4-11.

[216] This instruction of the Secretary's was not quite correct. The Supervisors' resolution required the local inspectors be instructed "not to permit of alloy application by any method which shall not exclude all pressure from the alloy which shall tend to separate its components." The alloy was to be "enclosed in a case or tube… (etc)," but no part of the resolution singled out Evans's device as a requirement. This seeming fine point would be a major source of problems for the Supervisors in 1859, when the safety guard issue came to a head. Booth's inquiry of the Secretary, see 1854 4-28. Secretary Guthrie's answer: "The Board of Supervisors at their late meeting at Washington adopted a resolution… [that it is] imperative to use fusible alloys on the principle of Evans' Safety Guard," 1854 5-1. The Committee drafting the resolution consisted of Crawford, Embree, Burnett, and Copeland (Copeland had added the resolution on a motion). The meeting was held on October 6, 1854.

given temperature) was the one having a ratio of seven parts of tin to four parts of lead. “This is the alloy usually quoted as showing the reliability of the fusible alloys, & has led to some error in overestimating their value.”[217] But in order to express a pressure above 130 psi would require an alloy that fused at a higher temperature, and no one had been able to produce such an alloy except, presumably, Evans himself. For high pressures, a different ratio of metals would be required, and the alloys having these ratios had been showing poor reliability in Booth’s experiments. Booth had deduced that using either of two high-temperature alloys (1:4 tin to lead, allowing the tube to be withdrawn at 420 deg F; and 2:4 tin to lead, withdrawing the tube at 380 deg F) would allow an unacceptably large 65-degree temperature range, and this translated to a difference in pressure of 100 psi (!) Clearly, this would produce an alloy that would be “absolutely valueless.” He decided to lower his (and the Department’s) expectations. If the Secretary could tell Booth when and where he might obtain a safety guard, he could proceed to manufacture alloys for pressures of 130 psi and below, bringing to a close his preliminary investigations. “For greater pressures, my data are too unsatisfactory as yet.”[218] (See Fig. 35).

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[217] This translates to 64 percent tin and 36 percent lead (Calculation: 7/11 ratio = .64 for the tin fraction.) On the chart, therefore, the useful range of fusing points is clustered in a small circle near the intersection of the phase-change lines (at the 60/40 ratio). Beyond this cluster, the transition zone from solid to liquid widens such that the phase change is ambiguous; the resulting variable temperatures give a range of pressures that widens unacceptably.

[218] “…for that point ought to be taken, & only that one, as the fusing point, at which Evans’ guard will give the alarm. Which point in the extremes of 65 degrees is it?” The experiments were laborious for Booth and his assistant. Booth wrote the Treasury Secretary, “When you wished me to enter the… enquiry… I supposed that something more definite was known in relation to alloys, but I have been obliged to proceed step by step by experimenting upon numerous alloys of tin & lead, and of tin, lead, and bismuth… the results of the experiments are only ascertained by slow observation, repeated more than once… much time is consumed upon them.” A government official, perhaps the Secretary, wrote on the wrapper of Booth’s correspondence: “Try and get apparatus for Booth . . .” 1854 5-5. Five days letter Guthrie notified Booth that several models of safety guards were being sent to the Mint by Evans in Pittsburgh, but they were not “complete in all respects.” After some correspondence back and forth,

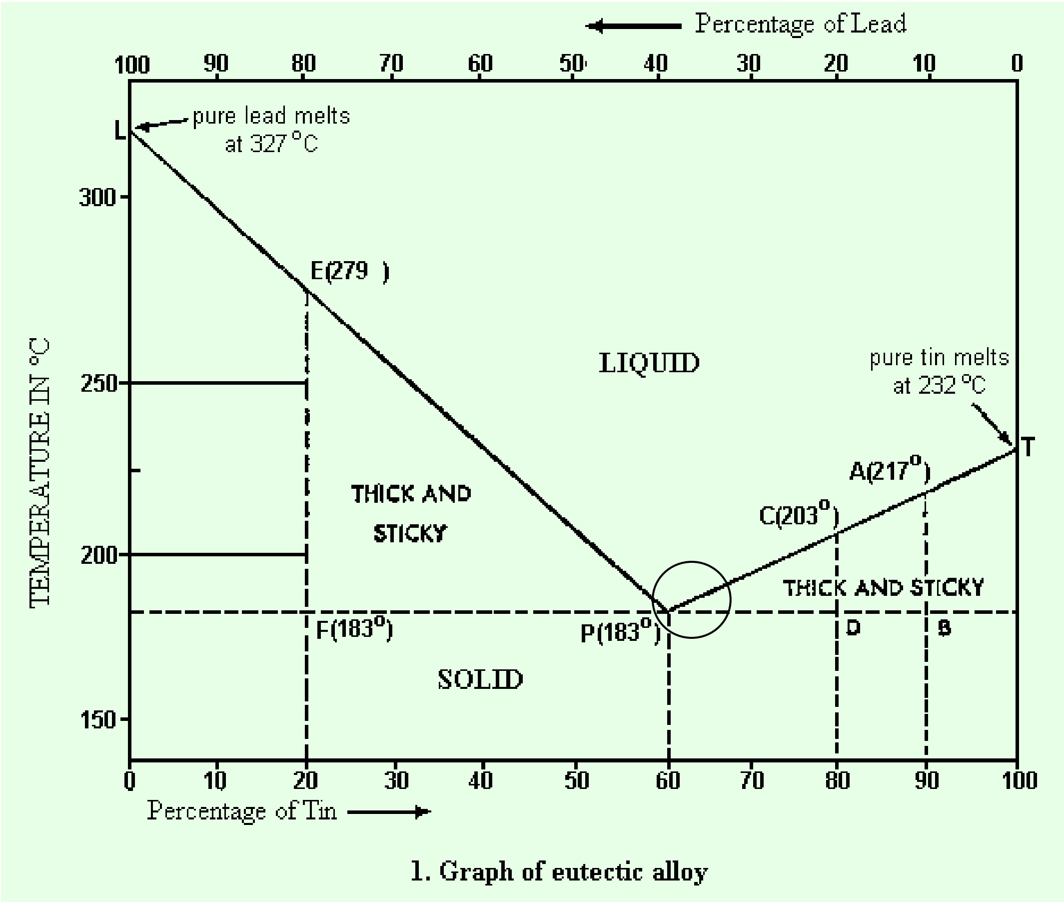

Figure 35. Modern phase diagram for a fusible alloy similar to the one developed by Booth. The circle indicates the quite limited useful range of temperatures observed by Booth owing to the sluggishness with which the alloy changed from solid to liquid. As the triangular area marked "thick and sticky" diverges toward the right of the figure, the alloy becomes less accurate in its fusing point.

Evans sent his best model, and Booth used this device to manufacture alloys for the lower pressures, 1854 5-10. Initially, Evans had sent his cheapest alarm-only models (the models most likely to be purchased by river men due to cost) because the Secretary had only sent him one hundred dollars.

In May, Supervising Inspector Davis Embree wrote the Secretary wishing to know if Booth had yet succeeded in making the alloy more reliable. Embree was also running short of fusible alloy, alloy that presumably had been furnished by Evans. "We are nearly out of Alloys stamped 150 and 160. It will require about 100 lbs of 150 stamps, & 50 lbs of 160 stamps to supply the Boats at this port." Embree also took the opportunity to strike a blow for his engineers. He wanted the words "alloyed metals" removed from Law, due to fears of the Evans monopoly. "If the words <u>Alloyed</u> <u>Metals</u> were out of the law; we could readily introduce other safe appliances." If Congress could not act in the present session, Embree asked, could it not pass a resolution to allow the local inspectors to suspend use of the alloyed metals until legislation could be drafted? Embree's request met with silence.[219]

By September, frustrated by problems in formulating alloy for the higher operating pressures, Booth prodded Gouge to help him fast track his research by stealing some of Evans's alloy. The trigger for this request was likely the fact that Evans had just died or was near death, his alloy secret threatening to disappear with him. Gouge, who was visiting Crawford in Pittsburgh at the time, indulged Booth's wish, communicating his plans in a letter marked "PRIVATE" to Assistant Secretary of the Treasury Peter G. Washington:

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[219] "I would inquire whether Professor Booth has succeeded in getting an Alloy for high temperatures more reliable than [those] in use, if so, would it not be well to furnish some of it to St. Louis." The St. Louis owners and engineers were fearful of the power of Evans's patent, particularly because they

> "I have seen Professor Booth. He can come to no satisfactory conclusion in respect to the alloys but he has the means of testing them with a boiler. Mr. C. Evans told me that he himself was experimenting on the alloys for a whole year, before he hit upon the true method of preparing them. In what this consists, he refused to tell. But it [seems] to me that it would be an advantage to Professor Booth, if he had some of the alloys prepared by Mr. Evans to experiment on. Perhaps the [result] consists in adding some chemical ingredient. If so Mr. Booth, would [deduce] what it is by analysis. He would like much to have some of Mr. Evans' alloys, if they could be obtained in a private way: and Mr. Crawford could probably obtain them without letting it be known for what purpose they are intended."[220]

It is not known if this plan for amateur industrial espionage ever panned out. If nothing else, it was a sign that panic was setting in at the Department over Evans's ill health and the decision to embark on a difficult research program, especially with growing calls by the inspectors to put the safety guard on ice until the alloys could be made reliable.[221]

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believed the guards were poorly manufactured, and thus the more they failed, the more dollars would accrue to Evans. See 1854 5-23.

[220] See 1854 9-8.

[221] A month later, the Department solicited a summary report from Booth as to his progress in preparing the alloys. The Secretary wished the report for his own annual report to Congress. Curiously, Booth was also informed that the Department had taken no position as to the merits of the Evans guard. "I will be obliged to you if you will make a report in full as to what you have done in relation to the preparation of fusible alloys..... Mr. C. Evans Safety Guard and Safety Alarm will receive the attention they merit: but, it is impossible to state at this moment to what conclusion the Department will come in respect to them." See letter from Assistant Secretary Washington,

Booth spent most of 1854 trying to create a more reliable alloy. Mostly this was an altruistic undertaking. He managed to prod the Department to procure a small $500 test boiler for his experiments, but he paid for bringing water into the laboratory himself. He paid the extra rent occasioned by the hazard of a steam boiler on the premises out of his own funds, as well as personally taking on the expense of preparing alloys during the first five months of activity. When he was not pursuing official Mint business, he labored to set up the casting furnace for the alloys, and he obtained the necessary casting pot, marking punches, fuel, and cast iron "shoe" molds. In February, a year after he had begun, Booth had compiled a table of fusing points, the first of its kind. Notably, the table stopped at 110 psi.[222]

4.4 Evans's Death, Jane Evans, and Booth's Production of Fusible Alloy (1854-1858)

In the summer or fall of 1854, Cadwallader Evans died. His widow, Jane Evans, inherited his "secret" of manufacturing fusible alloy. She approached the Secretary through an intermediary in October, explaining that when Evans was sick, she had superintended the weighing and mixing of the alloy, so she would be able to continue its manufacture. She also intended to manufacture the safety guard in her own name.

1854 10-28. The Department's sudden ambivalence likely was a reflection of hesitation by the Supervising Inspectors to embrace the alloys, which were under attack in their districts.

222 In "Results of Experiments on Fusible Alloys," enclosed with other 1855 2-22 materials. Although there were spaces left for temperatures corresponding to higher pressures, these were left blank. Ironically, Booth had trouble getting fire insurance for the building; the insurers were afraid the boiler would explode and burn it down. The shoe molds came from the Mint's stocks (1855 2-22), and the tin was procured from Trotter's in Philadelphia, a company that is still in existence (1859 7-7). Booth's manufacture of the first alloys at his own expense, from a letter in response to an inquiry by the

She offered to provide the alloy to the government under contract at the price of Gouge's old offer, one dollar per pound.[223]

By now, of course, Gouge had already engaged Booth in the manufacturing enterprise.[224] Gouge kept his options open, although he preferred to keep the alloy under the government's roof, for cost reasons. He noted that if Booth could not succeed in making the alloy reliable, Jane Evans could supply it. In that event, Professor Smith would be retained to test her alloys for accuracy. This arrangement served to satisfy all parties; as long as there was promise that Booth could manufacture a satisfactory range of alloys, owners could be instructed to install Jane Evans's safety guards while using alloy issued from the U.S. Mint. Booth would distribute his alloys, the quality of which was adequate for the lower pressures. For the higher pressures between 110 and 160 psi, the plan was to use "simple plugs of the fusible metal… as formerly practiced." The Evans Safety Guard would be the specified device for employing the alloy.[225] [226]

Department regarding excessive laboratory room rent, see 1859 1-3. It had taken nearly a year for Booth to derive the fusing points table that he had sought from the chemical community in April 1854.

[223] Evans died in the summer or fall of 1854, see 1854 10-21, "Evans is lately deceased." Prof. John Locke to TS Guthrie. The Jane Evans offer is captured in 1854 10-19; the intermediary was a D. Benson. Jane Evans noted that "The gentleman appointed by the government to manufacture the alloys has resigned." This was undoubtedly Booth's assistant Clarence Morfit, who left Philadelphia about this time to help establish the U.S. Mint's New York Assay Office. Jane Evans was intimating that with Morfit's departure, the Mint could not keep up with the government's demand for alloy. NY Assay Office sources (to place date of activity): See http://home.eznet.net/~dminor/NYNY1853.html, 1853 3-3, and 1854 5-5.

[224] Booth begins formulating and manufacturing alloy; See Booth's retrospective letter dated 1859 1-3.

[225] Booth's announced plan to use plugs for higher pressures is puzzling. Presumably, most steamboats operated in the higher pressure ranges and would require safety guards. It is therefore likely that the lower pressure alloys were used in safety guards on these steamboats in addition to the plugs. This would explain the "nuisance factor" of safety guards giving false alarms as retold by engineers (a chief complaint). The alloys were fusing at too low a temperature for the capacity of the boiler employed.

Booth now began to receive alloy orders from the local boards, although inspectors in some districts were still dragging their feet in making requests. Supervising Inspectors Crawford (Seventh) and Shallcross (Sixth), for instance, wished a postponement of use of the alloy, "until Booth completes his studies of the different apparatus..... The government alloys we have received before now have been defective." (These were the Navy Yard alloys). The "different apparatus" the Supervisors had in mind consisted of Bache's and Booth's modified safety guards (among others)--all intended to circumvent Evans's patent monopoly. Sensitive to the monopoly problems associated with linking the alloy to Evans's guard, Booth had expanded his workload to experiment with alternative mechanisms. He wrote that although he had little time to work with mechanical devices, he had learned that the most complex devices were those having rotating spindles. In October, he published a report on these and other mechanisms used in safety guards.[227]

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[226] With a strategy determined, Booth worried about manufacturing arrangements and cost. Manufacturing alloy at the Mint brought with it a range of peculiar problems. He feared that bringing in workmen to manufacture the alloy in bulk would expose the Mint's gold to theft or lead to its contamination; he therefore gave serious consideration to manufacturing the alloys outside of the Mint building. This idea was later abandoned in favor of production in Booth's own laboratory, "to save expenses." Cost of workmen was also a concern. Booth wanted to turn out a sufficient quota of alloy pieces for the many steamboats receiving safety guards, but he was afraid to ask for more assistants--the Secretary had stipulated economy in the operation. Nevertheless, after an oblique request, within a month help came. By March, in response to a "brisk demand" for the alloy, Booth had three assistants turning out three fifty-pound batches per day. Tests were conducted on the first and last samples of each batch, and then the alloy was stamped with the correct pressure and packed in small kegs so they could be rolled about until transported. Booth attached a one-page instruction sheet with each batch of alloy instructing the installer to make sure the metal tube of the safety guard touched the boiler's flue. 1855 3-13.

[227] See 1855 3-20, 1855 3-31, 1855 6-6, 1855 7-14, 1855 8, 1855 8-23, 1855 8-27, 1855 9-22, 1855 10-10, 1855 11-2. Booth's pamphlet entitled, "Report on Apparatus for the Use of Fusible Alloys in Steam Boilers," was dated August 1855. The pamphlet was reprinted in the Proceedings of the Fourth Annual Meeting of the Board of Supervising Inspectors held at St. Louis, October 10, 1855, p.56, author's index nos. 2C3, 2C5. Booth distributed a pamphlet version to supervising and local inspectors, and to machinists of steam engines. His stated object was "to elicit . . . inventions or improvements of

Booth also reiterated the pressure principle in describing the segregating tendencies of fusible alloys when exposed to pressure. He discussed the characteristics of fusible alloys and showed the "best form for [an alloy] plug" for the higher operating pressures (110-160 psi). These simple plugs were to be placed in the boiler without being part of a safety guard, and were vociferously opposed by at least one or two "scientific" inspectors.[228]

On May 23, 1855, Jane Evans wrote the Secretary complaining that steamboats were leaving port without Evans's guards, and she was losing money. Her correspondence

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apparatus for using fusible alloy." The pamphlet gave several alternatives besides Evans's device for employing the fusible alloy. The text described three types of guards: guards with circular movements (Evans's rotating impeller); vertical movement (Evans's downward and Bache's upward plungers); and lateral movement (no inventor given). These constituted an enlarged selection of safety guards based on the pressure principle and which would be in principle acceptable to the inspectors and engineers. Booth wished to "lay before the Board of Supervisors the whole subject of forms of apparatus [that] may be advantageously employed," trusting in their experience to determine the best form. "Other kinds of motion in the alloys can be imagined, such as of a lever placed vertically in an oblong box and tube, with its fulcrum about the middle . . . but these and the above are merely thrown out suggestively, in order that machinists may avail themselves of the principles involved in them, and bring them into successful operation." There was a printing run of 225 copies (although an order was placed for 500 copies of the artwork showing the mechanisms). Booth sent a copy to Bache of the Coast Survey, "for I availed myself of a suggestion of his for the vertical movement." This was the nippers arrangement shown in the report's Figure 1, designed so the operator did not have to manually reset the apparatus after a firing. Artwork was not included in the pamphlet, but rather was inserted in the 1855 Proceedings, on p. 56.

[228] Local inspector James Curry of New Orleans (District Four) did not agree with Booth's strategy for using simple plugs of fusible alloy for the higher pressures, or for any pressure for that matter. Curry had written the Department in January 1854 denouncing fusible alloy plugs. The plugs could not be applied "in a suitable manner," i.e., in accordance with the pressure principle, because they were not protected in a tube. He dismissed a report of St. Louis engineers that was critical of the alloy and of the safety guards (the report "does not deserve a passing notice"). Curry was fighting a seeming never-ending battle in his district. He had in the past year revoked the licenses of twelve engineers, mostly for loading the safety valve or fastening down Evans's safety guards or other devices. See 1854 11-1. Booth met with Crawford over the summer to discuss the alloy and plugs; he was impressed with Crawford's intelligence and experience. Booth made no recommendations to the Department on plugs, his experience being only "theoretical" with regard to them; the inspectors were better with the practical aspects, he wrote. 1855 8-9.

is interesting because it shows how personal factors create pressure on decision-makers with regard to the implementation of a technology. She wrote:

> "I would respectfully call your attention to the fact that notwithstanding the fusible alloy has been prepared by Prof. Boothe [sic] (at considerable expense to Government) for more than 3 months, yet the Steamboat Inspectors, both at this place and St. Louis and I believe in Cincinnati also fail entirely in performing the duties of their office as required by the Law in permitting boats to leave without the Alloy attached to their boilers in <u>suitable manner</u> and in giving said boats certificates that they have complied in <u>all</u> respects with the law. I did not understand the reason of this and I went to Philadelphia last week and seen [sic] Prof. Boothe who informed me that he had the Alloy made and subject to the order of the Hon. Secretary of the Treasury and I would have went [sic] to Washington City and saw [sic] you but had to return on account of my daughter's illness. I hope you will call the attention of the Inspectors to this subject and return me a favourable answer as soon as convenient as the Law is disregarded and I have already lost at least Two Thousand Dollars ($2000) by the neglect of these men to procure & apply the fusible Alloy."[229]

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[229] 1855 7-23. The words, "in suitable manner" in the handwritten letter were added between the lines of text, indicating that they were a late addition, either by Jane Evans or by the copyist; someone was invoking the applicable provision of the ninth section of the steamboat law. From this, we can surmise that some owners were installing non-Evans safety guards, or perhaps other unacceptable devices that violated the Supervisors' resolution enforcing the pressure principle. It is possible that Department

It is not known if the Department responded, but by October, Booth had shipped out more than 300 pounds of alloy to various districts, noting at the same time that business was diminishing rapidly. Officially, the Supervising Inspectors still supported the safety guard and fusible alloy, but evidently they were beginning to look askance at government alloy; there had been discussions of giving up the guards, including fusible alloy, and going over to plugs of pure tin.[230] (See Fig. 38).

From the summer of 1856 through 1857, despite Booth's proclamations that he would succeed in manufacturing reliable alloys at the higher pressures, experimental results were indicating otherwise. Experiments supervised by Professor Smith aboard the steamboat *Reindeer* reported in November disconcerting inconsistencies in the fusing points for the higher pressure alloys (i.e., those rated 140 psi and 150 psi). In the experimental runs, the fusing points were at least 10 or 15 degrees Fahrenheit too high. Compounding the failure was the fact that the local boards had ceased placing orders for the alloy altogether. As a result of the experiments, William M. Gouge conceded that Booth might not have possessed the ability to make the alloys as well as Evans after all. Still, he had difficulty reconciling this cognitive dissonance; he remarked that Evans's samples had fused consistently in a series of repeated firings as

support for the position of Jane Evans, a new widow suffering a loss of income, was tied to internal decisions about the safety guard, but there is no direct proof of this.

[230] Two hundred pieces of alloy went to Embree (St. Louis) over the summer, 1855 7-30, and 125 pounds (about 125 pieces) to Nashville. In addition, Wheeling had placed an order, quantity unknown. Changing from fusible alloy in a safety guard to plugs of pure tin, 1855 10-10. In the Supervisors' 1856 Proceedings, p. 29, there is a reference to the Supervisors advocating a revision of the ninth section of the Act to allow the use of fusible plugs or rivets of pure tin. See 1855 11 (author's D35).

Figure 36. Captain John Shallcross, Supervising Inspector of the Sixth District, Louisville. According to T. J. Haldeman, Shallcross originated the “ridiculous idea” of substituting plugs of pure tin in place of the Evans guard.

evaluated by a "committee of practical and scientific men at Pittsburgh."[231] Gouge had picked up the item on the Pittsburgh tests from Cadwallader Evans's 1850 Treatise. The experiments had been conducted in the late 1840s by "a Committee composed of scientific and practical gentlemen," and repeated in a second series by Professor Locke, whom Evans had characterized as one of "many [who] are illustrious in the departments of science, and associated in the annals of the country, with the progress of the arts. These men cannot be deceived—cannot easily be mistaken. With splendid reputations at stake, they would not give hasty opinions, founded upon half-tried experiments."

For his part, Booth was not convinced of the scientists' claims. After spending nearly three years in his laboratory trying to replicate Evan's results using an array of quirky metals, he wrote the Department expressing his doubt that Evans had ever been able to make a reliable high-pressure alloy as advertised. Nevertheless, Booth admitted

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[231] Business diminishing by the end of 1856, see Gouge's and Booth's retrospective notes, 1859 1-3 (Gouge) and 1859 4-11 (Booth). January 1857 appears to be the correct date for Booth's fall-off in business, however, as recorded in his 1857 1-12 letter. Apparently Booth was confused in a summary account he gave the Secretary of the alloy business in 1859 in response to a Departmental query about the rental costs of his laboratory space: "No orders have been received by me since the fall of 1856," he wrote, see 1859 4-11. (Booth's summary account to the Secretary was in response to accusations that Booth was using the government's portion of the alloy laboratory for other than official purposes [rent: $300]. He wrote, "The allegation to the Department shows a misunderstanding of the facts." He regretted the suggestion by "someone" that he was using premises rented by government for his own purposes. He said he had kept the Department informed of the trailing off of business, but the Department had kept silent in the matter. He listed the remaining inventory of equipment as follows: a small boiler, various stocks of metals, 1000 pounds of fusible alloys from 60 to 160 psi. Booth offered his defense "in simple justice to myself," not in a "vaunting spirit." From retrospective letter 1859 1-3. The Department reluctantly agreed to pay the room rent on the laboratory, 1858 11-17.) On the quality of Booth's alloy, Gouge noted in his 11-1856 letter that "Professor Booth, a melter and refiner at the Mint in Philadelphia, has high and important duties to perform. It is only the little leisure his official duties allow him that he can devote to the preparation of fusible alloys. It is easy to believe that, under such circumstances, the alloys prepared by him, may not be as good as those that were prepared by Mr. Evans." Still, for purposes of safety, Booth's alloy should suffice to meet the safety requirements of steamboats, he wrote. (The quality of Booth's alloys was still an open question as late as 1859; see 7-7-

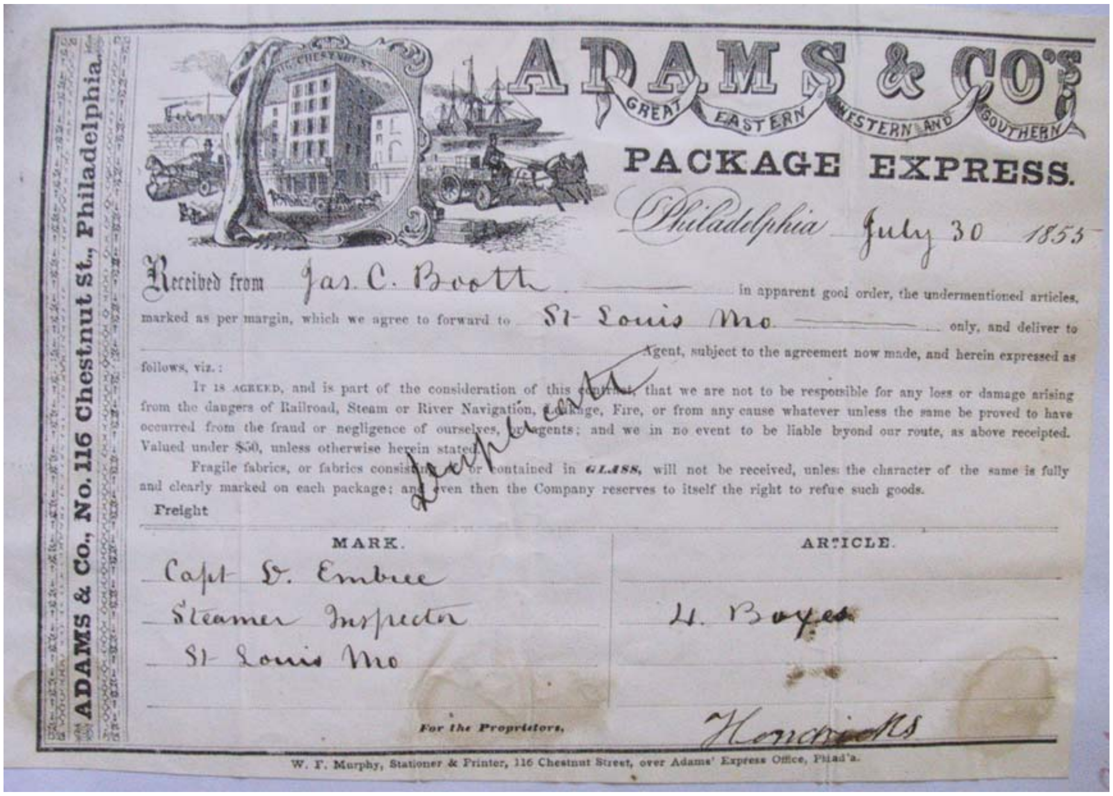
that when he had commenced preparation of the alloys, he had doubted their utility; now he was surer of their usefulness and he urged the Department not to abandon them.[232]

The Last Demands for Government Alloy

By the winter of 1856, Booth shipped out the last of his alloy pieces to the local boards in several southern and western states (Fig. 37). He shipped two boxes to New Orleans, five boxes to Mobile, two boxes to Louisville, and one box to Cincinnati. These orders constituted an estimated 500 pieces of alloy. It is not known how much alloy had already gone to the northern and eastern districts—we know of 300—or how much alloy was kept in storage until needed, but we can safely guess that enough metal for at least 300 to 400 working steamboats had by now shipped to the key ports of the country, and perhaps double that amount. This

1859 [D47] on Booth's admission that the ladles used to pour the alloy in the safety guards were defective, throwing off the alloy's melting points.)

[232] Experiments aboard the Steamboat *Reindeer*, see Gouge's draft letter dated 11-1856, in RG 41, Vol. 6, Item 64, author's IMG 1693-1711. Letter addressed to Supervisor Davis Embree; it is not known if this document was ever transmitted to him. Repeated tests aboard the Reindeer had revealed that at higher pressures the fusing temperatures were at least 15 to 20 degrees too high (and, investigators remarked, would have climbed higher had experiments not had to be terminated at an expressed pressure of 165 psi due the danger of explosion). Complicating the experiments was the fact that the alloy had assumed a "mushy character," i.e., was not perfectly fluid. (Note: this is the behavior of the alloy in the two triangular zones in the phase diagram of eutectic alloy provided in an earlier figure.) The *Reindeer* was likely the same boat that had suffered a flue collapse in March 1854, killing 38 persons, as reported in Proc 10-10-1854 (but there is no way to know this for certain, since duplicate names abounded in the steamboat fleets). Pittsburgh tests, see Evans's Treatise, 1850, p. 37. Booth on his initial doubts about alloy, 1856 7-1.



ADAMS & CO'S
GREAT EASTERN WESTERN AND SOUTHERN
PACKAGE EXPRESS.

ADAMS & Co., No. 116 Chestnut St., Philadelphia.

Philadelphia July 30 1855

Received from Jas. C. Booth in apparent good order, the undermentioned articles, marked as per margin, which we agree to forward to St Louis Mo only, and deliver to Agent, subject to the agreement now made, and herein expressed as follows, viz.:

It is agreed, and is part of the consideration of this contract, that we are not to be responsible for any loss or damage arising from the dangers of Railroad, Steam or River Navigation, Leakage, Fire, or from any cause whatever unless the same be proved to have occurred from the fraud or negligence of ourselves, or agents; and we in no event to be liable beyond our route, as above receipted. Valued under $50, unless otherwise herein stated.

Fragile fabrics, or fabrics consisting of or contained in *GLASS*, will not be received, unless the character of the same is fully and clearly marked on each package; and even then the Company reserves to itself the right to refuse such goods.

Duplicate

Freight

MARK.	ARTICLE.
Capt D. Embree	
Steamer Inspector	4. Boxes
St Louis Mo	

For the Proprietors, Hendricks

W. F. Murphy, Stationer & Printer, 116 Chestnut Street, over Adams' Express Office, Phila'a.

Figure 37. An 1855 Adams' Package Express receipt for four boxes of alloy being shipped to Embree's district. Each box contained between 50 to 55 pieces, at one pound each. The receipts showed that Booth shipped out hundreds of pieces of alloy by 1856.

confirms that the major government initiative to push the safety guards occurred in the 1855-1856 time frame.[233]

In January 1857, Supervisor Benjamin Crawford submitted an amended bill to Congress favoring plugs of tin over fusible alloy. Booth opposed the bill; he noted that a combined remedy (i.e., fusible alloys and tin plugs) would secure safety more thoroughly than abandoning fusible alloys altogether. Booth now claimed to be impressed with the safety guard's value as an "acting thermometer." However, Crawford's amendment was gaining momentum among the supervising and local inspectors and evidently was having an effect on the demand for alloy. As orders to Booth from the local boards dried up, Crawford drew attention to the "signal failures" of government alloy in the 1858 *Proceedings* of the Board of Supervising Inspectors. He took a further step by introducing a resolution to form a committee to investigate "rescinding the resolution in regard to fusible alloys passed by the Board on April 13, 1854."[234]

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[233] Adams Express facilitated the second set of shipments in November and December 1856. Booth was precise in his notekeeping. In addition to recording the destinations of the alloy, he noted that one box of alloy weighed about 50-56 pounds, and each piece of alloy weighed about a pound. Thus, each box contained approximately 50 pieces of alloy. See 1856 11-19, 1856 12, 1856 12-1. Booth's actions to distribute his latest batch of alloy appear to have again provoked the engineers' fear of monopoly. In January 1857, "citizens navigating the Ohio and Mississippi Rivers" (likely these were engineers and steamboat owners) making "remonstrance against the ninth section of the 1852 bill, praying the government to purchase and make free Evans' Safety Guard." 1857 1-7. That same month, Booth lamented that he had "received orders a second time [for alloy] from only a few local inspectors." He feared that "previously existing prejudices remain against their utility." 1857 1-12.

[234] Booth impressed with safety guard's value, 1857 1-12. Crawford noted signal failures of government alloy, see 1858 *Proc*, meeting held 10-18-1858, pp. 12-13.

4.5 Gouge's Perspective on the Safety Guard (versus that of the Practical Engineers)

Before proceeding to the final act of the safety guard drama in this chapter - - the final confrontation between Treasury Secretary Cobb (and Gouge) and the supervising inspectors in 1859 over the safety guard - - we shall examine three documents that emerged between 1854 and 1856 that allow us to compare the attitudes of the key parties toward expertise. One document is a lengthy reaction of Gouge's toward a critic of the safety guard, local inspector James W. McCord of St. Louis, who has raised objections to government alloy on grounds that it is inaccurate with respect to pressure.[235] In this document, Gouge argues that McCord is mistaken because the safety guard is designed to react to *temperature*, not pressure, and hence McCord has missed the whole point of fusible alloy as successor to the inadequate safety valve. Gouge also attacks McCord for undermining the steamboat law by selective enforcement based on "[McCord's] own practical views of the law's expediency." The other two documents are reports from two engineers' associations, at St. Louis and Wheeling, in which they attack government fusible alloy for its reliance on the incomplete and inconsistent results of scientists.[236] The reputation of the engineers is upheld as the only sure way to guarantee safety from explosions. Let the safety guard stand or fall on its own merits, they pronounce.

[235] The draft letter or memorandum is 1856 11, NARA Vol. 6, item no. 64. It is seventeen handwritten pages.

[236] Wheeling, 1854 9-25; and St. Louis, 1854 10-2. The Wheeling report is one handwritten page; the St. Louis report is eighteen handwritten pages.

Comparing all of these documents side by side is important because they neatly sum up the roles and claimed territories of the opposing parties in the debate. In the reports, we see clearly the outlines of the different perspectives of the groups we have introduced in earlier chapters—scientist, inventor, government official, practical engineer. We learn how their professional and experiential biases provide different outcomes with regard to what they perceive as expertise.

Before discussing these documents in detail, it is important to understand the voices and perspectives of the actors.

Gouge's bias is toward the work of establishment scientists and inventor Cadwallader Evans. He accepts the received knowledge of the safety guard as a flawless and accurate scientific instrument and argues that the universal principles of chemistry in the laboratory do not differ from those principles put to practical use on the rivers.[237] More importantly, this received knowledge is seen by Gouge as the linchpin of the legal authority of the steamboat act itself. He remarks that the safety guard will make a "fair experiment" of the act, and censures subordinate officers such as McCord for trying to decide on their own (in the absence of a complete scientific understanding) the merits of the device. Coming through in Gouge's letter in a subtle way is the view that although scientific truth is the foundation of the Department's technological

[237] "Perhaps it will be said that these were only experiments in a laboratory. And so they were. But the laws of nature are the same in the laboratory and on board a steam boat. And however difficult may be the condition of things on board the steam boat from what they are in the laboratory, they cannot affect the principle that, if there is a sufficiency of water in the boiler, the fusible alloy will melt at a very different pressure from what it will if there is a deficiency of water, or if the steam is, in any other way, surcharged with heat."

strategy, the more important principle is that government legal authority must not be challenged. Gouge sees himself as a conservative defender of the scientific status quo and of the legal order, whereas McCord is the uninformed disrupter of that order.[238]

The St. Louis and Wheeling engineers' voice upholds real-world science supplemented by man in control of technology by virtue of his character, skill, and training (rather than control by the self-acting mechanism). As practical men, the most important principle is that engineers have a duty to put the ideas of scientists to the test in the real world. The practical manifestation of a scientific idea should stand or fall "on its own merits" and not simply be granted authority as a useful practical invention because it is supported by the opinions and manipulations of interested parties (i.e., the inventor and his friends). Here we see the self-defined role of the practical engineer as "applied scientist," or technical arbiter of scientific knowledge as it is received from scientists. The engineers' words betray a sense that their perceived equal role in the development of practical scientific knowledge is not sufficiently acknowledged; they believe their positions should carry the same authority and respect as that of the "first men of the country" (scientists).[239]

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[238] Gouge's aforementioned quote is here repeated: "The Evans Safety Guard is a most useful contrivance. No fair experiment could be made of the law of 1852 unless they be generally adopted." 1855 2-21.

[239] The engineers' reports were solicited by Joseph Sweegar, Local Inspector at Louisville (sixth inspection district) (see 1854 11-7). To Gouge, who received them in Washington, the reports must have seemed unwelcome. The engineers' approach to testing science is a respectful one, but one that challenges the status quo. One is tempted to perceive a tinge of ambition in the report; the engineers appear to want to take over the scientists' role, as evidenced by a desire to conduct their own experiments. But this would be a misperception. The engineers' only wish is to assume the role of "cross-checkers" of science, and then to be respected and left alone in their judgments as they selectively apply scientific knowledge to their machines. They are too respectful of the institution of science and of scientists to usurp science, but they plead for an independent role as practical experts, which is in keeping with their tradition of shop culture. For Gouge, of course (as legal authority) the

The Gouge Memorandum: The Known versus the Unknown "But as a Cup of Water to the Ocean"

We shall first examine Gouge's memorandum, written in November 1856. Ostensibly, Gouge wrote this 6000-word memorandum for Supervising Inspector Davis Embree, in which Gouge defended the Evans safety guard and fusible alloy. The memorandum was in response to a recent letter of Embree's in which a local inspector at Saint Louis, James W. McCord, had criticized the safety guard, and in particular, the inconsistency of operation of the fusible alloy on which the invention was based. McCord noted that he had gathered accounts from some 80 steamboats. On these steamboats, the alloy used had melted at points that varied between 10 and 30 pounds per square inch pressure.[240] Gouge attacked McCord for basing his argument on the fact that the fusing point discrepancy was in pounds per square inch, not degrees, since fusible alloy was designed to react to *temperature*, not pressure. He pointed out that the alloy's fusing at different pressures testified to its usefulness rather than its disutility. He wrote:

> "These alloys are not intended primarily as indicators of <u>pressure</u> (as Mr. McCord seems to have supposed), but as indicators of <u>heat</u>… It is

disagreement will soon become a symbol of disobedience and intractability with regard to the authority of science and the legal establishment of the United States. This is what Gouge means when he states that "no fair experiment" can be made of the Act of 1852 without the safety guards.

[240] McCord: "I have… evidences of some eighty boats before me where these alloys have been applied, together with the evidences of many intelligent and observant engineers who have used them, that in every instance the fusing point has invariably shown a discrepancy from 10 to 30 pounds, and

most astonishing that so intelligent a man as Mr. McCord would have supposed that fusible alloys are of no use, because they melt under different degrees of pressure, according to the circumstances of their [sic] being a plenty or a scarcity of water in the boiler, in according to the circumstance of the steam being, or not being surcharged with heat. It is most astonishing that he should use as an argument against fusible alloys, that which is the chief argument in their favor."[241]

Gouge's point was that the alloy would fuse when the iron became red hot, and this could occur at a full range of pressures depending on the water level in the boiler. Gouge cited Haldeman's observation that in his experience, the same composition of alloy had fused at a 100-psi pressure difference depending on whether the water in the boiler was at a normal level or had dropped below the flues.[242]

Evidently, what had thrown McCord off was that a pressure number was stamped on the alloys, and the fact that the steamboat act had expressed the alloy requirement in terms of pressure (alloys applied to the inside boilers were to be "10 pounds greater

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not in one isolated exception have the results been anything like satisfactory; thus showing practically, and, I think, conclusively, that the results thereof are not to be trusted or relied upon."

[241] Gouge's emphasis.

[242] Evans remarked in his 1850 Treatise on page 10 that iron loses its tenacity at 570 degrees Fahrenheit. Gouge noted that at 349 degrees (presumably red-hot iron), the pressure in the boiler would reach 160 psi, the upper safe limit of pressure. Haldeman: "The great advantage of the Evans Safety Guard is, that it measures both pressure and temperature at the same time. I have seen it go into operation on a boat under a pressure in the boiler of <u>150</u> pounds to the square inch, <u>when there was plenty of water</u> while the boat was under weigh: and I have again seen it go into operation when the boat was lying to, under a pressure of not more than fifty pounds to the square inch: <u>but the water in this case had sunk below the flues</u>, upon the tops of which the tubes rested that contained the alloy; and the fire passing through the flues, consequently the heat was communicated to the alloy which raised its temperature to 360 degrees, and put the Guards into operation." Gouge's emphasis.

pressure than said metals on the outside boilers.") This misconception about pressure stampings had been poorly explained (or not explained at all) to the rank and file practical engineers and local inspectors, and it is little wonder that the error proliferated among even intelligent engineers such as McCord. It appears from this that only those practical engineers who corresponded regularly with the Franklin Institute, e.g., T. J. Haldeman, were familiar with Bache's and Evans's emphasis on heat in promoting fusible alloy.[243]

What was particularly distressing to Gouge was the effect of McCord's remarks in undermining the steamboat law. McCord had been active in lobbying the supervising inspectors for the removal of the fusible alloy requirement from the law. Gouge remarked that, "This provision of the law is just as positive as that to which Mr. McCord owes his office and his salary; and yet he would have the Board of Supervisors suspend its operation! We shall have a beautiful government indeed, if each subordinate officer enforces the laws, or leaves them unenforceable, according to his own practical views of their expediency." And the renegade actions by engineers also undermined the entire concept of a country ruled by laws: "Supposing, however, that the fusible alloys [in] use are regarded with disfavor by many

[243] "The objections which certain engineers make would carry great weight with them, if it did not appear that they, like Mr. McCord, had entirely mistaken the object in using the fusible alloys—in supposing them to be used primarily as indicators of pressure, instead of indicators of heat..... If Mr. McCord proved that the alloys prepared by Professor Booth melted and hardened at uncertain and widely different temperatures, he would have proved something to the purpose. Proving that the same parcel of alloy melts and hardens at different degrees of pressure, is proving nothing to the point. It is intended that the alloy should do so. It is desirable that they should do so. They are intended primarily as indicators of heat when it works at certain degrees; and only in a secondary sense as indicators of pressure." Emphasis in the original. This restates Bache and Evans's conception of the safety guard as a detector of excessive heat in the flue (to prevent flue collapse during the low-water condition) and heat as steady generator of steam pressure in the steam chamber (causing shell fracture and explosion).

engineers, that is not a sufficient reason for rejecting them. The very object of the law is to provide safe guards for life, which steam boat owners and steam boat officers would not provide without law." Thus, Gouge holds up the law itself as the fundamental safety device, because owners and officers will not provide safety on their own.

McCord represents the traditional practical engineer's perspective; instead of pushing the safety guard, he favors instead that the law concentrate on "boilers constructed of good iron and made in a good workmanlike order, with a sufficient amount of safety valves, and an adequate amount of [water] supplying apparatus, with a steam guage attached, to render the increase and decrease of the pressure visible, and a sober, decent, and competent engineer in charge, and him hold to a direct accountability for the correct and faithful discharge of his duties."

Gouge opposes McCord's statement that there had been a perfect safety record in the fifth inspection district since the time of passage of the Act of 1852 owing to conscientious engineers using traditional methods. Gouge thought perhaps luck was the operative reason for this success: "I remain in opinion with Mr. McCord that the freedom from accidents in the St. Louis district during the last year, has been chiefly owing 'to the unremitting attention of the engineers.' Yet I know not that their 'attention' as during the last year, been more 'unremitting' than it was in former years, and during those years many terrible calamities occurred. Not one of those boats on which these lamentable events occurred, was fitted up with Evans Safety

Guard. They may have been supplied with fusible alloys, but those alloys were not applied in a 'suitable manner,' but in such a way as to be disintegrated by the pressure of the steam."[244]

Gouge next objected to a move by the Supervisors to substitute traditional French fusible alloy plugs for safety guards. The Board of Supervising Inspectors had met in special session in Washington in April 1856 to consider Crawford's latest amendments to the Steamboat Act. Plugs of alloy or pure tin were now being proposed in lieu of devices operating on the pressure principle.[245]

Gouge expressed frustration with what he perceived as the retrogressive actions of the Supervisors: "If Congress can't come up with anything better, it

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[244] McCord's statement as quoted by Gouge: "In looking over our statistics in this district, you will find that during the year ending this day, that we have not had explosions, and but one death from the injurious escapement of steam, (and that caused by fright), and you and the public might naturally infer, that all this was owing to the protecting influences thrown around steam navigation, by these alloys and water guages; when I am satisfied in my own mind, that such an unexpected and happy result as this, is attributable to no such cause: but on the contrary, as a result of the unremitting attention of the engineers, accompanied by the fact that they are being held to a strict accountability for the faithful performance of their duties." Gouge reacted with indignation: "From what is here said, the reader might draw the inference that the steam boat law might be safely abolished, and the services of the Supervising and Local inspectors dispensed with. It is no part of my duty to contravert [sic] such an inference; at times I am tempted to think it a correct one ..... But I deny that the fusible alloy, when applied in Evans Safety Guard, or even when applied in his Safety Alarm, have 'nine tenths of the time been inoperative.' On the contrary they have, according to Mr. McCord's own shewing, been so "operative," as to prove an "annoyance" to the engineers—that is letting off steam when they wanted to keep it on in order to make a suitable display of speed in passing a town, or when the wished to beat a rival boat in a race."

[245] Benjamin Crawford's proposed changes affected 26 sections of the Act, covering not just boiler safety but also fire safety, thickness of boiler iron, and the administration of official oaths. Other amendments concerned inspectors' compensation, the hiring of contractors to remove snags (cheaper than having the government do the work), and a provision to bring tow boats under the law. Section Nine, the fusible alloy portion, was to be revised to allow the use of fusible plugs or rivets of pure tin. Fusible plugs were the same devices rejected in the 1830s by Bache. See Proc, April 16, 1856 session, special meeting of the Supervising Inspectors held in Washington D.C.

had better give over all attempts by legislation to protect passengers . . ." Because the bill specified another form of technology (plugs), it would effectively ban the safety guards. To Gouge, this was tragic because the guards had performed flawlessly.[246]

Gouge concluded his memorandum by stating that with regard to fusible alloys, the Act of 1852 had been imperfectly carried out. When applied in a suitable manner, the effort had been eminently successful. But the "enemies of the safety guard" were mobilized due to their fear of monopoly. "I have never heard such an outcry [against other patent inventions used on steamboats]," he wrote. In his closing statement, Gouge defended the government's brand of expertise that, in the face of the attacks by the inspectors, was slowly slipping away and whose pending loss he perceived as undermining the entire body of steamboat safety law. He cited as authority for his views a host of experts: "If I am in regard to the use of fusible alloys when 'applied in a suitable manner, and so as to let steam escape,' I have the satisfaction to know, that I am in company with many of our most distinguished men of science, with many of our most helpful steam engine builders, and with many of our most able engineers and other steam boat officers."

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[246] There were now hundreds of safety guards in operation on hundreds of boilers, he wrote, only four of which had blown up. Two of these were because the safety guards had been tied down. A fifth steamboat had blown up; it had been fitted with a "mongrel" device (presumably still operating on the pressure principle). Some steamboats blew up for unknown reasons, such as the *Thomas Haight*. There was still mystery attached to the science of steam, Gouge commented, and he quoted another writer that "All we know in comparison with the unknown, is but as a cup of water is to the ocean."

The Practical Engineers Weigh in on the Safety Guard—the St. Louis and Wheeling Reports

In the fall of 1854, at the same time Gouge and Crawford were contemplating the theft of a sample of alloy from Evans for Professor Booth, members of two steamboat engineers' associations stated their views to the Department on the subject of the Evans Safety Guard. The two communications were from Wheeling, Virginia (Crawford's District Seven), and from St. Louis, Missouri (Embree's District Five). Both reports provide insight into the associations' concerns and fears about the safety guard, the perceived professional status of their members, and their relationship to higher authorities (scientists, government officials, and "self-interested" parties).[247]

The presentation style of the two groups is quite different. In the case of the Wheeling engineers, we see a summary, unpolished criticism of the safety guards. The demonstrative manner of the writer, who lacks sophisticated rhetorical skills, betrays that of a common practical engineer. In contrast, the St. Louis engineers offer a more refined, persuasive, and well-articulated critical assessment of the safety

[247] The reports are mentioned in a letter from Local Inspector Joseph Sweegar, Louisville, to the Treasury Secretary, 1854 11-7. There may have been reports provided by the other western districts 4, 6, and 8, but if so, these do not survive. Sweegar noted that according to "some of the most experienced engineers on our western waters," the fusible alloys had "utterly and entirely failed." Sweegar's views did not stop with condemning the alloys; the Board of Supervisors was redundant and expensive, he wrote, and the new inspection service was completely disorganized. He called for a streamlined organization in which the Board should be eliminated and replaced with selected members of local boards from around the country. This central board would meet once a year with the Secretary, presided over by a figure who possessed "scientific attainments." The 1852 act was defective as well; Sweegar wrote that it was "objectionable and in need of amendment." The wrapper of this letter indicates it was transmitted to Gouge.

guards and fusible alloy. The writer has a more erudite, polished rhetorical style, and his careful arguments are designed to bring into doubt the scientific validity of the safety guard. He is a “gentleman engineer” of the type described by Calvert.

Let us begin with the Wheeling letter:

> “Gentlemen: The undersigned officers of the union association of Steam Boat Engineers of Wheeling Virginia—beg leave to report the action of our association on your communication of Aug. 24th 1854. In relation to the Government “Fusible Alloy” employed as a measure of Safety on Steam Boilers—our association appointed a committee of experienced practical engineers to which was committed your letter of inquiry—and after having carefully and patiently investigated the subject—report as follows:
>
> In answer to the inquiries made by the Steam Boat inspectors of Louisville Ky in Regard to the Government Fusible Alloy and its application as a preventative of Explosions in Steam Boilers—we are unanimous in saying so far as our experience and observation goes, it has proved a perfect FAILURE and an imposition on Steam Boat money. Most of the members of our association have used the fusible alloy on different boats—applied in different ways--and it invariably requires according to our observations a higher degree of heat to fuse

> the alloy the second time—on this last account we regard the alloy in every form in which we have known it to be used or applied to Steam Boilers as PERILOUS and UNSAFE—and NO SENSIBLE and CAREFUL engineer would for one moment risk his life or that of his fellow beings in such an agent to warn him of danger—we would therefore esteem it a wise measure to REPEAL that provision of the Law of Congress beginning the use of the fusible alloy on steam boilers. We should unanimously recommend the use invariably of the steam guage [sic] as an apparatus indicating with reasonable certainty the pressure of steam, and the water guage with a well adjusted OLD fashioned safety valve and try cocks as simple and efficient contrivances. That in the hands of SOBER, CAREFULL [sic], SKILLFULL [sic] and EXPERIENCED MEN AS ENGINEERS will ensure safety to life and property in steam boat navigation."[248]

Several points in this letter stand out: (1) the old criticism and prejudice from the 1840s persists - - upon multiple heatings, the alloys undergo chemical changes that alter their fusing points; (2) steamboat owners are involved ("an imposition on steam boat money"); (3) the safety guard is unsafe; safety is only guaranteed by the sober and careful engineer using old-fashioned devices and methods; and (4) the law enforcing the pressure principle should be repealed.

[248] Letter from "officers of the union association of Steam Boat Engineers of Wheeling, Virginia" to Messrs. John Livager and Rueben Dawson, "Inspectors of Steam" (local inspectors of machinery and boilers) at Louisville, Kentucky, 1854 9-25. Emphasis in the original.

Contrast this report with the careful reasoning style and erudition of the St. Louis Association of Steam Boat Engineers. Their report is "the unanimous expression and sentiment of… 280 steam boat engineers."[249] A committee of engineers begins by stating that they have given careful consideration to the subject of the reliability of safety guards, that their duties require them to occupy the post of greatest danger, and that "consequently, they ought [to be] the first to hail with pleasure" any device that will relieve them of danger. For this reason, the public may be assured that the engineers will not unjustly criticize "any plan for safety that can be relied upon for the prevention of steam boiler explosions." The engineers observe that because of the Act of 1852, their qualifications are now bound up in the public weal: "the rigid examinations [we] are now subject to under the law of the United States is a guarantee that [our] moral as well as professional character claims for their views the unprejudiced judgement of [our] fellow citizens." (See Fig. 38).

The engineers discuss the supporters of the safety guards; these are the inventor and "friends" of the device. These parties base their confidence in the guards on two points, the "supposed certainty of their operation," and their "capacity to act independently of the engineer." The engineers observe that the independent action of the guard appeals to the public and to this they claim to lodge no objection in principle. But if the character of the steamboat engineer were as "reckless as it was

[249] 1854 10-2, "A Report on Fusible Alloys and Safety Guards Made to and Adopted by the Saint Louis Association of Steam Boat Engineers." IMG 1149-1166, D18.

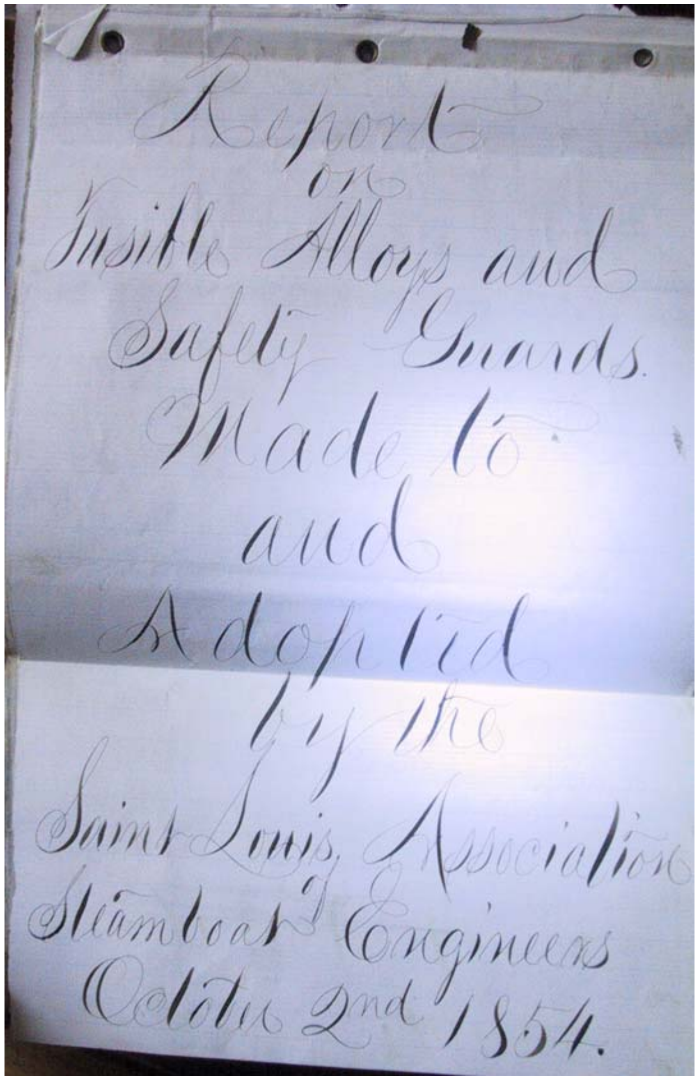

Figure 38. Saint Louis engineers' report cover, 1854.

once supposed to be," they argue, the public would be justified in requiring such a self-acting mechanism on every steamboat boiler. With regulation, they state, engineers are now held accountable by a rigid examination and licensing process. Therefore, the requirement for a self-acting mechanism is unjustified:

> "…we have cheerfully submitted to the laws of Congress, and with a full knowledge of the high responsibility they impose upon us, and of the pains and penalties to which we subject ourselves for any disaster that may result from our negligence or incapacity, we still offer ourselves as humble instruments in promoting the prosperity of the public interests, by the safe transportation of persons or property. We do not present this as an argument against the Fusible Alloy Safety Guards. It is our purpose to investigate them upon their own merits, but we think it a favorable opportunity to defend ourselves against some of the claims which their friends present for the purpose of securing public approbation."

On the point of the supposed certainty of the safety guard's operation, the engineers state that the device is flawed and is not what it is represented to be. The engineers protest its being thrust upon them under false pretenses (i.e., with false claims that it is reliable) to which they "as good citizens and honest men" ought not to be subjected.

> "We are not enemies to the inventive genius of our own or any other country. We sincerely hope that if there has not been, there may yet be, discovered some guard or protection against explosions. All we ask of those who presume they have realized the happy conception is to present it to the Engineers and the public upon its merits and not seek to give it an importance by reflections or imputations upon the former, or by improper appeals to the feelings or fears of the latter."

The engineers use the remainder of their communication to attack the metallic alloys that are the heart of the safety guard, claiming that the chemical complexity of such alloys calls for a more thorough investigation and verification process, "before any reliance should be placed upon [them] for so important a purpose as a safety guard for steam boilers." The engineers understand that the Achilles Heel of the alloys is the precision of their melting points; without a precise thermometer as Bache had envisioned, the safety guards are useless at best, and misleading and dangerous at worst.

The engineers demonstrate that the composition and characteristics of fusible alloys are not well understood by scientists. Thus, precise melting points have not been achieved for these types of metal. Evidence that this is so has been provided by a Navy commission in a series of experiments. They elaborate: (1) not all metallic alloys of a given composition are always fusible at a given temperature; (2) scientific authors differ as to the point of fusion of the metals commonly used in making fusible alloys; (3) alloys are inconsistent when manufactured by different persons and institutions; (4) because of impurities, inconsistency is common, and repeated firings of the alloy yield inconsistent results over time; (5) mechanical injury likewise can alter melting points; (6) on the molecular level, the alloys are intrinsically defective and cannot be made uniformly reliable because they do not melt in the manner of a homogenous metal but rather as self-contained cellular structures; and (7) it has been demonstrated that French safety rondilles (plugs) did not work, so why should supporters expect fusible alloy safety guards to fare any better?[250]

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[250] The erudition of the St. Louis engineers is evident in their arguments. On Points 1 and 2: ". . . scarcely any two [scientists] operate in their experiments in exactly the same way, and with the metals in the same state of purity, aggregation, &c. How then, are we to expect that alloys should be more uniform in their results? Point 3: "Experience has shown that fusible alloys made by different persons, with the same proportion of elementary metals do not always fuse at the same temperature . . . . If left to private citizens little reliance could be placed upon their uniformity and he or they who would supply the best could only be relied upon as long as it was his or their interest to give proper attention to the preparation." (This appears to be a direct attack on Evans as monopolistic private producer). Point 4a: "metal . . . may be very seriously affected . . . by the admixture or combination of a very small percentage of foreign matter ..... Point 4b : "Nor can we be always sure that the alloys . . . will always melt at the same temperature even for the second and third time, unless we can have some assurance that the original elements of which they are composed are always in the same state of purity, and perhaps, the same process always used for uniting them." Point 5: "It is well known that metals may be generally modified in their physical properties by very slight causes, as for instance, iron in its softest, most fibrous and ductile condition, may by simple percussion be converted into a crystalline, brittle state, in which it looses [sic] so much of its original tenacity, as to become dangerous to be used for many purposes to which in the former state it was adopted. The breaking of rail-road car axles has been frequently attributed to this cause . . ." Point 6: "[alloys] do not melt in the manner of a homogeneous metal as has been supposed, 'in fact, the more fusible metal melts in the minute cells of the less fusible metal long before the whole mass becomes liquid.' ..... This process is well known as liquation or elignation . . . ." The engineers quote a prominent engineer-scientist in England "to show how vague is the information even amongst scientific men on the subject of the fusing point of alloys....." "Experience has established no law by which we can say a priori, from the knowledge we have of the melting points of each individual metal, at what point certain combinations of these will melt." Point 7: "This whole thing of fusible alloys as safety guards, has been a deception and a failure . . . . Pr[ofessor] Ure, in his Dictionary of Mines & Manufactures says, the employment of fusible metals or safety rondilles, to apertures in the top of steamboilers, has been proposed in France, because they would melt and give way at an elevation of temperatures under those which would endanger the bursting of the vessel, the fusibility of the alloy being proportioned to the quantity of steam required for the engine. It has been found, however, that boilers apparently secured in this way, burst while the safety disc remained entire . . . . we know that on the Western Waters, where this mode of protection has been urgently pursued by those interested, that numerous explosions have taken place, with the best machines or devices that have yet been used."

Although they admit they are not scientists, the engineers assume for themselves the role of practical men who take theoretical knowledge and make it useful. In this sense they view themselves as applied scientists. They write: “It is not to be expected that we should treat [the fusible alloy issue] in a thorough scientific manner. We profess to be practical men availing ourselves of the knowledge which scientific men develop and applying it to practice and useful purposes.” Although they admit they are consumers of the experiments and productions of scientists, the engineers are careful to preserve their critical faculty with regard to the output of science. They demonstrate that the scientific work on fusible alloys is inconsistent and incomplete. They do not seek to indict science or scientists; on the contrary, they see much value in the work of these men. Rather, the problem in the case of fusible alloys is that the scientific knowledge is new and incomplete, and the outsiders - - the inventor and enthusiastic “friends” - - have blurred or glossed over gaps in that work. These parties are acting in their own self-interest to push the safety guard with the public when the research has not been completed or agreed upon by scientists and engineers.[251]

[251] The engineers explain that in the area of metals, scientists are more familiar with iron. Iron has been studied extensively, has been applied in the world, and offers a large knowledge base to the researcher or engineer who wishes to use it. Fusible alloy has not been the subject of such intensive investigations and thorough understanding, and therefore requires more circumspection.

We may surmise from the engineers' statements that inventor Evans is perceived as disrupting the natural process of knowledge creation and transfer: (1) knowledge is to be created by the scientist and from thence it descends to the engineer; (2) the engineers subject it to debate and refinement through study and practical trials; and (3) after these trials, the engineers adapt it to useful application. Those in power (government officials perhaps, certainly the inventor and friends pushing the safety guard) appear not to have recognized the process. It is a process that they, the engineers, claim for themselves as technological arbiters. The engineers believe passionately in the role of science (and wish not to attack scientists' authority; for example, regarding scientists' own doubts about safety guards, they write, "…if we have to regret that they did not avow their doubts in stronger language, we should at least be thankful they have left us no necessity of combating authority in pulling down what cannot sustain itself on its own merits"). They state that they would conduct their own experiments if they could afford them; in this they tacitly acknowledge that they are on a par with scientists, but that they do not see this as their ordinary role. Rather, engineers are specialists who critically examine the output of scientists and translate it (with a critical thought process) into practical inventions. Hence the innovation of the shops, which rely on scientific texts as a source of valuable information, and the engineers' dread of inventors' monopolies, which stifle innovation.

In analyzing the engineers' "flow down" theory of science and technology, however, Layton stated that "This model is not so much false as misleading. It assumes that science and technology represent different functions performed by the same community. But a fundamental fact is that they constitute different communities, each with its own goals and systems of values."[252] There are two possibilities, therefore, in explaining the perception by the practical engineers' of their role: (1) They believed in the science-engineering symbiosis theory, although they did not realize that both were separate institutions with separate cultures, or (2) In the 1850s, science and technology were not as separate institutionally as they are in modern times. Evidence for the second explanation might be found in the close relationship of engineers and scientists in sharing knowledge in lyceums and in the shops (e.g., employment of practical engineers in the Franklin Institute studies of the 1830s.) However, we underscore the first explanation as the best. Based on the source material, we know that scientists and engineers operated within their own communities, with their own "goals and systems of values," and this separation is in the main what caused the conflict over the safety guard.[253]

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[252] Layton, Edwin: Mirror Image Twins (1971), p. 565.

[253] The practical engineers' axiom that an invention must sustain itself on its own merits appears repeatedly in the engineers' writing, and the same concept can be found in Evans's earlier 1850 Treatise (it is clear from this source that Evans considered himself first and foremost a practical engineer, and thus an "applied scientist.") This is informative because it points out the engineers' strong belief that science and engineering are a quest to establish objective facts and relations from nature, and that scientific authority of itself should not enter into judgments about technical merit. As Alan G. Gross pointed out in regard to such authority, "The progress of science may be viewed as a dialectical contest between the authority sedimented in the training of scientists, an authority reinforced by social sanctions, and the innovative initiatives without which no scientist will be rewarded . . . [but] at times, the effects of scientific authority can be stultifying." Gross, Alan G.: The Rhetoric of Science (1990), p. 13. The engineers' was an oversimplified belief, to be sure, because the engineers held to their own systems of authority (i.e., those of the associations, and of shop culture). However, the posture that inventions must speak for themselves in justifying their existence did allow the engineers to undermine--or at least question--scientific authority with regard to the safety guard. They effectively used the writings of scientists themselves to make their case. For example, the engineers skillfully quote from Booth's own report: "Since the fusing points in most of the alloys is very uncertain, and cannot well be determined within many degrees, there should be a wider limiting range of pressure allowed for high pressure .... If we understand Prof. Booth, he means that although alloys are so inaccurate at the fusing point of high pressure, they should be used, though they do not

The engineers conclude with a plea to the Government to at least make the alloy in a consistent manner and protect them from Evans's monopoly:

> "Finally, Mr. President and gentlemen, after having given this subject our most careful consideration, and after having proven our opinions by many years experience as practical engineers during which we have had the most ample opportunity of determining the value of alloy safety valves, we have arrived at the candid conviction that they are useless to the Engineer, and of no protection to the traveling public…. In conclusion, permit us to say that if the Congress of the united States shall still insist upon the use of fusible alloy safety guards, we respectfully ask that it will cause such investigation to be made… as will insure them to be uniform in operation and satisfactory in their results… and that the mechanical device, by which the alloy may be applied be left open to the inventive genius of the Country…"

4.6 The Engineers' Rebellion Comes into the Open, 1859

After Professor Booth suffered a decline and cessation of orders for government alloy in early 1857, two more years passed with little or no activity in the Philadelphia Mint's laboratory. In February 1859, the steamboat *Princess* exploded at Port

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indicate the exact pressure to which our steam boilers are by law subjected. It is scarcely necessary to say, that such an application of them would be entirely useless, as they would not accomplish the object for which they are applied."

Hudson, Louisiana, in which "scores" perished. The *Princess* had been considered one of the safest by thousands of the boat's habitual passengers. Haldeman was astonished at the fact that this hitherto safe boat exploded with the "large and approved" Evans guards on each of her boilers.[254]

In April, Booth wrote the Treasury Secretary wishing to be relieved of the duty of manufacturing the alloys "since they are an unnecessary expenditure and a Supervisor has informed me that it has been determined that the alloys are no longer to be used."[255]

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[254] The *Princess* exploded on February 27, 1859; the second engineer died and so could not be prosecuted. Haldeman guessed that the safety guards had been tied down, but the explosion damage was too extensive for the local inspectors to determine this. See "Report of the U.S. District Grand Jury," reprinted in a newspaper whose banner was clipped off by the filer, and no date, but probably in the spring of 1859 (see 1859 3, D48). The grand jury's findings were that the boilers exploded due to low water, that the chief engineer had employed a second engineer who had been known for carrying high steam and suffered the Evans's guards to blow off steam on two separate occasions (indicating a low water condition), and that the chief engineer had not reported recent patches made to the shell of the boiler (thus, inspectors were not aware of the repairs and so had not hydrostatically tested the boilers after the repair). In addition, the captain bore some culpability in not supervising his engineers more carefully. See 1859 3-12 (local inspectors take testimony); The other steamboat that exploded at about the same time was the *Panola*: Crawford prosecutes that boat's engineer Buffington, who pled guilty and was fined $200 for a misdemeanor after being threatened with 18 months in prison, 1859 3-16; 1859 4-8; Haldeman's observations on the explosion, 1859 9-12 (D46); Booth testifies, 1859 5-3; Booth on forensics, 1859 7-7; Crawford approves Booth's new ladle design following discovery of faulty melting points of alloy in the case 1859 7-12; Crawford: "The inspectors and river men are all lately against the safety guards. The Buffington Case will bring them to their senses."1859 12; official report of the accident, 1859 *Proc*, pp. 54-55 (IMG 1458); and 1861 or 1862 (date uncertain), author unknown, but Booth forensic analysis attached, in which he cites his experiments to prove the fusing points of the alloy in the case. The public testimony of Booth, if it followed this letter, appears to have contradicted Crawford's correspondence 1859 7-12 in which the ladles are implicated in contributing to the explosion. Evans's safety guard had been in use on the *Panola* for one year.

[255] 1859 4-6. Five days later, Crawford placed a large renewal order for 900 pounds of alloy with Booth. "This is by far the heaviest order we have received," Booth wrote, 1859 4-11. He cited details of reopening the business, but by July there was only one man making alloys ("he is slow but trustworthy.") Crawford's order appears to have been the final one for new alloy. The timing of this order, occurring at the same time that Crawford was pushing for the prosecution of engineer Buffington in U.S. District Court, is suspicious. Crawford had tried "strenuously" the previous fall to have the Steamboat Act amended to strike the requirement for fusible alloy, but his actions were rebuffed by the Department. The renewal order may have been an indication that Crawford was trying to reverse his policies in order to get back in the good graces of the Secretary. See 1859 12-8, in which Ross notes Crawford's strenuous efforts to abolish the alloy requirement.

This latter statement that the Supervisors were ceasing use of the alloy (and thus the safety guards) must have been surprising news to Gouge and Treasury Secretary Howell Cobb, especially in light of the explosions of the *Princess* and *Panola* earlier in the year. Supervisor Crawford's "strenuous" attempt to abolish the use of the safety guards at the October 1858 annual meeting of the Supervising Inspectors had backfired because, according to Crawford, "the patent of Mrs. Evans would soon expire." The exact meaning of the relationship of the expiration of the Evans patent expiration to the persistence of the safety guard remains a mystery. However, aside from this complication, it is clear that the Department did not want to part with its key safety invention at any rate.[256] With pressure from local inspectors—backed by owners—primarily in Districts Five and Six (Embree, St. Louis; and Shallcross, Louisville) as well as parts of Crawford's District Seven (Wheeling), the Department began to perceive the trend toward dismantling the law that sustained the safety guards.[257]

[256] It appears the timing of the expiration of Jane Evans's (Cadwallader Evans's) patent with the action of the Board of Supervising Inspectors may have prompted intervention by the Department to defeat Crawford's initiative. Another factor was that the passage of Crawford's resolution was expected to endanger his bill containing revisions to the 1852 Act, which at that time was before Congress. Crawford noted that the bill "if passed, [would] have all the desired effect of the resolution." 1859 12-8. The attempt to scuttle the safety guards was made again the following year, and defeated once again for the same reasons. The sponsor of the second attempt was Supervisor Charles W. Copeland, Second District.

[257] Behind the trend lay the long history of engineers tampering with or scuttling the guards, documented herein. Much circumstantial and some direct evidence testifies to the wholesale rejection, sabotage, and lack of support by rank-and-file engineers and inspectors toward the safety guards from the time of their introduction on the western rivers: prejudice of numerous engineers toward Evans's invention, plus witnessing of tampering, referenced in Evans's 1850 Treatise; Crawford admitting to Secretary Cobb in 1859 that the supervising inspectors, local inspectors, and river men were all against the safety guard due to the unreliable alloy, 1859 12-26; Crawford's earlier moves to get the law changed to exclude the requirement for fusible alloy, 1859 12-8 and Proc 1858 10-18; owners' and engineers' fear of Evans's monopoly 1854 5-23 and others; Jane Evans's letter that the local inspectors were letting steamboats leave port without Evans safety guard, 1854 10-19; Jane Evans's agent

Secretary Cobb Reacts

With Gouge and Secretary Cobb thus on a hair-trigger over the Supervisor's plans to dismantle the Steamboat law, the final straw came in the late summer of 1859. In the previously described case in which Supervising Inspector Charles Ross of St. Louis barred entry of the wayward engineer Robert Hood on board the steamboat *City of Memphis* (Hood had been found carrying too much pressure in his boilers), a fellow engineer on the same boat, Daniel Bloys, had filed a tit-for-tat grievance against Ross. Bloys's affidavit alleged that Ross had expressed contempt for the safety guard, instructing Bloys to "pour the damned thing full of lead."[258]

Ross denied the charge that he made the statement to Bloys, but he provoked the Secretary when he revealed his low opinion of the safety guards. He made all of Embree's former arguments, that the guards were "an unnecessary expence [sic] on our Steamers and of no utility," and that "the Supervising Inspectors at their next convention would probably abolish their use." Ross went on, "I advocated the abolishment and use of these so called safety guards, and gave as my reasons that these guards were attached to every high pressure passenger Steamer boiler that had exploded in the West in the last four years, and none of them had given the required

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Oglesby noting cases of wired-down safety guards, 1859 4-4; a supervising inspector reported instructing his inspectors to sabotage the guards, 1859 9-21; Haldeman's observations that steamboats had exploded with wired-down safety guards intact; Buffington's prosecution over tampering, 1859 3-16; Local Inspector Grace's comment that the safety guard "loses its character by neglect of the engineers or being so tampered with as to prevent its telltail [sic] operation," his belief in the efficacy of the alloys, but "the bitter prejudice of river men prevented its usefulness," 1862 1-17; the engineers favoring plugs over safety guards; and many others.

alarm, and that I believed they had been the chief obsticle [sic] to a healthy enforcement of the law in the West." Ross also noted in a postscript that nowhere in the law was Evans Safety Guard mandated:

> "The words 'Evans's safety guards' are not found in either the Steamboat law or Acts of the Supervising Inspectors. To find the meaning of them, see Proceedings of Supervising Inspectors Washington City 1854, Page 90. And Crawford's resolution (which I supposed was not published) Buffalo 1856, Page 12-13. What was said and done on this subject this year at N. Orleans I think will not be published."

Ross's statement was true. The language of the Supervisors' resolution of April 1854 had been carefully framed so as not to inflame the engineers and local inspectors by specifying Evans's safety guards. Now the imprecise language had come home to roost for the Department.[259]

Treasury Secretary Cobb responded to Ross's letter within the week, addressing his response to Supervisor Burnett in Boston and copying the correspondence to all the Supervising Inspectors (except Ross himself). He

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[258] Bloys's affidavit, 1859 9-21.

[259] In making his case, Ross refers to the April 1854 special meeting, as noted on page 90 in the annual Proceedings, concerning the passage of the resolution that mandated the pressure principle. The resolution craftily left open which mechanisms could be used to meet the requirement of isolating the fusible alloy from the pressure of steam, and was undoubtedly Crawford's and Embree's doing.

expressed his displeasure with the independent actions of the Supervisors in the matter of Evans Safety Guard:

Sir,

Sundry charges have been preferred against Charles Ross Esq., Supervising Inspector at St. Louis. Among other things, one witness alledges [sic] that he, the said Ross, “mentioned Evan's Safely Guards--what an absurdity they were, and said at the next meeting of Supervising Inspectors, they were going to abolish them altogether, and that they should not go on boats any more. He also enquired [sic] of one, if ours gave us any trouble, and said if it did, to run the damned thing full of lead.”

In his reply to this charge, W. Ross says, “he has no recollection” of such a conversation, but he may have made the remark that Evan's Safely Guards “were an unnecessary expense on our Steam Boats, of no utility, and that the Supervising Inspectors at their next convention would probably abolish their use.” W. Ross makes many other remarks to the same purpose, all apparently founded on the opinion that the Board of Supervising Inspectors have full power to do just what they choose.

The Steam Boat law gives great power to the Supervising Inspectors, but no power to repeal <u>any</u> provisions of the Act of August 1852, or any other act of Congress. The Supervising Inspectors have power to make rules and regulations, but those rules and regulations should be such as are adapted to carry into effect the provision of Acts of Congress--not to defeat them.

The Act of Congress of August 30th 1852 provides, among other things, for the use of "fusible alloys" in such a way as "<u>to let steam escape</u>." Of the [illeg] of this or any other provision of the law, the Supervising inspectors are not judges--theirs is to see that this, and all other provisions of the act, are carried into effect according to their true sprit. We shall have anarchy instead of regular government if each subordinate officer undertakes to enforce the laws, so far only as, to himself may seem expedient. The Supreme Court of the United States has power to decide on the constitutionality of laws, but not in their expediency. From W. Ross' letter, it appears that he, and at least a part of his fellow Supervisors, suppose[s] they have more power than the Supreme Court professes.

If any contrivance can be found which will better than Evan's Safety Guard fulfill the requisitions of the law, in regard to the use of "fusible alloys," so as "to let Steam escape," that contrivance ought to be adopted. Thus far the Supervising Inspectors have full power over the subject, but they have no power to dispense with the use of fusible alloys, or with their use, in such way, as, "to let Steam escape."

If the Supervising Inspectors believe that the use of fusible alloys, in any way and every way, is useless, it will be perfectly correct, in them, to make a specific report on the subject to this Department in order that the same may be laid before Congress. But so long as the law remains in its present form, it is their duty to enforce this and all other of its provisions, according to their true spirit and intent.

Very respectfully,

Howell Cobb,

Secretary of the Treasury[260] (See Fig. 39)

Responding to the Secretary's admonishment, the Supervising Inspectors now felt compelled to defend their positions on the safety guard. Caught in an uncomfortable middle ground between their own local inspectors and the Secretary, they responded with carefully measured words. Under the microscope, all now were careful to uphold the legal provision in question. However, signs of reservations about the fusible alloys and the Evans Safety Guard appeared through the carefully crafted rhetoric.

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[260] 1859 12-19, p. 401 of the NARA bound volume; B7. Emphasis in the original. Gouge almost certainly drafted this letter for the Secretary. The reply bore Gouge's unmistakable syntax, choice of words, and lecturing tone. The Secretary mirrored Gouge's thought and language almost verbatim. For example, note the wording in Gouge's internal notes of November 1856, in which Gouge chastised Inspector McCord: "We shall have a beautiful government indeed, if each subordinate officer enforces the laws, or leaves them unenforceable, according to his own practical views of their expediency." (1856 11, Vol. 6, Item 64). Contrast these words with Cobb's sentence above: " We shall have anarchy instead of regular government if each subordinate officer undertakes to enforce the laws, so far only as, to himself may seem expedient." (1859 12-19). Another example from an earlier Gouge letter: ". . . the power to make rules and regulations is confided solely to the Board of Supervising Inspectors," 1855 2-21. Cobb's words above: "The Supervising Inspectors have power to make rules and regulations . . ." (1859 12-19).

Figure 39. Treasury Secretary Howell Cobb. Cobb upbraided his inspectors in 1859 in regard to laxity of enforcement of the pressure principle and the Evans safety guard. His efforts were to no avail. In 1871 the steamboat law was changed to allow tin plugs in steam boilers.

Supervising Inspector John S. Brown of Baltimore (Third Inspection District) stated that fusible alloys had given his district no trouble because there were few high-pressure boats there. “We are duty bound to enforce the law regardless,” he wrote. John Shallcross, Supervisor of the Sixth Inspection District, and the man who originated the idea of substituting plugs of pure tin for fusible alloy, agreed with the Secretary that the Supervisors had no power to change any provision in the law, and that Evans’s safety guard was the “best mode of using the alloy now known.” Objections by engineers in his district were numerous, however. The problem was with the “imperfect manufacture” of the device (implying that in principle the guards were fine). The imperfection resided in the alloy. With such imperfections, the safety guard would not be a “true and reliable indicator” of safety. The best solutions were still the qualifications and practices of the personnel running the engines. For safety purposes, “the engineers have the steam guage and safety valves,” he wrote.

Supervising Inspector Charles W. Copeland of New York (Second Inspection District) noted that formerly an unnamed member of the Board (this was almost certainly Embree) had a “difference of opinion” on the subject of the alloys but was overruled by the majority. Copeland did not hide his distrust of the alloy; they were “a source of trouble and anxiety” to him. There were “constant complaints” that the alloys did not act as designed. He doubted that the alloys worked any better in the absence of pressure than in the presence of it (Gouge must have recoiled at this repudiation of the pressure principle). He closed by volunteering to aid in experiments leading to a more reliable method than employing the alloys.

Crawford, in the Seventh Inspection District, Pittsburgh, waffled between opposing the safety guard and touting the party line. He noted that the supervising inspectors, local inspectors, and river men were "all against the use of safety guards." Agreeing with Copeland, he believed the unreliable alloys were the problem. He admitted that he had had much difficulty enforcing the use of the alloys; there were constant complaints that they "fused at far less pressure than allowed by their certificates." The sympathetic local inspectors had repeated these complaints. Crawford noted dissent in the St. Louis district. Local Inspector James H. McCord, boiler inspector there, had requested the Board of Supervising Inspectors suspend the provision of the law relating to alloys. Supervisor Embree, who was Charles Ross's predecessor at St. Louis, had not enforced the provision in that district; this made it harder for Crawford to enforce it in his. Recent accidents, however, had brought the Supervisors to their senses. Crawford argued that successful prosecution of the engineer of the *Panola* had made an example of the offender and this had had a beneficial effect. As experience revealed that a number of steamboats had exploded with guards installed on them, Crawford noted that he had been desirous of a change in the law, "but still I upheld the law." He went on to write that since Buffington's prosecution there was scarcely a complaint now against the safety guards. Booth had even changed his mind regarding the efficacy of safety guards with his forensic testimony in the Buffington case. Now all that was needed was to make the safety guards tamperproof. Commenting on the ninth section of the law, Crawford wrote, "I should regret to see the provision of the law regarding the use of alloyed metals changed," Crawford wrote.

The last letter received was that of Supervising Inspector William Burnett of Boston (First Inspection District). Burnett admitted of little experience with the safety guards in his district (these were mostly low-pressure steamboats), and he was not aware of any of Ross's statements regarding sabotage of the safety guards. The law was clear, however. The safety guard's "exclusive use" was "demanded substantially by a resolution of the Board passed at Washington in 1854." The Board could repeal that provision "if use should prove to be improper," he wrote, but he believed the Board still thought the safety guard effective. As far as is known, no letters were received from the other districts.[261]

[261] Letters in the NARA RG 41 records as follows: Robert Hood and Daniel Bloys sworn statements, 1859 9-12 and 1859 9-21 respectively; Ross defends self to Secretary Howell Cobb, 1859 12-8; Cobb's reply, chastisement of Ross, 1859 12-19; Supervising Inspector Brown's letter, 1859 12-21; Supervising Inspector Shallcross's letter, 1859 12-24; Shallcross as prime mover in "ridiculous idea to substitute block tin for fusible alloy (i.e., Haldeman's letter to Gouge), 1859 4-8; Supervising Inspector Copeland's letter, 1859 12-24; Supervising Inspector Crawford's letter, 1859 12-26; Supervising Inspector Burnett's letter, 1859 12-26.

4.7 Epilog: The End of the Safety Guard and the Clouds of War

The safety guards were dead. By the time of the next revision of the Steamboat Act in 1871, we know that they were no longer in use and that Supervising Inspector Shallcross had moved to replace the fusible alloy requirement with plugs of pure tin. The death of the safety guard can be registered sometime in the early 1860s. We have a letter, for example, from a hull inspector to Gouge in 1862 in which the inspector noted that "the safety guard loses its character by the neglect of the engineers." The inspector wrote that the "bitter prejudice" of the river men prevented the usefulness of fusible alloy. He concluded that the engineers "are jealous and conceited, view any device as an infringement of their rights, a slur on their own knowledge or practical skill. I worked with them on the river for 22 years and I know them well."[262]

Even as early as January 1861, informed that the ninth section of the steamboat act was being rewritten to make fusible alloy optional, Jane Evans roused her agent to urge Congress to reinstate the alloys, which had fallen from grace with the vast majority of inspectors and engineers. "In the name of suffering humanity, let's have them!" the agent wrote.[263] But it was too late; the device had been defeated first at the lower levels of the inspection service, among the engineers and local inspectors,

[262] 1862 1-17, Vol. 4, Item 21.

[263] Jane Evans's agent to Mr. Bigler, 1861 1-28. At this time, orders to Booth were spotty, and he only provided alloy to Pittsburgh (Jane Evans's locale) and New Orleans. This alloy was issued from Booth's old stock (i.e., from Booth's old 1855 batches).

supported by the steamboat owners, and then by the powerful Supervising Inspectors. The Department, hamstrung by its own legal strictures, and by its lack of real power over the districts, was forced to admit defeat by taking a neutral position.

The Civil War and the Steamboat Inspection Service

Much of the safety guard controversy was shoved in the background with the advent of the U.S. Civil War, although serious accidents still occurred.[264] Patriotic inspectors such as J.V. Guthrie resigned his post in April 1861 to join a regiment. Benjamin Crawford assumed Guthrie's inspection duties in what Guthrie supposed would be a short three-month war. As time wore on and Guthrie wrote that he must postpone his return, Crawford asked to be paid for time spent doing Guthrie's inspection work. Inspectors who stayed home sometimes wrote effusive letters to the Secretary, a surviving example of which is provided below. The vignette was provided in February 1862 by inspectors of the third inspection district (Baltimore) praying to save the Union "in our little Basement Office, under the Collector's Room":

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[264] The worst steamboat disaster of all time occurred in April 1865 on board the steamboat *Sultana*. 1500 lives were lost when the Sultana's tubular boiler, which was in poor repair, became overstrained and exploded. The boat had been designed to carry a maximum of 376 passengers, but the captain packed 2000 additional returning Union Army prisoners on board. This excessive load was simply too much for the overworked boiler. See Hunter, SBOTWR (1949), p. 543.

Congratulatory

And now Hon. Sir, I desire to say that on hearing of the Glorious News, of the tremendous Victories of our Army and Navy, it makes my heart thrill with Joy. In the day of our Country's trial and at the Bull Run defeat, and when the Hearts of all men quaked with fear, In company with my Local Board, we bowed our knees, we humbled our souls in humiliation and prayer, here in our little Basement Office, under the Collector's Room, and implored the Great God to show mercy, and Save the Nation. And now We will rejoice and say Glory to God in the Highest and on Earth Peace and Good Will to Man. And next—Glory to our Army and Navy. And All Honor to the President of these United States. And All Honor to his Cabinet, and to the General in Chief. And highly to be honored is the honorable Salmon P. Chase and his Aids [sic]—for his long, continued, arduous labours in financeering and then providing for A Million people, An Army in the field— and Women and Children at home. Glory— Glory be to our Good and Blessed God. Glory be to our Country— Glory be to our Country's present Rulers in putting down this Wicked Rebellion. The Glorious Day Star from on high is brightening—and shining upon us..... And long, long may our Glorious Banner wave O'er the Land of the Free, and home of the Brave.

Yours with great respect, J. Nells.[265]

Further west, nationalist versus anti-Union passions ran hot among the inspectors as the long run of the Mississippi River cutting across both northern and southern states aggravated sectional strife. Directives for the purging of disloyal local inspectors from the inspection service began to issue forth from the Department in March and April 1862 in response to reports of disloyalty among the inspection corps. On the prompting of inspectors, the Department issued a requirement for all inspectors to sign a loyalty oath swearing to "support, protect and defend the Constitution and Government of the United States against all enemies, whether domestic or foreign." With the appearance of the oath, old inspection hands like Local Inspector Singleton of St. Louis found themselves threatened not over the old, familiar, technical proficiency matters but over political loyalty. Eight "citizens of St. Louis," probably pilots and engineers, petitioned the Secretary asking for Singleton's removal. He was aged, incompetent, and a "secesh," they wrote. He took the oath, the men continued, but "that is moonshine in our opinion." In reality, they complained, Singleton

[265] Guthrie desired to "save my country" and "sustain the government against the traitors," 1861 4-29. Short war, 1861 7-1. Crawford assumes Guthrie's inspection duties, 1861 12-21. Congratulatory letter (emphasis in the original), 1862 2-18.

advocated states rights and nullification. The critics went on to write that there were thousands of men like Singleton in their midst.[266]

While the inspection service was undergoing a cleansing of secessionist sympathizers, the Department concentrated on how it should fit in with the new military requirements of the U.S. Army. It began to reorganize itself to allow the quick mobilization of the steamboat fleet for troop and supply transportation needs of the western army. Hunter wrote that beginning in January 1862, "In addition to the immense forward movement of troops, munitions, and equipment, food and forage supplies of all kinds, draft animals, and livestock, there was a lesser return flow of wounded soldiers, prisoners of war, soldiers on furlough, captured equipment, and contraband goods ..... To handle this traffic the Federal authorities issued contracts and charters to large numbers of steamboats of all classes and even purchased and built many vessels for both transport and patrol purposes." The total number of steam vessels in government service under contract or charter at one time or another during

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[266] Assistant Secretary of the Treasury to Supervising Inspector Charles S. Stephenson, Esq., of Galena, Illinois: ". . . it would seem to me that those officers ought not to employ any Engineer or Pilot who manifests an unwillingness to take the Oath of Allegiance to the United States . . ." 1862 3-11, B2. Four inspectors (two of boilers and two of hulls) were listed as "disloyal inspectors" in a communication sent from the Treasury Secretary to the Supervising Inspectors of the respective districts. 1862 4 , B1. Supervising Inspector James N. Muller of the Third Inspection District noted that "Some pilots and engineers in charge of vessels chartered by the government are secessionists." He asked if he could summon these men before him to take the Oath of Allegiance. (1862 3-10). The oath Muller referred to read as follows: "FORM OF OATH Prescribed by Congress, August 6th, 1861: I _______ do solemnly _______ that I will support, protect and defend the Constitution and Government of the United States against all enemies, whether domestic or foreign, and that I will bear true faith, allegiance and loyalty to the same, any ordinance, resolution or law of any State Convention or Legislature to the contrary notwithstanding; and further that I do this with a full determination, pledge and purpose, without any mental reservations or evasion whatsoever; and further that I will well and faithfully perform all the duties which may be required of me by law.—So help me God. ________, and subscribed before me this _______ day of ________ A.D. 186_." See 1862 Proc, 1862 10-16, Proceedings title page, Civil War Loyalty Oath of 8-6-1861, annual meeting held at Philadelphia. IMG 1436-1437. Singleton as "secesh," 1862 2-5.

the war was 640. Together with railroads and military organization, the steamboats "formed the backbone of the service of supply that made possible the successful prosecution of the critical campaigns in the West, by which one part after another of the Confederacy was severed from the main body and brought under Federal domination."

We close with a note on how the western practical engineers contributed to the Union war effort. Hunter relates that they provided a vital service to the Union Navy through their conversion of conventional steamboats to "light drafts" or "tin-clads." These vessels were side and stern wheelers of the traditional western type that had been specially modified for war use. To protect passengers and crew from musket shot, the engineers added oak-plank and sheet-iron armor for the boats, lowered boilers and steam pipes to a less exposed position, and placed an armament of six to eight light cannon. With a light superstructure, these tin-clads had less draft than monitors, which could not negotiate the shallow western waters. Hunter noted that U.S. military commanders were impressed with the innovative, improvisational engineers: "Admiral David D. Porter commented admiringly that in the time that the professional naval engineers would have taken simply to make drawings and prepare for operations, these native mechanics had not only assembled materials and equipment but actually completed the job."[267]

[267] Hunter, SBOTWR (1949), p. 560n. Hunter's source: Official Records . . . Navies, Series I, XXV, p. 756ff, Porter to Welles, February 16, 1864.

4.8 Chapter 4 End Notes

Biographies of Selected Supervising Inspectors and Other Persons

Charles W. Copeland (1815-1895) was the first Supervising Inspector of the District of New York (the second district), was a prominent naval engineer and a founding member of the American Society of Mechanical Engineers. As a child in Hartford, Connecticut, Copeland learned the rudiments of machinery under the guidance of his father, who was engaged in constructing steam engines and boilers. Copeland took a course at Columbia College and in 1836 at the age of 21 became Superintendent of the West Point Foundry Association. In this post, he designed the machinery for the *Fulton*, the first steam war vessel constructed under the direct supervision of the U.S. Navy Department. In 1839, with the official title of naval engineer, he designed machinery for five more U.S. Navy ships. In 1841 he patented a low-pressure steam engine, and in 1850 he became superintendent of the Allaire works in New York City, where he designed and supervised the construction of numerous merchant steamers of the Collins Line. Two of these steamers broke transatlantic speed records. Also in this time period, he was a trustee with the New York Floating Derrick Company, which built floating derricks used to fit large machinery such as pistons, boilers, and masts to ships. The company also performed salvage work. Just before the Civil War, Copeland became the director and consulting engineer of the Norwich and New York Transportation Co. During the war, he adapted merchant vessels for service in the Northern blockade of Southern ports, and after the war until nearly the time of his death, he was engaged as the constructing engineer for the U.S. Lighthouse Board. Copeland died in Brooklyn, New York, in 1895. Copeland is listed as a patentee for at least two patents, one for an improved method of flooding and entering powder magazines (No. 6842; 1849), and the other for a stop cock (No. 6913; 1849). There is some controversy attached to Copeland. A Treasury Department letter dated October 20, 1857, charges him with corruption involving kickbacks in the construction of the U.S. Navy steamer *Niagara* (outcome unknown), see 1857 10-20 (B3). Biographical data are taken from: Johnson, Allen; and Malone, Dumas (eds.): Dictionary of American Biography, Vol. II, Charles Scribner's & Sons, New York, 1929, p. 423. Original source from which the DAB article was written: Trans. Am. Soc. Mechanical Engineers, XVI (1895), pp. 1191-92; and obituaries in the New York Tribune and Hartford Times newspapers dated Feb. 7, 1895. Second source: http://www.bobcat.nyu.edu. Third source (patents): http://www.rootsweb.com. Fourth source: Correspondence of the Steam Boat Inspection Service of the U.S. Treasury Department, NARA RG 41, 1857, containing letters detailing the corruption charges against Copeland.

John Shallcross (? - ?) was the first supervising inspector for the sixth district, Louisville, Kentucky. Shallcross was a native of Louisville, Kentucky who became an engineer and then a captain of steamboats. In the late 1820s, he was captain of the steamboat *Diana*, which won $500 in gold from the U.S. Postal Service for being the first steamboat to make passage from New Orleans to Louisville in less than six days (the *Diana* sunk in October 1834). He was also a captain of the *Grey Eagle*, and possibly of the ferryboat *Black Locust*, and the *Peytona*. Shallcross was appointed the first U.S. supervising inspector of the Louisville district in 1852 after becoming active in pushing for the original steamboat inspection laws in 1851. His district consisted of the Ohio River and its tributaries to above the mouth of the Kentucky River, with Louisville as headquarters. Shallcross seems to have been on a comfortable basis with Benjamin Crawford, who presided over an adjoining inspection district. Biographical data are taken from: U.S. Coast Guard site, Steamboat Inspection Service (Discussion), from: http://www.uscg.mil/hq/g-cp/history/h_Westernrivers.html. Steamboat data are taken from http://members.tripod.com.

Alfred Guthrie (1805-1882), a Chicago practical engineer appointed first supervising inspector for the eighth district, had designed and constructed the hydraulic works of the Illinois and Michigan canal. Before passage of the 1852 law, he conducted his own clandestine 16-month study on boiler explosions, spending $1000 of his own money and disguising his role as investigator aboard steamboats by pretending to be an ordinary passenger paying full fare. Guthrie summed up the results of his investigations in a pamphlet, reviewed by the Franklin Institute in 1852. Guthrie's results were in perfect accord with the Institute's 1836 report: "[Guthrie's] results are precisely in accordance with those before arrived at by Messrs Bache, Reeves, and others of the Franklin Institute committee."[268] In 1850, he had turned the knowledge he gained from his investigations into political currency by becoming a consultant to Senator Davis of the Commerce Committee, the member of Congress charged with

[268] JFI, Vol. XXIII (new series), 1852, p. 424.

drafting the 1852 legislation. Guthrie advocated Evans's safety guard from an early date as the most reliable mechanism for the employment of fusible alloy. Later, he qualified his acceptance of fusible alloy because of concern that although the alloy performed well in the laboratory, it did not work satisfactorily in actual river use (1853 12-15). During attempts to remove him from office in 1853 for political reasons, he noted that "Mr. [Benjamin] Crawford and myself are the only ones who have had the toil and trouble of [investigating boiler explosions] from the beginning." Regardless of his technical expertise, Guthrie served as supervising inspector for only a little more than a year before being replaced by Isaac Lewis. Guthrie's father, Dr. Samuel Guthrie, a chemist, was the inventor of chloroform and the inventor of percussion powder for firing cannon. Biographical data are taken from: NARA letter Item 256 in Vol. 2, spring 1853, and http://freepages.history.rootsweb.com/~dav4is/people/GUTH158.htm.

Benjamin Crawford (1809-1873; dates uncertain), first supervising inspector at Pittsburgh, was a key figure in drafting and administering the 1852 Act and promoting the safety guard. Little is known about Crawford outside of his numerous letters in the correspondence of the Treasury Department. He is listed as a mechanical engineer (M.E.) in one source and a foundry mold maker in another. There is a reference to a "B. Crawford" of Allegheny City, Pennsylvania (made a suburb of Pittsburgh in 1906) in the Carnegie Library of Pittsburgh's Science and Technology Department as the first citizen of the city to receive a U.S. patent. The patent was granted in 1844 for a steam engine condenser boiler (Patent No. 3,732). Reference to this patent number in the Catalogue of American Patents confirms the patentee as Benjamin Crawford. This source lists five other patents in his name: a water gauge for boilers (No. 8,787; 1852), a pressure gage (No. 8,797; 1852), a steam-boiler furnace (No. 7,051; 1859), a “hame” (No. 75,250; 1868), and a steam generator (No. 90,506; 1869). It is possible but uncertain that this is the correct Benjamin Crawford, but if he is the same person, he would have been actively developing inventions during a very hectic period discharging his duties as a high executive within the Treasury Department, which seems doubtful. There is no mention of inventions in any of Crawford’s letters in the NARA letters. There is also a Captain Crawford listed in a list of steamboats belonging to the Pittsburgh U.S. Mail Line (as captain of a boat named *Pioneer*, but it is unknown if this is the same Crawford. Moving on to the NARA records, we know that Crawford helped Senator Davis of the Commerce Committee write the act of 1852. Crawford was appointed supervising inspector of the seventh district at Pittsburgh in 1852 after serving as president of his steamboat engineering association. Crawford was a key player on the Board of Supervising Inspectors; he was instrumental in establishing and organizing the inspection service, serving on many important committees of the Board for nearly a decade, working assiduously in researching and drafting key amendments to the act of 1852. In his committee assignments, he led the way in introducing new areas of steamboat safety research such as fire protection. Commented one Charles Thaler of Crawford’s many talents pertaining to administering the 1852 Act, "No man in the Country is more able to elucidate [the SB Law]. He had so much to do with the law’s inception; he is its virtual author. Crawford has practical skill and theoretical knowledge, a man of integrity and justice. He is worthy due to not only knowledge but also his 'quasi-judicial discrimination." (1858 7-22). Thaler's praise of Crawford's administrative skills was not hyperbole; his considerable talents, tact, and slyness in shaping and coordinating execution of the act in the western districts come through clearly in his writings. However, the supremely organized Crawford had chaos in his personal life and was severely criticized by his own local inspectors for being "supremely ignorant" in technical matters. Critics charged that Crawford lived extravagantly, borrowed money irresponsibly, and hid his assets in his wife's name to shelter them from multiple creditors, some of whom lodged cases against him in court. In court papers, a victimized creditor wrote that Crawford skipped bail in his pending suit, pronouncing acidly that "a more dishonest, dishonourable, and ungrateful man lives not out of a penitentiary." Crawford's debt and credibility problems threatened his relationship with Treasury Secretary Howell Cobb. Cobb once noted that if Crawford were proved guilty on a particular unpaid debt charge, a case about which Crawford had apparently lied to the Secretary regarding the facts, he would "turn the rascal out." (1858 9-8). Crawford's debt debacles even insinuated themselves in his management of his inspection district; he was investigated for graft by the Department when it was found that he had instructed his local inspectors to reject certain unpatented lifeboats when he owed the agent of the patented article a sum of money. (Letter filed with 1859 correspondence, no date, See NARA RG 41, Box 1, Item 338, IMG 1507-1508). Of more serious import for the integrity of the inspection service, in 1859 Crawford stood accused by his own local inspectors of assorted serious charges: double dealing; violations of law; evasion of duty; technical ignorance; lying to the Secretary; distortion of facts and manipulation in regard to assorted steamboat accident investigations; and nepotism and graft in exonerating a guilty engineer and punishing an innocent one in the *Fanny Fern* case. (A complaint of thirty-five such deficiencies was lodged against Crawford by his local inspectors Dickey and Watson and published in their 70-page pamphlet on the explosion of the steamer *Fanny Fern* in January 1858). Apparently Crawford's more serious crime as far as the Treasury Department was concerned was that he belonged to the wrong party; he was a Whig in a newly formed Democratic administration. Crawford was accused of secretly supported Whig party candidates for inspectors' positions while pretending to be a Democrat; he was humiliated in a report to President Buchanan when loyal Democrats refused to certify Crawford as one of their party, accusing Crawford of "baseness and want of moral honesty" in disguising his Whig sympathies. The facts of Crawford's money, credibility, and corruption problems came to be used against him in a move to replace him with a Democrat as supervising inspector beginning in late 1858. Crawford was resilient, however. When he was replaced by Edward M. Shield in 1861, he found his way back into the inspection service as a temporary local inspector, filling in for an inspector who reported for duty with the U.S. Army. Removed once again when his temporary position became filled, Crawford may have regained his footing as a local inspector at Pittsburgh in 1862 (he requested the assignment but whether it came about is uncertain), and he was listed as a special agent in 1867. In 1872 and 1873 he appealed and was granted $15,000 relief by Congress for use of a patented steam blower. Clearly Crawford was a fixture in the inspection service, and a survivor as well, in light of the severity of the longstanding accusations against him. It is regretted that the author could find no portrait for Crawford; he must have had an interesting face. (Sources of biographical material: See *Scientific American*, February 14, 1857, p. 181; http://carnegielibrary.com/locations/scitech/ptdl/pgh/pathfind.html and http://www.history.rochester.edu/Scientific_American/vol1/vol/n004/coap.htm. On the captain of the boat *Pioneer*, see http://digital.library.pitt.edu. Many letters by Crawford appear throughout the NARA volumes and are too numerous to catalog here.)

[Supplemental Vital Data: According to information provided to the author in a genealogy forum by C. Henig, Crawford was born in 1809 in Port Chester, New York and died in 1873 in Pittsburgh. His father was a John Crawford of Port Chester, NY. Benjamin married Mary Armour (alternately spelled Armerer) from Morpeth, England. Crawford had sons (number not provided) who served in the Union Army and a daughter named Marion, whose husband was from Vicksburg and served in the Confederacy. Although genealogy information can be quite dubious due to the number of persons having identical names, the above-described person is the only Benjamin Crawford found by the author whose birth and death dates seem to reasonably correspond to the range of dates in the life of the Supervising Inspector. For example, in 1852, the above-named person would have been 43 years old, and the last record for Benjamin Crawford in the NARA records is February 10, 1873. Further research will be required to ascertain Crawford’s identity with certainty, however.]

Davis Embree (1787-1870?) was the first supervising inspector for the fifth district, St. Louis, Missouri. A Cincinnati brewer, he introduced steam equipment into the family brewery. Born in Pennsylvania into a family of iron founders from Tennessee, he moved to Cincinnati in July 1811 and married in 1813. He became city treasurer in 1814 and a trustee of the Lancaster Seminary in 1815. At this time he constructed a steam-powered brewery (possibly with his brother Jesse). He was a well-known Quaker in Cincinnati, and one source claimed he "dispensed drinks free of charge and lived until the second half of the nineteenth century." Embree filed a report to Congress in 1832. He claimed to have been "engaged in steam works for several years." He reported a want of proper inspectors on the rivers and noted that boilers were built of poor materials, Gov Doc. 478, p. 41 (January 1832). It is not known when Embree entered the steamboat trade, but in 1848, he began editing a periodical entitled *The Western Boatman*. The magazine contained a steamboat directory, a registry of pilots and engineers, and steamboat news of the day. Embree must have been a powerful figure in 1850, because Haldeman mentioned him in a letter to Congress; he complained that Embree opposed the safety guard (now required for use on boilers by the French government) in favor of the doctor pump, see 1850 12-23. In August 1852, Embree was appointed by President Fillmore to take the position of Supervising Inspector at St. Louis (District 5), see 1852 8-31. As a captain and owner of steamboats during this period, Embree was known to be sympathetic to St. Louis steamboat owners and river men. He became embroiled in a fracas with Benjamin Crawford over the revocation of a drunk pilot's license (Hamilton), railing against the "monstrous power of the Board [of Supervisors]" and opining that "the community will revolt at the law" because it impoverished steamboat men without a proper hearing. Crawford calmed him down and castigated Embree for inflaming emotions, which had resulted in a $5000 suit against his local inspectors. He directed his local inspectors to "let the matter rest," and regretted the loss of peace and harmony in his district. See 11-16-1853, C9; and 1853 12-2, 1853 12-5. Embree was criticized by engineers and others in 1854 for allowing an obsolete boiler to pass inspection and for hiring inspectors and engineers by mail instead of in person as required by the Act. In addition, he had not required an examination or oath for engineers. Anyone criticizing this met with Embree's "hostility," see 1854 5-24, C10; and 1853 1-1; C10. In 1854, Embree opposed the resolution calling for the instituting of the pressure principle in the steamboat law, on grounds of monopoly, angering Gouge (Embree was the sole supervisor in opposition). Embree was reported in 1855 as having not inspected steamers in his district, 1855 7-29. He was removed from office in December 1858 and was replaced by Charles Ross, who continued Embree's underground fight against the safety guard. Crawford complained about this to the Treasury Secretary. See 1858 12-8, 1859 12-26. Embree lived a long life. There is a Davis Embree listed in the 1870 census for Clark County, Ohio, Mad River Township. He is listed as 83 years of age and living with his daughter. (This appears to be the Embree of our story because the listed age corresponds exactly to his birth year of 1787 as specified by the Cincinnati Historical Society, the source for some of the biographical information above. Census background, see http://www.rootsweb.com, in Surnames Index, 1870 Census, Clark Co., OH.)

Oliver A. Pitfield (1809-1880), appointed third Supervising Inspector for the Fourth Inspection District, listed his profession as steamboat or steamship captain. He was born in Saint John, New Brunswick, Canada. His father, George Jefferson Pitfield, was a loyalist in the American Revolution and was deported to Saint John in 1783. Oliver Pitfield was connected with steamships all of his adult life. M.D. McAlester, a Captain of Engineers, noted a memorandum of information obtained from Mr. Pitfield, "who, as supervising inspector of steam-boats under the Federal Government before the war, has visited the whole navigable portions of the rivers ... I place the fullest confidence in the above statements of Mr. Pitfield, who is a very intelligent, truthful man, and whose occupations and opportunities have been such as to enable him to know and judge correctly as to these rivers." Pitfield appears in the 1857 *Proceedings* as the Supervising Inspector of the Fourth District, New Orleans. Evidently in the Civil War Pitfield left the federal government for the Confederate cause. In 1861, he is recorded as commanding the [Confederate?] steamer "Arrow" and is said to have been a blockade runner (although another source credits Pitfield as being "U.S. Navy" [unproven]). Pitfield's name does appear in *The Official Records of the Union and Confederate Armies in the War of the Rebellion*. May Terry Gill, in her book of poetry, "Mind and Melody," credits Captain Pitfield with the statement, "A river has a unifying influence on the land it traverses." Pitfield died at his home on January 20, 1880. He is buried in the Greenwood Cemetery in New Orleans. Biographical data from a genealogy website: http://www.terry-family-historian.com, article by George W. Terry, and from 1857 *Proceedings.*

Biographies of Other Persons

James Booth (1810-1888), professor of chemistry at the University of Pennsylvania and then metallurgist at the U.S. Mint in Philadelphia, received his scientific training under Charles Keating at the University of Pennsylvania, Amos Eaton at the Rensselaer Polytechnic in New York, and Friedrich Wöhler and Gustav Magnus, analytical chemists, in Germany. Booth also studied in Vienna in the early 1830s and toured chemical factories on the Continent and in England. Taking a great interest in his mentors, he learned important trade secrets as well as the important principle that the chemical laboratory and the chemical industry were two sides of the same coin, only different in size. Booth returned to Philadelphia in 1836. From 1836 to 1845 he was a chemical consultant and professor of chemistry at the Franklin Institute, and took part in geological surveys of Pennsylvania and Delaware. From 1842 to 1845 he taught chemistry at the Institute-sponsored Central High School, and in the 1840s to 1850s he wrote and published (singly and with others) reports, pamphlets, and books on the extraction of metals from ore, improvements in the chemical arts, and theoretical and practical chemistry. He translated at least one chemical text from the French. In 1849, Booth assumed the role of melter and refiner at the U.S. Mint in Philadelphia, where he comes into our story as the developer of government fusible alloy. At the Mint, his primary responsibility was to develop and scale up laboratory techniques for improving the refinement and production of gold brought into the U.S. coinage system after the California Gold Rush, and to improve methods for manufacturing the country's silver, copper and copper-nickel coinage. These innovations in inventing and refining metals were entirely original—they had not existed before—and Booth spent many years developing them in the laboratory. Booth retired from the Mint in 1887, exhausted from continual government demands to alter coinage specifications. He died in 1888. On the subject of Booth's work creating government fusible alloys, his correspondence in the NARA holdings, RG 41, SBIS, are voluminous (weekly or daily reports over several years) and precisely detailed, tracing every step he took in the heretofore virtually unknown history of the development and distribution of government fusible alloy used in steamboats.

William M. Gouge (1796-1863), high clerk to the Secretary of the Treasury, began his career as an associate editor of the Philadelphia Gazette (1823-1829), and a reporter of the debates of the Delaware Convention of 1831. He was the author of several books and a journal on economics: *A Short History of Money and Banking in the United States* (1833), *History of the American Banking System* (1835), *Expediency of Dispensing with Bank Paper* (1837), and the *Journal of Banking* (1841), and *The Fiscal History of Texas* (1852). Early in his career he opposed paper money, banks, and corporations, but he softened on these positions later. He became a special agent with the U.S. Treasury in 1854. It is possible that Gouge was brought in by the Secretary in this capacity specifically to push scientific technology as represented by the Evans guard. Circumstantial evidence for this conclusion exists in the fact that (1) Gouge's letters treated no other subject besides the fusible alloy safety guard, (2) he was the chief officer who tried to get the law changed to accommodate the guard, and (3) if he had been a general executive in the Department, there should be letters covering all areas of administration, not just one narrow area of technology; there are none. However, notes or letters of direction addressing this issue do not exist, and so this conjecture remains unsupported by direct evidence. It is likely that either Haldeman, who had close ties to the Department, or another of the government's experts furnished Gouge with a copy of Evans's *Treatise*. In 1857 Gouge left the Department and became the accountant for the State Bank of Arkansas, writing the *Report of the Accountants of the State Bank of Arkansas* in 1858. He died in Trenton, New Jersey, in July 1863. Biographical sources: *Appleton's Cyclopaedia of American Biography*, Vol. 2. *Dictionary of American Biography* (New York: Scribner, 1928-81). *National Cyclopaedia of American Biography*, Vol. 24. *Texas State Gazette*, April 17, 1852.

Thomas J. Haldeman (1810?-1874), was appointed local inspector of hulls for the seventh district (Pittsburgh) in 1852. He spent 25 years on the Ohio and Mississippi Rivers in the capacity of engineer and commander of steamboats. His ambition early in his career had been to leave his native Louisiana to improve his craft as a practical engineer in the engine-building shops of Cincinnati. He moved there in 1830 ("I have been here [in Cincinnati] about one year, for the purpose of gaining all the information I could relative to the steam engine; and as Cincinnati is famed for building good engines, and for good mechanics, I have been favored with every opportunity I wanted.") (see Doc 478, p. 92, 1830.) Evans gave Haldeman lengthy praise in his 1850 Treatise (page 53): "He has passed through all the grades of service, from an engineer upwards, and has served so long and successfully, that our practical river men must feel compelled to respect his opinion. He has not rested satisfied with the mere manipulations of his profession, but he is looking keenly into the deep truths, which are both developed by practical men, and at the same time lie at the foundation of all practice. He has patiently and modestly studied his profession, which embraces so noble a circuit of physical knowledge, until he has evidently attained an eminence even enviable to his competitors, and in the highest degree useful to the community." In 1840, Haldeman went into business with riverboat Captain George Walker in which they began manufacturing steamboats and opened a paper mill. By 1850, Haldeman was writing long letters to Congress from his steamboat *Yorktown* in which he advocated emulating the "French system" of safety (i.e., employing self-acting devices such as fusible alloy and a French safety guard) and properly training young engineers, many of whom "need regulation as so many of them know so little of the science of engineering." (see 1852 4-24). His letters were often published in the *Louisville Courier* and other commercial newspapers of steamboat towns.   Haldeman defended the safety guard and fusible alloy through thick and thin: he wrote in 1852 that accidents would abate if Congress mandated the device; and that regulating engineers was not enough ("I have no objections to having engineers examined by the Inspectors, but this will do but little good in my opinion to prevent explosions.") In 1854, a year in which the safety guard was approaching the zenith of its unpopularity with the engineers, Professor John Locke recorded that Haldeman was solidly in favor of the safety guard ("he thinks its application the most essential part of the steamboat law"). In 1858, Haldeman wrote the Treasury Secretary protesting the attempt to replace Supervising Inspector Benjamin Crawford on political grounds. In 1859, Haldeman again defended fusible alloy, stating that supervising inspector Shallcross was the prime mover in the "ridiculous idea of substituting block tin for fusible alloy" (an idea that eventually won out). Haldeman frequently expressed a trust in the efficacy of the safety guards over the skepticism manifested by engineers. He believed any malfunction of the guards was the result of tampering, not a defect in the alloy. He was always deeply suspicious, for instance, that engineers had been tying down the guards since explosions were happening on boats that had the devices installed. Haldeman is mentioned briefly in an 1861 correspondence that mulled over the appointment of Benjamin Crawford as a temporary local inspector, and then he passes out of view. Nothing is known of Haldeman's life after this time.

Both T. J. Haldeman and Alfred Guthrie had their articles and letters published in the *Journal of the Franklin Institute* and in commercial newspapers from as early as 1832. After 1852, Crawford was interviewed in numerous newspapers on the progress of the board in quelling steamboat boiler explosions (and he once commented on the need to extend the knowledge gained to stationary boilers on land). The articles ruminated on the poor quality of steamboat engineers, the neglect of the science of engineering, and sometimes the laxity of Congress. The criticisms aimed at bad engineers resonated with rank-and-file engineers, who had been forced to compete with these men in the labor pool. Haldeman wrote, "There are now many men engaged and engaging in the engineering business, through the influence of their friends and relatives, who are interested in boats, who are not mechanics of any description; they learn, in a short time, how to start and stop an engine, but know nothing about the first or constituent principles of the machinery, or the construction of it ..... and so long as men of this kind are employed in boats, so long will accidents occur…" [269]

[269] See Haldeman article in JFI, Vol. IX (new series), 1832, p. 24.

CHAPTER 5. CONCLUSION

The purpose of the foregoing study has been to ask some basic questions about engineering expertise in the nineteenth century steamboat inspection service. Where did reliable, useful expertise to solve the problem of boiler explosions come from? How did the U.S. Congress and Treasury Department marshal that expertise and create a body of law for putting the technological "lessons learned" into practice? What were the obstacles to this process, and what were the reasons for the ensuing difficulties? How did time affect how expertise was defined? How did institutional, political, and economic factors influence the accepted definition? Finally, what were the power relations among the participants, and how did power influence the selection of expertise? This chapter will attempt to answer these questions and arrive at a deeper understanding of technological expertise.

As we have seen, the Treasury Department assumed the responsibility for deciding what constituted expertise, and for gathering that expertise for placement in a legal framework. Circularization in the 1830s of the steamboat community had contributed early practical expertise, but this information was highly contradictory and anecdotal. Much of the testimony on accidents was provided by persons untrained in engineering; experience with witnesses further indicated that no two accounts seemed to agree. Forensic studies of wrecks sometimes provided valuable information about the causes of explosions, but often the violence of an explosion obliterated evidence that could point to specific causes.

Thus, it became the key goal of the Department in 1830 to investigate the true causes of accidents, not with hearsay reports alone but by adding the tools of science. Science, in fact, was the primary thread running through the pre-1852 attempt to control steamboat safety, and functioned as a touchstone long afterward. As the professional frame of reference for the most powerful parties--elite scientists and government officials—science would define the technological expertise. Inventor Cadwallader Evans joined with these scientific communities in the early 1830s. Science was also the frame of reference for the practical engineers, who used it as a source of information but preserved their critical faculty in evaluating its merits.

We have seen how scientific expertise behind steamboat boiler safety originated in the late 1820s and early 1830s with Alexander D. Bache and Walter Johnson, chemists at the Franklin Institute. Their purpose was to use heat theory as a means of detecting the low-water condition. We saw how years later another scientist affiliated with the Franklin Institute, James Booth, joined in the endeavor to make a reliable government fusible alloy as a component in the “apparatus” devised by Bache and Evans. American scientists gleaned much of their expertise from French and British scientists and engineers. Even so, American scientists pushed into new areas, in this case toward a radical new type of safety device based on the detection of heat rather than steam pressure.

We have also noted how Evans used his connections within the Franklin Institute’s inventors’ network to assist in visualizing this new direction. Evans’s ties to the

Franklin Institute and his reputation as the son of a famous American inventor and steam engine pioneer, Oliver Evans, cemented his scientific credentials. Although Cadwallader developed his 1832 prototype safety guard primarily as a means of preserving fusible alloy, this earliest design was the one favored by the Franklin Institute for its *scientific* virtue of heat detection. We have also seen that although Evans did not immediately promote his invention from a mere appliance to a scientific instrument, he did so in 1850 by publishing his *Treatise*, whose scientific rhetoric was so influential in government circles. High Clerk William M. Gouge's reading of the *Treatise* resulted ultimately in the government action to distribute government fusible alloy aboard hundreds of steamboats in 1855-1856.

While Evans worked out the details of his clever mechanism, self-made "scientific" practical engineers T.J. Haldeman and Alfred Guthrie joined with the members of the Franklin Institute in moving the safety guard and hence scientific engineering into the engine rooms of steamboats. Haldeman was a staunch advocate of the safety guard, encouraged engineers to read Evans's *Treatise*--which he considered a scientific tract--and advocated scientific training for novice engineers. We recall that both Haldeman and Guthrie invoked scientific principles to provide technical guidance on safety devices to Senator John Davis's 1850 Commerce Committee, an action that resulted in their being given positions as inspectors in the new inspection service. Among the association engineers (particularly those of Cincinnati, Louisville, and St. Louis), science figured prominently as well. Members saw their role as performing a valuable adjunct function in screening the results of scientists. The St. Louis engineers in particular used extensive scientific argument to discredit the safety guard and its fusible alloy as they made the case for an equal share of responsibility with the nation's top scientists in transforming theoretical scientific concepts into practical applications.

So, it was in this setting that antebellum science gave birth to the Evans Safety Guard. And yet, if science was the backbone of the Government's expertise, why was it that so much that determined the final outcome of the government's safety program had nothing to do with science, or modified the scientific themes for other purposes? For example, for all of Gouge's faith in the science behind Evans's safety guard, his main concern was that the Department's scientific expertise as codified in law be strictly obeyed. Gouge's legal orientation (i.e., his emphasis on clarification of the pressure principle in the ninth section of the Steamboat Act) seemed to blind him to the practical problems associated with the safety guard and thus impaired his critical faculties with regard to the scientific expertise he was trying to promote. This is readily apparent in Gouge's retrospective correspondence of 1854-1856, which in turn led to the official position of the Department as expressed by Secretary Cobb in 1859 ("We shall have anarchy instead of proper government . . . [etc.]").

The reason that science became only a framework for expertise after 1852 was that the problem of steamboat safety opened up into many areas besides science at that time. One area was traditional engineering expertise as practiced for decades by the practical engineers from the shop tradition. This area of expertise was somewhat antithetical to the orientation of the government experts because it came from the engineers' artisanal roots and emphasized praxis over the laboratory-developed, single-silver-bullet scientific solution represented by the self-acting safety guard. Freedom of technical innovation was a large part of the engineers' concept of expertise, and this is the main reason the engineers fought the safety guard: they perceived Evans's government-granted monopoly powers as a powerful threat to the freedom of innovation. We saw in our story many instances of engineers memorializing Congress to purchase Evans's patent so that it could be disseminated free of charge. This was what we might call the engineers' "democratic technological vision," a vision they expected the national government to absorb into its institutional framework of regulation.

Another important nonscientific factor was the engineers' conservatism in using traditional safety techniques and devices, which had "frozen" by about 1850: water gauges, safety valve, steam gauge, knowledge and training, etc. Self-acting mechanisms that robbed the engineer of control over machinery were not wanted, especially if they were perceived to be malfunctioning and thus creating a "nuisance" or safety hazard. As practical engineer and Local Inspector McCord remarked, all that was needed were old-fashioned principles such as boilers constructed of good iron and workmanship, a steam gauge to indicate pressure, and a "sober, decent, and competent engineer in charge."

Joined with traditional engineering practice was another nonscientific thread of expertise that was centered on the moral character of the engineer. This thread had its roots in contemporary religious moral codes of behavior. Here the practical engineers' Victorian sensitivities intersected with those in high government circles (Bache built his later career as a Whiggish shaper of educational and governmental scientific institutions; Secretaries Guthrie and Cobb, Clerk Gouge, Supervisor Crawford, et al. focused sharply on inculcating Whiggish character traits in rank-and-file steamboat engineers). The quack engine-driver of dissolute habits was to be replaced by a technically proficient practical engineer who displayed qualities of temperance, morality, and a calm and steady demeanor. Inspectors were to "be as sacred men."[270] The near-ecclesiastical personality traits desired in engineers and inspectors thus became bound into law by the examination, licensing, and grading provisions devised by the Cincinnati Association of Steamboat Engineers.

To the elites in government, the safety guard illuminated its creators' concerns with the difficulties of enforcing the prevailing Victorian cultural norms. Attempts to civilize engineers through religion had largely failed, as did attempts to have captains and passengers spy on them in the 1820s. Building morality into the machinery promised a remote corrective. The safety guard would "tell a sad tale" on the bad engineer in a most effective, albeit impersonal, way. If one could not control the heart of a man directly, the reasoning went, one could at least intervene physically to stop his sinful nature from killing others. It may seem an exaggeration, but in a very real sense, after 1852 the safety guard shed its scientific meaning and instead took on the regulating function of the Congregationalists' All-Seeing Eye, the Holy Bible, the

[270] *Scientific American*, September 18, 1852 (author's M1).

Rosary, or the priest’s confessional (the safety guard was called, after all, a “tell tale” device). Thus, safety technology would serve as a mechanical extension of morality, and went hand in hand with more overt personal means of control such as Crawford’s campaign to “get the drunks out.” If overt means failed, covert methods would provide the “extra means of safety.”

A final thread of expertise in the drive to regulation was the bureaucratic framework, personnel organization, and administrative set of skills provided by the Customs Service, an area completely overlooked by some historical accounts. This was the science of human organization, not machines. We have seen how the District Courts teamed with the Customs Service to confirm inspectors, how a licensing apparatus for enforcing the personnel provisions of the steamboat law was set up, and how Customs Collectors and Surveyors contributed their labors in the management and processing of licenses and certificates. Expert investigators could now depose witnesses and organize legal proceedings against offending engineers following accidents, as the scientists at the Franklin Institute had originally desired (in keeping up with the British practice of inquests). This would provide valuable feedback on the causes of accidents. The lumbering and inflexible nature of the Customs Service’s organization would also come into play, and we have seen how this caused a sea change on the western rivers in 1852. Owners and engineers balked at the high costs of regulation, which they thought unfairly levied on them (and which they had been able to escape under the administration of the 1838 inspectors, who “never gave them any trouble”). Regulation also provoked a fear of the Federal government exercising a new and “monstrous” power over the property and intellectual freedom of its citizens. Finally, the Customs Service’s political patronage system ensured that technical expertise would be subordinated to the needs of the party in power. The penalty was a less expert technical corps of inspectors, a particular source of irritation to the engineers.

Thus, although science was the primary thread of expertise up until 1852, it was not equipped to solve human and institutional problems. For these areas of expertise, there was a need for the steamboat inspector, the Customs official, the legal mind, and the moralizing Supervisor. These men took over and served in an active personal role (as opposed to the passive role of scientists). In this way, a time dimension (scientific expertise giving way to institutional expertise as a result of the passage of the Act of 1852) acted to redefine expertise.

The fact that the engineers would not accept the safety guards was not known until the Department began receiving anecdotal evidence after 1854 that they were being tied down (these actions being attended by observations of much prejudice against the guards among the river men). This leads us into the area of conflicts and barriers to government expertise that arose because of the different perspectives of these two groups toward expertise.

The Department had assumed that the latest scientific innovations would be well received by the steamboat community. In making this assumption, they had not given proper consideration to the rank-and-file engineers’ proclivity for tampering with the common safety valve. For years, engineers had used the safety valve as a throttle to provide more power when needed. The question arises, If the Department could not stop tampering with the safety valve over a period of some decades, what made officials think the safety guard would not suffer the same fate?

The simplest explanation was that Department officials were blinded by the possibilities of science providing the silver-bullet solution to explosions. Who, they must have reasoned, would *not* want a precision instrument developed in a scientific laboratory to serve as an improvement over the obsolete and ineffectual safety valve? The common practice of the "fast" engineer stacking five or six heavy wrenches on the weight side of the safety valve would end once the heat principle of the safety guard became understood. Engineers such as T.J. Haldeman and the publication of Evans's *Treatise* would help spread the news. It was only a matter of time before all steamboats would be protected by Evans's guards and explosions would cease. This was the promise the Department made to itself in the 1830s, and the one it tried to execute in 1854.

In point of fact, the engineers had longstanding reasons for rejecting the safety guard. First, they believed it to be a threat to innovation and an "imposition on steamboat money;" second, it was a nuisance and a danger to the engineer; and third, it was an unnecessary addition to the engineer's arsenal of traditional safety devices and procedures. These objections resonated with the local inspectors, who in turn convinced the Supervisors to substitute tin plugs in their place.

Ironically, the insistence by which Gouge pushed the safety guard, and his failed attempt to fashion a legal tool for his initiative, created another obstacle to the transmission of government expertise. For Gouge, the legal stakes were more important than the foundational science on which Department policy was based. Although his comprehension of the practical engineering aspects was limited and amateurish, his appreciation for the bureaucratic skill of the Supervisors in blocking the safety guard was even more limited. Despite his intent to pass a law favoring Evans's safety guard, the Supervisors had been careful not to associate the law with any particular device. Therefore, Gouge could never fasten responsibility for enforcement of the guard on the inspectorate. Further, although it tried, the Department could not enforce the use of the Evans Guard in fulfillment of the 1854 resolution because the Act of 1852 had granted the Supervisors autonomous legal status.

The answers to the questions of institutional, political, and economic factors affecting expertise reinforce the observation that the determination of the proportions and mix that formed the final outcome of expertise in the Inspection Service was not a homogenous process. Institutional traditions, ways of working, scientific and technical knowledge, power relationships, economic factors, politics, religious and cultural norms, time, and individual personalities were the key factors influencing how and in what proportions the various strands of expertise came together to form a "consensus expertise." We have discussed all of these aspects in the main body of the study. No doubt, these forces apply to modern examples of regulating technology as well. In such cases, the losing side in any struggle to define expertise does not simply give up the fight and disappear, hence the instances of tampering with safety devices. One could in fact argue that in our particular case study, the expertise of the laboratory and its heat theory as passed down by Bache and Evans never reached its destination. As we have shown, there is a strong suspicion that hardly any of the safety guards were ever “left free to act” by the engineers.

We could expend much space mapping out and summarizing how the final outcome of expertise was determined in the case of the Evans Safety Guard, but it will serve us better to highlight the main features and the principles at work. This way, we may learn how the process works in modern examples, or perhaps we can apply it as a tool for the discovery of patterns in other historical examples.

First, we might conclude that what we call “technological expertise” is largely nontechnical in nature, at least at the stage at which research ceases and institutional policy takes over. This is at first surprising since in our case study—concerned as it is with steam technology—we presume that the parties are most concerned with machinery, physics, chemistry, and the manufacturing and mechanical arts. But this turns out not to be so after 1852. As just one example, we have seen that the rank-and-file engineers were most focused on personnel reform, for the reason that they wished to gain back their old authority, positions, and pay. We have also shown how the elites’ moral shaping in our story dealt with human behavior and not machines.

Examples of many more "nonscientific" motives can be found in the narrative that influenced the bias of the actors toward nontechnical expertise.

Second, we can see that a few powerful figures at the top of the power structure can exert an inordinate influence on the outlining of expertise (whether or not the outline is actually followed). In our case, the Treasury Secretary and William Gouge struggled against the Supervisors for several years to push through the safety guards. This delayed by a decade or more the use of tin plugs, the preferred technology once the controversy died down.

Third, power at the level of the users--in this case steamboat owners and engineers--was diffuse but it was tremendously influential. There were many more owners and engineers than government officials, and they used their motive and opportunity to sabotage the safety guards at will. Particularly in the case of the engineers, proximity to the technology (opportunity) resulted in an eventual victory for their group. Prosecutions such as Buffington's provided no lasting deterrent because there was no power base supporting these actions.

Fourth, diverse institutions do not tend very well to share expertise. Referring back to the Introduction, we recall historian Tracy McDonald describing Heizen's notion of *vedomstvennost*, "an institution has cultures, political interests and constituencies that shape its actions, often in unexpected ways." Each group has its own culture (elite versus aspiring professionals), political interests (patronage versus professional/economic), and constituencies (public/bureaucratic versus private/guild like) that shapes their attitudes toward technology, and these attitudes in turn are instrumental in guiding the technological development of the final product. In our case study, isolation seemed to be the order of the day. Chemists worked with chemists; engineers worked with engineers; rank-and-file engineers did not always understand (or wish to understand) scientific concepts; scientists did not always understand, or go out of their way to understand, steam engineering praxis on the western rivers; practical engineers appraised the results of scientists, but there are no indications that scientists were aware of, or had the inclination to react to, such questioning of their institutions; politicians/government officials ignored technical matters altogether at times since their priorities were focused on building a power base for their political party in the new government agency; religious and moral concepts suffused the higher ranks of society but did no reach down to the rank-and-file engineers; and on and on.

Fifth, all groups concerned with a technological outcome tend to view the technology in question through filters. The filters can be politics, economics, social order, knowledge, personal relationships, feelings of nationalism or patriotism, power relationships, institutional framework or mindset, and many others.

Finally, the stated technological goal is rarely the real goal. In our case study, for example, the stated goal—safety of the public—was often of secondary importance. What seemed to matter more were the ambitions and orientations of the various groups of actors. Scientists focused on their experiments, engineers fought for socioeconomic position and prestige within their profession, owners worried about imposed costs, politicians were consumed with patronage, and government officials fretted over anarchy in the ranks, and so forth. Of all these parties, the local inspectors were probably the truest with regard to the primary goal of safety to the public, but they had to negotiate many difficulties of a nontechnical nature in trying to uphold right principles in the legal-bureaucratic environment of the post-1852 period.

A New Picture Emerges of the Steam Boat Inspection Service

With all of these complex dimensions accompanying the notion of expertise, one is struck by how the story of the safety guard gives a different impression of the Steam Boat Inspection Service from the one offered in the familiar accounts. These accounts embrace the idea of a smooth process of government regulation reforming an errant industry, of a consortium of experts and government officials getting at the bottom of the boiler explosion phenomenon and furthering a remedy. Historians' focus on the legal code as it evolved tells us much about hardware, procedures, and methods, but little about the human motives and the human drama behind the attempt to design, construct, and use safe technology.

The Evans Patent Safety Guard as a central technological actor provides needed relief to this previously featureless landscape. In the case study we have presented, the main lesson we can carry with us is that success of the government's technological program was a much more contingent affair than the received impression. From the amount of archival correspondence devoted to the subject, the matter of the fusible alloys was a significant one, one that threatened to tear the fledgling inspection service apart (as Gouge believed, the safety guard issue was the make-or-break legal challenge for the Steamboat Act of 1852). As we have seen, although the western Supervisors regarded the Evans's Guard in high esteem for a short time, immediate and strong opposition in their districts for various reasons (not all of them technical) reached a fever pitch by 1854-1855 and converted the Supervisors over to the engineers' side. They then dedicated their energies to try to replace Evans's guards with tin plugs. In this way, in terms of practical technological preferences, the die had been cast early, and in hindsight we can see that Secretary Cobb's 1859 admonition to the Supervisors after the Ross disobedience was probably an ineffectual and late reaction.

For his part, Gouge's faith in Evans's ability to precisely formulate the alloy was probably misplaced in light of Booth's failed attempt to manufacture a reliable alloy for the higher pressure boilers, and in light of the engineers' frequent reports of safety guard "nuisance" alarms. Whether Evans was an unusually talented chemist (he was not known for this; his expertise was in designing and making self-acting mechanisms) and had produced the only reliable "high pressure" alloys, thus demonstrating that the safety guard had worked as designed, or whether Booth had been correct in his appraisal that it was unlikely Evans had ever fulfilled his claims of perfection, shall perhaps never be known. Both the government and the engineers provided evidence and arguments pro and con regarding the effectiveness of the guards, and because we do not know the exact experimental conditions (i.e., steamboats at rest or moving, careened or stable at the wharf, engine horsepower constant or abruptly changing, qualifications of the chemists involved, conditions of their experiments, experimental techniques employed, etc), we shall never be able to properly assess this technology. We do know in hindsight that Gouge was presiding over an experimental program (although Evans had convinced Gouge through his *Treatise/*sales brochure that his 1850 improved guard had reached “perfection”), eutectic alloys were poorly understood at the time, and the guards’ spindle mechanism appeared in so many forms and evolutions that it demonstrates circumstantially and convincingly that there must have been major fusing problems with the alloy.

Whatever the situation, it is fortunate for historians of technology that the safety guard created such a high level of controversy among the interested parties. It has shed much light on how the inspection service functioned in its first years, how expertise was defined and negotiated, and how technology intersected with government, industry, and society.

Appendix A—Index of Annual Proceedings of the Supervising Inspectors of Steamboats

APPENDIX A

	SELECTED FACTS – BOARD OF SUPERVISING INSPECTORS ANNUAL PROCEEDINGS	
Date	**Description**	**Page**
10-27-1852	First Meeting of Supervising Inspectors, Washington, D.C. Minutes: start 10-27-1852. Rules for the government of the Board of Inspectors whilst in session. Committee be appointed to examine the law, and report to the Board for their consideration, rules and regulations for the govt of the local boards of inspectors. Committee: Embree, Murray, and Skipwith. Two further committees be appointed to prepare rules and regulations of pilots and masters to prevent collisions. Another committee be appointed to confer with the TS to prepare forms for certificates.	3-4
10-28-1852	Forms adopted. A committee appointed to superintend the printing of blanks. Lists the various forms. Inquiry as to whether the Board may direct the max number of passengers allowed to carry. Consult with atty general.	4-5
10-29-1852	Appoint a committee of three—one from the lakes, one form the Miss. valley, and one from the Atlantic coast—to report on the division of the districts in which the Super Inspectors shall discharge their duties. Lists the limits of each of the districts. Districts assigned to the various Super Inspectors. They are named. Rules recorded for the government of pilots.	5-6
10-30-1852	Reply from Atty General on the matter of specifying the max number of passengers. Local Boards compelled by law. If Super Inspectors not compelled, they should at least adopt some rule to control the decision of the local boards, to make them uniform. Committee appointed to specify the amount of space needed on boats for deck and second class passengers.	7
11-1-1852	Further discussion on Report on rules and regulations. (p.7) Letter to Hon. Wm. L. Hodge, Asst TS: Hydrostatic pump agreed upon by Super Inspectors, pump to be provided by your dept., beg leave to suggest that the mfg of them be put under contract soon. (p. 11)	7, 11
11-2-1852	Rules for local boards: steam pipe for holds to extinguish fires; force pumps; life preservers; areas of safety valves (with a table); fusible alloy – owners may with approval of the local inspectors elect as to the mode of its application; water gauges must be conspicuous; size and thickness of flues; earlier boilers must meet 15% margin of safety in terms of pressure test; additional means of steering in case of fire; when stopping engine, open furnace doors, close dampers, etc.; life boats required; fire buckets and axes (with large table of buckets needed, etc);	7-10
11-3-1852	Two committees be appointed: rules for local boards re: number of passengers boats may carry. Also additional rules for pilots in cases of steamers meeting and passing each other. Board, when it adjourns, will meet next in New York on 12-8-1852. Resolved that Local inspectors be instructed to furnish the Super Inspectors with all the info called for by the tabular form annexed. Purpose: to give a proper understanding in regard to the character of the machinery in use upon the several boats in the several districts under their charge. Committee to obtain from the TS the mode of making up our accounts with the Treasury for traveling expenses, and the orders for offices, stationery, etc. Acting TS Hodge refers them to the First Comptroller for this procedure. Letter to Acting TS Hodge. Arrangement needed to pay local inspectors in port of San Francisco for traveling there and for transportation of the necessary implements for testing boilers, etc, and a room for the preservation of the instruments to be furnished by the Department, and for other purposes.	11-13

	SELECTED FACTS – BOARD OF SUPERVISING INSPECTORS ANNUAL PROCEEDINGS	
Date	**Description**	**Page**
	(11-3-1852 cont) Letter from Navy Department Acting Secretary Jos. Smith, dated 11-2-1852. Orders will be issued to manufacture a certain number of hydrostatic pumps at the Navy Yard in this city, for the use of the Supervising Inspectors, under the late Steamboat law.	
11-4-1852	Discussion of alloyed metals, hose for hydrostatic pumps.	13
11-5-1852	Ask TS to give information to mfg of boiler plate as to stamping rqmts. Order collectors to furnish local board the info required to be furnished to other collectors (under Section 23 of law). Order collectors to furnish room for preservation of instruments, and for their offices for exam. of engineers and pilots, at the following ports (lists them). Procure instructions to be given to the commandant of the Navy Yard to make 35 sets of instruments for testing boilers; also the alloyed metals required by the second clause of ninth section of the law. Next annual meeting at Cincinnati Ohio to be held on the first Monday of September next (1853).	14
11-6-1852	Board secretary P.H. Skipworth reported that he called upon the TS, and in answer to then resolution submitted to him yesterday, he requires time to examine into the law, and will make out the necessary forms and instructions as soon as practicable, and transit copies of them to each member of the Board. Board adjourned.	15
12-8-1852	Special Meeting: no minutes recorded.	NA
8-1-1853	Special Meeting. Pittsburgh	
8-1-1853	Provisions and regulations adopted at 12-8-1852 meeting in NY called up for revision, modification, alteration. Subject of carrying lights on steamers discussed.	2
8-2-1853	Pilots not to receive licenses w/o producing satisfactory evidence of their experience.	2
8-2-1853	Some districts are inspecting nonpassenger steamers. Law only says inspect passenger strs. Resolved – inspect only passenger steamers. Resolved – take up matter of inspecting <u>all</u> steamers – should be inspected under law just like passenger steamers.	3
8-3-1853	Jurisdiction in case of accidents. Investigation will be the responsibility of the supervising inspector in the district in which the accident occurred.	4
8-3-1853	Double-acting forcing pump specifications – stroke of not less than 6 in. – Doctor pumps.	4
8-3-1853	<u>Pressure table</u> – standard pressures for a 42-in. boiler, ¼ in. iron. Various boilers from 34 in. to 46 in. dia. + iron 3/16 in. to 5/16 in. thick.	5
8-3-1853	Any [Supervising?] inspector may call on the Local Board of any other district to obtain testimony, etc., for investigations. Duty of local board to comply with such request.	5
8-4-1853	Mode of ascertaining uniformity of action of the various local boards – present specimens of all certificates, licenses, tabular reports.	6
8-4-1853	Data in tabular reports – list.	6-7
8-4-1853	Embree on the grading of engineers. Local Board granting original license is the only entity capable of raising grade. Only when “special and satisfactory” reasons given. Shall be endorsed on new certificate granted.	7
8-4-1853	Next meeting – Cincinnati – First Thursday in November 1853.	7
8-5-1853	Rules re: number of deck passengers to carry on boats. Resolution to continue committee work on this (in view of the absence of a member) and report at next meeting in Cincinnati.	8

	SELECTED FACTS – BOARD OF SUPERVISING INSPECTORS ANNUAL PROCEEDINGS	
Date	**Description**	**Page**
8-5-1853	Crawford to pay bills for Supervising Board special meeting.	9
11-19-1853a	First regular yearly meeting. This Board at their meeting at Pittsburg in August last, passed a resolution requiring the Local Boards of Inspectors to prepare and present to their Supervising Inspectors, reports showing the amt of duty performed by each Board, and all such other general information in regard to the operation of the law under which they act as may be of value or interest. We find upon examination of the reports from the Local Boards, they are not so complete in many respects as might be wished, . . . but they are of the opinion that the information is sufficient to show that the operation of the law has been highly beneficial . . .	53
11-19-1853b	Table of info from Local Boards, with numbers of steamers, boilers, accidents, licensed engineers, etc.	55
11-19-1853c	Opposition to 1852 law was great in beginning, from owners, engineers, and pilots. This opposition to the law has decreased rapidly; many of those formerly arrayed in the ranks of its enemies are now numbered among its strongest friends.	64
11-19-1853d	Insurance companies are far more ready to take risks upon those Steamers which have been inspected under the law than upon others.	65
11-19-1853e	Law is not perfect; we have found many difficulties in carrying it out… further legislation needed. Quotes from Local Boards of inspectors. Some met little opposition, "we have been met by the owners and officers of the Steamers with kindness and a determination to carry out the spirit of the law." Public will make the law popular when they understand its workings. System of licensing engineers has had a good effect in stimulating a laudable ambition to perfect themselves in a knowledge of their business.	65
11-19-1853f	Boilers and engines now kept in better order than formerly, and that enquiry is awakened among Engineers, and that both they and Pilots have become sensible of the great responsibility resting upon them.	66
11-19-1853g	Another Local Board reported: The opposition to the law has in a great degree settled down, and is becoming more popular with those who understand its features, and it is only necessary for the traveling community to know the safe guards that have been thrown around them, and all opposition will cease.	66
11-19-1853h	Another Local Board reported: "There have been twenty-one steamboats built and finished in this district since the first of January last." These steamboats have given entire satisfaction; the captains and engineers (many of whom were opposed to the standard of steam) have given information that their boats perform well, and do more work with the same amount of fuel than under similar circumstances, with boats, before the passage of the law. There has been considerable opposition in this district to the law in general, and particularly to the standard of steam. This opposition is fast wearing away; the working of the act of 30th August, 1852, has demonstrated the value and utility of the law, hence the change now taking place in the views of owners and captains of steamboats. At the time the law went into effect, there were very few, who entertained a favorable opinion of it, believed it impracticable, but as the season advanced, those most opposed to the law at its commencement, have come forward and expressed warmly their approbation of its success . . . is fast gaining the confidence of the traveling community . . . Insurance Companies have taken a deep interest in the carrying out of the law . . . they went so far as to call a meeting an passed resolutions to use their influence in favor of such vessels as have been equipped according to law.	66-67

	SELECTED FACTS – BOARD OF SUPERVISING INSPECTORS ANNUAL PROCEEDINGS	
Date	**Description**	**Page**
11-19-1853i	Licensed engineers and pilots "have urged in the strongest manner that the pilots and engineers of freight boats, towboats, etc. be required to take out licenses under the law." Unlicensed pilots of freight steamers and tow boats frequently annoy licensed pilots. The former are "utterly indifferent, forcing licensed pilots to avoid collisions – because former are "not amenable to the law." Annoy the licensed pilots "in every possible way."	68
10-6-1854	Annual meeting held at Detroit, MI. Mentions minutes of previous special meeting held at Washington 4-7-1854.	14 (?)
10-6-1854 (?)	Navy Yard experiments with fusible alloy. (Page not copied) "Experiments made in the Navy Yard at Washington."	88
10-6-1854	Resolution of Super. Bd that local inspectors be instructed not to permit of alloy application by any method which shall not exclude all pressure from the alloy which shall tend to separate its components. Alloy shall be enclosed in a case or tube etc. Committee – Crawford, Embree, Burnett, Copeland (Copeland added on a motion). [Auth's note: This resolution was a "search list" item and was found in 3-10-05 session. Excerpts are now typed and are filed with the other Proceedings docs.]	89-90
10-6-1854	Gouge invited to be present during sessions. Professor J. Lawrence Smith – requested by TS to meet the board – gave his views on alloyed metals and explosion of boilers. His investigations. [Long presentation occupied two sessions, discussion with Board]	98
10-7-1854	Reports of local boards. Reports referred to a committee of three – Copeland, Crawford, Lewis.	99
10-9-1854	Crawford presented a communication from local board Cincinnati on the classification of engineers on the Western waters. Referred to a committee.	101
10-9-1854	Oaths not recognized by law – do not issue license. Pilots/engineers.	102
10-9-1854	"Small boats" defined as all having three boilers or less. "Large boats" have greater than three boilers. For purposes of the classification of engineers.	103
10-9-1854	"It having been stated to this Board, that their action in regard to the application of fusible alloys, as set forth on p. 90 of the Proceedings, has been understood by some of the Local Boards to conflict with their former actions, by unanimous consent the following explanatory note is here inserted, viz: that while, by approval of the local Inspectors, as to the <u>mode</u> of application, they may still do so, but at the same time the Local Boards are instructed <u>not</u> to approve of any mode of application in which such alloys shall be exposed to the <u>pressure</u> of steam."	103
10-10-1854	Copeland presented his report on the local board data. First comparative report of accidents on the Western waters. Tabular results and a statement of accidents (narrative of accidents). "Generally the law has been carried out more fully, and with much less labor and difficulty, during the current year than the previous year." Greater familiarity of Local Boards with their duties; greater readiness of steamboat owners and officers in aiding the inspectors. Reason: by virtue of the evidence forced upon them of the beneficial and salutary effects of the law.	106
10-10-1854	Explosions – "Kate Kearney" 2-16-1854. Fifth District – Embree. 15 dead; license of engineer revoked. "Timour No. 2" 8-26-1854. 19 dead – no decision yet re: engineer.	109

	SELECTED FACTS – BOARD OF SUPERVISING INSPECTORS ANNUAL PROCEEDINGS	
Date	**Description**	**Page**
10-10-1854	"Reindeer" (flue collapse) 3-1854. Sixth District – Shallcross. 38 dead. Negligence/carelessness of engineer. License revoked, but he died before he could be prosecuted. "Van Ness Barlow" 8-12-1854. Seventh District (Crawford). Two hands killed. Case under investigation.	111
10-10-1854	Collision of "Fanny Fern" and "Thos. Swan." "Swan" sunk. Boat and cargo a total loss. 3-1854. Steamer "Cuba" ran upon the wreck of the "Fanny Fern" 5-1854. "Cuba" sunk. No loss of life.	111
10-10-1854	Our experience since our last annual report continues the favorable opinion then expressed re: general operation of the 1852 law. "The opposition to the law and its execution, which had then been exhibited to some considerable extent, has been diminished, as its favorable effects have been exhibited. In fact, we may say that many of those connected with steam navigation who now rank among the firmest friends of the law, were formerly its strongest opponents." Insurance companies have refused to take risks on uninspected steamers.	113
10-10-1854	A practice of steamboat owners has led to confusion. Painting different names on different parts of the boat. Same steamer three or four different names. Remedy: name registered must be the exclusive name panted on all parts of the boat.	113-114
10-10-1854	Confusion as to who brings suits, in the name of the U.S. or an individual. Recommends it be U.S. Also, difficulty because no specific provision for the necessary expenses. Inspectors are thus powerless to enforce the provisions and penalties of the law. Amendments are needed to "correct these evils."	115
10-10-1854	In issuing the certificate for a steamer with new boilers, Local Inspectors should insert the name of the manufacturer of the iron, and where manufactured. Adopted.	116
10-11-1854	James W. King, Chief Engineer U.S. Navy, appeared before the Board in accordance with instructions from the Navy Department.	117
10-11-1854	Embree presented a "comparative report of steamboat disasters on the Western Waters. Board secretary requested to condense report, which appears on p. 118.	117-121
10-11-1854	Embree's report mentioned TS report to the U.S. Senate dated 1-21-1852. Number of boats lost through various means.	118
10-10-1855	Fourth Annual Meeting – held at St. Louis. Minutes of previous annual meeting, held at Detroit, read and approved.	1
10-11-1855	Gouge present. William E. Everett, Chief Engineer U.S. Navy present.	4-5
10-15-1855	Inflated life preservers not reliable.	7
10-17-1855	Crawford's resolution – Committee be appointed to prepare a form re: such general instructions for the guidance of the Local Boards in preparing their annual report to this Board, as shall secure more full and uniform information upon the various points designed to be embraced therein." Committee – Crawford, Brown, Lewis.	9
10-17-1855	Board views invention model. Mr. Pangborn. Patent lifeboat and apparatus for extinguishing fire.	9-10
10-18-1855	Crawford presented communication from W.W. Guthrie, inspector of boilers and machinery, Cincinnati, re: use of fusible alloys. Referred to committee on the supplementary law.	10
10-18-1855	TS James Guthrie letter of 10-13-1855. Received 225 copies of Booth report re: mode of using fusible alloy. Transmit one copy to each Local Board. Distribute to inspectors so they will put before steam engineers for their suggestions in improvements in using the alloys. Committee formed to go over Booth report. Crawford, Copeland, Embree, Burnett.	10-11

	SELECTED FACTS – BOARD OF SUPERVISING INSPECTORS ANNUAL PROCEEDINGS	
Date	**Description**	**Page**
10-18-1855	Letter by Supervising inspectors to TS Guthrie (draft) dated October 1855. St. Louis. Operation of the law has been favorable. Constantly decreasing opposition. Special request of non-passenger steamers for inspections. Pecuniary interest at work (in best interest to inspect boats). Local boards more familiar with their duties. Number of contested court cases is constantly decreasing. Changes to rules by supervising inspectors are ongoing necessity, but should reduce in time. Will step on some toes with rule changes, but must sacrifice individual interests to the general good. Table of data attached on p. 15.	12-15
10-18-1855	Local inspectors typically refuse licenses due to intemperance of applicant. In FN of table on p. 15.	15
4-1-1856	Proceedings of special meeting held in Washington.	3
4-1-1856	William E. Everett, Chief Engineer U.S. Navy, invited to meetings.	4
4-2-1856	Crawford chairs meeting to discuss steamboat law amendments.	5
4-3-1856	Board meets with Congress - Senate and House committee on Commerce consisting of Hamlin, Washburn, Kennett.	6-8
4-3-1856	Letter received from LI Burnett. Unable to attend due to his summons to appear as an important witness at Superior Court of Boston.	6
4-3-1856	Continued discussion of Crawford's amendments.	6
4-4-1856	Continued discussion of Crawford's amendments. Into evening session. Nineteen sections agreed upon on motion.	7
4-5-1856	Crawford's amendments – discussion completed. 26 sections agreed upon.	8
4-7-1856	Mention of a letter from Henry N. Sands, Surveyor of Customs, re: fees. .p. 9. Taken up on p. 11.	9-11
4-7-1856	Hamlin, Washburn, Board, submitted to them six sections of the draft supplementary law.	10
4-8-1856	Paducah citizens petition for a local board. P. 9 Taken up on pp. 12-13. Refused.	9, 12-13
4-8-1856	Collectors, Surveyors of Customs want more compensation due to SBIS duties.	11
4-9-1856	Reeder's patent safety guard.	14
4-11-1856	Board meets with President of U.S. (Pierce?)	16
4-11-1856	Dickey and Watson letter received by Board 4-9-1856.	16
4-11-1856	Supplementary law drafted, copied three times for use of the U.S. Committees on Commerce. This was a draft bill.	16
4-12-1856	Removing snags on Western rivers. Good detail. Contractors to do work, cheaper than government doing it.	19-20
4-14-1856	Amend Corwin's original circular to the manufacturers of boiler iron. Add thickness.	18
4-16-1856	Patent – detachable saloon cabin.	26
4-16-1856	Supplementary Bill reproduced in proceedings. [Auth note: Truncated – some not copied.] Brought towboats etc into compliance with the 1852 law.	27-35
4-16-1856	Section 9 of Supplement Draft – Override of existing provisions re: fusible alloy. Use fusible plugs or rivets of pure tin.	29
4-16-1856	Supplement Draft – add Galena IL local board.	31
4-16-1856	Supplement Draft – add asst. inspectors at local board of NY.	32
4-16-1856	Supplement Draft – inspectors' annual compensation, bottom p. 32. Cincinnati - $1800; Wheeling - $800; Pittsburg - $1800.	32
4-16-1856	Supplement Draft – Customs officials warrant licenses based on local inspector signature.	32
4-16-1856	Supplement Draft – How informants to be paid. [Auth note: This is the first instance found of "informants" re: SB law. Ties to Customs Service mode of operating.]	34
4-16-1856	Supplement Draft – Summonses of witnesses. Powers.	34
4-16-1856	Supplement Draft – Collector of Customs – Responsible for administering official oaths.	34

	SELECTED FACTS – BOARD OF SUPERVISING INSPECTORS ANNUAL PROCEEDINGS	
Date	**Description**	**Page**
4-16-1856	Supplement Draft – Officers of Customs to be paid $1.50 for each set of certificates processed.	35
10-15-1857	Proceedings – Sixth Annual Meeting, Louisville, KY	
10-15-1857	Biographical data – First annual report with "Appendix Containing a List of All Inspected Steamers, Together with the Pilots and Engineers, &c., &c."	61
10-1857	Local Boards – difficulties encountered performing duties – Supervising Board steps in.	55
10-1857	Stamping thickness of boilerplate needed.	56
10-1857	"Before and After" tables of operation of law. (5 years before vs. 5 years after) Table on p. 32. Lloyd's SB Directory – Western rivers only. No statistics on Northern or Eastern waters.	32
10-1857	"With these facts before us, we conceive that the beneficial effect of the law can no longer be a matter of doubt."	33
10-1857	Turning up equipment defects by inspections.	33
10-1857	Hydrostatic test now generally recognized. Contracts for new boilers require test before being contracted for. Accidents due to defects decreasing.	33
10-1857	Temptation to overload safety valves, however. P. 33 Resolution – no engineers permitted to weight safety valves. P. 34	33-34
10-1857	Ambiguity in law met with "true intent and meaning therof."	34
10-1857	Codify law – we will index it better for local inspectors. Lots of changes prompting confusion as to interpretation. [Auth note: Backs up Hunter's claim of better system, organization, due to SBIS].	34
10-1857	Greatest loss of life due to collisions. See table.	39
10-1857	"The local boards generally more and more familiar with their duties; difference of opinion as to requirements of the law, or correct method of carrying out its provisions, have been so far harmonized by the Board of Supervising Inspectors." Differences constantly decreasing both in number and importance. More good detail on the differences of opinion.	38-39
10-25-1858	Annual Report, Buffalo, NY. Last report we reported loss of life and property was regularly diminishing. Not this time. "Several of the most serious disasters are of an unprecedented character." Mainly fire.	39
10-1858	Fraudulent stamping of boiler iron. TS Howell Cobb.	43-45
10-1858	Salt water corrodes boilers. More frequent inspections needed where there is salt water exposure.	44
10-1858	Towboats embarrass inspectors. Still not covered by 1852 law, but when they blow up, the newspapers blame the inspectors.	45
11-15-1859	Annual Report, New Orleans. TS Howell Cobb.	31
11-1859	"In our last annual report we were compelled to admit that the statistics of disasters for the previous year did not exhibit the continued beneficial results which the friends of the law had hoped."	31
11-1859	This year, losses have been far less than in any year since the law went into operation. The decrease may be attributed to the beneficial operation of the law, greater familiarity with its requirements on the part of SB owners and officers, and inspectors; also, as new causes of disaster or accident are developed, immediate measures are taken by this Board to remedy the evil.	32
11-1859	Crawford, Copeland – good experimental report on fire-retardant paint.	33
11-1859	Cotton bales as fire hazard.	35
11-1859	Explosion due to wrong use of "doctor pump."	37
11-1859	Instead of throwing out obstacles, licensed officers of SBs now cooperate with us.	42
11-1859	Stamping fraud (iron). Extensive in nature; difficulty of prosecuting.	40
11-1859	[Table of statistics available, but not copied.]	

	SELECTED FACTS – BOARD OF SUPERVISING INSPECTORS ANNUAL PROCEEDINGS	
Date	**Description**	**Page**
10-25-1860	Annual Report, Ninth, New York. TS Howell Cobb	23
10-1860	Explosions – “Ben Louis” and “Alfred Thomas” Alfred Thomas was uninspected boat.	26-27
10-1860	Improvement of construction of boilers brought about by hydrostatic test.	27
10-1860	SB laws – proof of effectiveness – SB laws are being used to regulate towboats, etc, and land boilers by cities. I.e., seen to be effective, therefore other nonregulated industries are using the regulations developed by the Board.	27
10-1860	Except for collision of Lady Elgin, “the total loss of life for the past year has been much less than for any previous year since the law went into effect.	28
10-1860	The tabular statement presents a highly favorable result as compared with any previous year, especially if the increased number of passengers is considered.	28

Appendix B—Index of NARA Correspondence

APPENDIX B
INDEX OF CORRESPONDENCE WITH RESEARCH NOTES
SECY TREAS - NARA STEAMBOAT INSP SERVICE RECORDS (RG 41)

LEGEND: A = Corresp FROM TS (typed notes); B = Corresp FROM TS (typed notes except B7); C = Corresp SENT TO TS (typed notes); D = Corresp SENT TO TS (microfilm); E = Commissions for Local Inspectors of Hulls and Boilers, 1852-96 Vol. 1; M = Misc; JFI = Jour Franklin Inst; Proc. = Proceedings of the Annual Mtg of the Supervising Inspectors. 2C, 3C, 4C, etc are more C letters or notes typed or copied on large copier during different research sessions. 2C = 3-10-05 session; 3C = 3-16-05 session; 4C = 3-30-05 session; 5C = 4-6-05 session. GD = Gov Docs notebook. See details of NARA bound volumes at the end of this appendix.

Date	Description	Source
1831 4	Bache's first device, early 1831. *Safety Apparatus for Steam Boats, being a combination of the Fusible Metal Disk with the common Safety Valve*, By A.D. Bache, prof of natural philos and chem at the Univ of PA. Combines fus plate with safety valve. Good dwg. This is the very first invention connecting fus plate with valve, but plate is directly beneath valve. Also story of engrs cooling fus plate with water to defeat it. Fear of drifting hazard. His valve/alloy combo is remedy for this.	JFI Vol. VII, No. 4, pp. 217-221
1831 12	L. Herbert response to FI circular. Haste makes waste--production rush facilitates burstings. Intense heat weakens iron. Draft of fire causes a torch phenomenon. Arrangement of flue a factor, no sudden bends. Soot--safety valve didn't help. Tendency of the engr to get excited and do imprudent things. Engr leans on safety valve, etc Bakewell response to circular: Cincinnati 1830 report. Bakewell's background. Hydrogen gas theory. Want of water. Injecting water dangerous. Lo vs. hi pressure boats - politics have a lot to do with preference. Etc.	JFI Vol. VIII, No. 6, pp. 374-388
1832 X	C. Evans first mention of fusible alloy application, with dwg, p. 94. This is the same idea he patented in 1834. Also his expanding rods (w/dwg) and his mercury device (nice dwg incl). Careening dwg, how his inventions prevent problems. Letter of John G. Cassedy - starts p. 94. Loading of safety valve. Racing story - "I will beat her or else blow up." "To men so destitute of principles of prudence, the life of an unwary passenger should never be intrusted." Put safety valve out of reach of him. Praise for FI labors in investigating explosions.	JFI Vol. IX new series, pp. 89-101
1832 X	Ingham letter, Haldeman ltr, others. Praise of sci institutions by GWL. Haldeman - poor quality engrs. Perkins theory. Flash theory. Ignorant engrs. Effect of mud on water levels. Copper rivets no good. Concept of "proper attention" by good engr. Captain causes accident. French law - hydro test. Even prac engrs not equal in skill. French regulations. Good engr best defense. Most engrs can't calculate a safety valve.	JFI Vol IX new series, pp. 12-31
1832 8	French Royal Ordinances, 1823-1830. Includes mention of table of fusibility of metallic plates. Forbids cast iron in boilers. Rules on fusible plates, temps that they must fuse at.	JFI Vol. X, No. 2, pp. 104-111
1832 8	Article on perforated tube for improving the common gauge cock. Thos Ewbank.	JFI Vol. X, No. 2, p. 79-82.
1833 X	Andrew Jackson's annual msg (State of the Union). Fatal accidents - he blames navigators of vessels for criminal negligence.	Gov docs GD 24
1834 5-8	Evans Patent No. X8185. *Improvement in the Mode of Applying a Fusible Alloy as a Guard against Explosion of Steam Engine and Other boilers.* Evans' first SG using alloy, one of which is a short cup applied to the shell; the other a rotating device with weight.	Gov docs GD 22

Date	Description	Source
1834 12	Evans patent specification, p. 391. Patented 5/1834. This is the same as 1832 version. Plunger version of fixture using fus alloy. Vague generalities are present in specification, to cover all ideas.	JFI Vol. XIV, p. 391.
1836 10	*Report of the Cmte of the FI on the explosions of steam boilers, Part II*. Also includes the Nov. issue (cont of article). Key pages are 296 and 297, which explain C. Evans and Bache SG ideas, giving history of these devices (see FNs). Mentions early Bache idea, then Evans's fus. alloy SG idea, and also his expanding rods and mercury guard ideas. JFI judges which they like best.	JFI Vol. XVIII, No. 4, pp. 217-233; No. 5, pp. 289-306
1838 10-1	Prac and theoretical engr Wm. B. Dodd complains that act of 1838 misses the point. Rather than test boilers and inventions Congress should be testing engineers. Not one in ten is a practical and theoretical engineer.	Doc 21 p. 398. Gov docs GD 25
1838 12-13	Memorial of Shallcross and others engaged in SB navigation for Congress to alter and amend the SB act.	Gov docs GD 15
1839 2-7	Navy commission surveys inventors' safety appliances.	
1846 3-6	Memorial of travelers on Miss. and Ohio Rivers praying for passage of a law to compel the owners and capts of SBs to place Evans SG on each outside boiler, referred to the Committee on Commerce.	Gov docs GD 11
1850 No date	Cad Evans, *A Treatise on the Causes of Explosion of Steam Boilers w/Practical Suggestions for Their Prevention, to Which Is Added a Description of Evan's Improved Safety Guard, or Engineers' Assistant,* Pittsburgh 1850.	Tray 26 RG 46 Commerce Recs IMG 0995-1068, in Fldr 1 of 2; see also C4
1850 12-23	Haldeman's articles in newspaper. On board Stmr Yorktown, etc. Explosion of the Knoxville. Explosions will continue w/o Evans SG reqd by law. Water low in boilers, instant steam production opn water hitting overheated flues (flash theory). Shock of explosion felt. Wishes it to be the last. Shrieks and scalded victims drown. Eng had declined to buy a booklet on Evans SG. Seeks law to compel Evans SG. Two other devices: Bordens Mercurial steam gauge and Fabers water gauge. Cost of SGs an objection $200. Death of most estimable citizens. French law requiring SGs. Embree disparages SGs, prefers doctor-pumps. Haldeman criticizes him. French law compelled use of a SG (not as good as Evans's). Etc.	Tray 26 RG 46 Commerce Recs IMG 1091-1092
1850 12	No date, but with other 12-1850 materials. Newspaper article about bill before Congress sponsored in Senate by Mr. Davis, Chmn Commerce Committee. Need govt regulation badly. Careless, ignorant, mismanagement among SB interests/operators. Shameful delay, etc. Inspection system has been a failure. Features of the bill: Hydrostatic test, better mfg of boilers, better iron, manufacturer penalties for using cheap iron. Explosions rare in France. "French System" works. Some SB engrs profess difficulty in mfg a fit alloy . . . this is absurd.	Tray 26 RG 46 Commerce Recs IMG 1093-1094
1850 12	No date, but with other 12-1850 materials. Newspaper article , Louisville KY. Memorialists representing owners of boats object to bill before Congress. Too expensive; most objectionable is 100 lb pressure steam limit. Boats operate at double this pressure. Millions of dollars would be lost on these boats. Suggested provisions of the law whereby old boilers are retired.	Tray 26 RG 46 Commerce Recs IMG 1095-1096
1851 X-X	In JFI, Dr. J. L. Smith, presenting before the New Orleans Lyceum, desires to "make it punishable to insert any thing but fusible metal in the holes of the boiler meant for that purpose (p. 413). "Fusible plugs have not been found to answer as well as was expected (p. 414, FI commenting on Smith's lecture.)	JFI

Date	Description	Source
1851 11-20	A. Guthrie to Hon John Davis. Letterpress form letter. Solicits aid regarding prevention boiler explosions, Guthrie wishing to put the matter before "the first men in the country." "Prejudice and opposition to be encountered." Papers apparently were attached to this corresp. Some general cursory biog info. Ltr xcribed 4-2006.	Tray 26 RG 46 Commerce Recs. Folder 2 of 2 IMG 1134
1851 12-2	Form letter of intro of A. Guthrie to Hon. John Davis. Letterpress form letter signed by J.D. Webster, US Topg Engrs. Has witnessed Guthrie's invention to prevent steam boiler explosions. See Tray 26 shot - IMG 1132. Ltr xcribed 4-2006.	Tray 26 RG 46 Commerce Recs. Folder 2 of 2 IMG 1133
1852 3-19	Copy of Certificate of Seaworthiness for SB "Golden Era."	D7
1852 4-24	T. J. Haldeman to Hon John Davis, Chmn of the Comm. on Commerce. Onboard the Steamer *Indiana*. 16-pp letter. Haldeman biog (cursory). Bill is a good start, but needs changes. 1st - Evans SG should be mandated. 2nd - cast iron heads should be prohibited as in France. 3rd - Use wire tiller ropes. 4th - Law should compel use of Fabers Magnetic water guage, prevents flue collapse from want of water. 5th - compel a manometer or mercury steam gauge. Xcribed 4-2006.	Tray 26 RG 46 Commerce Recs. Folder 1 of 2 IMG 1116-1131, see also 5-3-1852
1852 4-28	Alfred Guthrie to Hon. John Davis, Senator & Chmn Commerce Cmte. Chicago. Has been to New York, consulted w/engrs there. They of opinion that new bill is perhaps too liberal wrt max press. for lo-press. boats - 50 lbs. Mentions high quality of engrs operating on Northern Lakes. Also mentions explosion of *Prairie State*, result of recklessness. Boat was racing, water was shut off. Will "return to Wash. by 5-15 and make the test as was contemplated." Ltr xcribed.	Tray 26 RG 46 Commerce Recs. Folder 1 of 2 IMG 1113-1115
1852 5-1	Ltr from Thos. J. Haldeman of Cincinnati, OH, to TD, New Orleans 5-1-1852 A. Guthrie's theory that mud caused explosion "ridiculous." Louisiana boat exploded due to Evans SG being tied down. Advocates SGs, several types. Fusible plates. French have used 30 years (in this shape). Prejudice agnst Evans SGs. Engrs tie down SG and boat blows. Prejudice agnst SGs, scientific engineers. SB "West Wind" coming up from St. Louis [1842], SG keeps going off, weighed down by engr w/Capt's concurrence, blows up. Passengers note SGs tied down. Guthrie implies Evans SG has sunk into oblivion, but it is on 132 boats plus 3 more recently put them on at Cincinnati. Stitched letter. [Ltr xcribed 3-2006.]	Tray 26 RG 46 Commerce Recs IMG 1070-1090
1852 5-1	Report to Capt T.J. Haldeman on SB Indiana, New Orleans, re numbers of Fabers Magnetic water guages in use on Southern & Western waters. Guages are quite durable in use. Writer: Wm. Bryce.	Tray 26 RG 46 Commerce Recs IMG 1101-1104
1852 5-3	A. Guthrie to Hon. John Davis, Commerce Committee re: Louisville memorialists. See also IMG 1095, 12-1850. Looks like masters and owners don't want restraint. Laws proper for everyone but them. Just-built boats: "Let them blow up and when we build we will do better." Cost of Davis's bill to industry an issue, but owners can install larger cylinders, lower pressures, pass hydro test. Lifeboats interfere w/design of boats, then builders have no conception that the hydrostatic test has to be hi pressure to guard against the carelessness of engrs in allowing their boilers to become overheated.	Tray 26 RG 46 Commerce Recs IMG 1097-1100

Date	Description	Source
1852 5-3	Thos. Borden to Capt. T.J. Haldeman, SB Indiana, New Orleans. Report of number of Borden's steam guages. Started making them in 1847, called 'humbug' and useless. Much difficulty in introducing them. Saw a French manometer at sugar refinery.	Tray 26 RG 46 Commerce Recs IMG 1105-1107
1852 5-3	Newspaper article. TJ Haldeman article excerpted in New Orleans Commercial Bulletin dtd 4-21-1852. Engrs are in Washington lobbying re: new law, but do not inform chairman of "useful improvements", i.e., Evans SG. Accidents would abate if Congress mandated Evans SGs. We've lost 3000 persons; if we had only been like the French. Costs of appliances: Evans - $150; Borden guage $80; steam guage $60-80.	Tray 26 RG 46 Commerce Recs IMG 1108-1112; like IMG 1091 12-1850
1852 5-10	Crawford petitions for acceptance of 1852 bill. He is the rep for Pittsburgh Assoc. of engrs. See GD 18	gov docs GD 17
1852 5-13	Crawford's memorial is being printed up. See GD 17	gov docs GD 18
1852 8-31	Pres. Fillmore nominates men to be supervising inspectors of SBs. Includes Embree, Crawford, Shallcross, Murray, etc.	gov docs GD 13
1852 9-6	Crawford's appointment. Crawford accepts.	C11
1852 9-18	Sci. Am. Article. Details of new act of 1852; details of insp districts; frustration of New Orleans man who wants tech educ for his son in U.S. but will send him to France if need be; explosion of SB *Reindeer*, NY; SB companies removed good inspectors.	M1
1852 10	LIST OF INSPECTORS (ONLY SUPERVISING)	1852 Proc IMG 1456
1852 11-18	Fusible alloys. First preparation of alloys, after experiments are completed.	D2
1852 11-19	Atkinson and Watson defended by Crawford. Steamboat capts. and owners want old inspectors, who never gave them any trouble. Qualifications of Insp of Hulls, Boilers explained. Discussion of politics, Whig, Democrat, status of inspectors. Atkinson owns boats.	D1
1852 12-1	Supervising inspectors. Most if not all are persons engaged in business. Printing journals. Specs for stamping iron (e.g., "No. 1CH" etc). By James Murray.	D3
1852 12-13	Licensing issue. Crawford asks about Treasury Dept Policy on surrendering unexpired licenses.	C5
1852 12-20	Licensing issue. Asks for authority for Super Insp. to publish notice of district boundaries and where to apply.	C6
1852 12-29	Ques. about oath reqd to grant licenses. (Local Insp.)	C6
XXXX X-X	Circular. "Questions proposed in the inspection of engineers." (Pilots too). Very detailed. Can get qualifications somewhat from this. No date, but with 1853 matl.	D21
1853 1-1	Newspaper clipping. Embree will be visiting. Not sure of date.	D13
1853 1-1	Various letters charging Capt. Embree with approving inspectors by mail and not in person as reqd by law. Anyone criticizing this is met with Embree's "hostility."	C10
1853 1-10	Commission of Loc. Insp James Curran as inspector of boilers for Baltimore.	E1
1853 1	C. Evans patent notice in JFI, Jan-Jun 1853, Vol 55 (LV), first patented 4-15-1839; reissued 11-23-1852.	JFI 1853
1853 2-3	Boiler plate. Stamping rqmts; offices for Local insp. (No provision for this in the Law); sober men - appeals don't work for drunks. "Most we have done is license pilots/engrs. Crawford.	C6
1853 2-10	Official notice to the mfgs of boiler iron. Stamping conventions listed. Excerpts from 1852 Law.	D42

Date	Description	Source
1853 3-3	TD directs establishment of an assay office in New York. Web reference see 1-06 class folder.	Internet ref
1853 3-11	Loc inspectors to TS Guthrie. Wash. City. Seven insps urge the continuance of Crawford in office. Have heard that "an attempt will be made" to remove him.	Box 1 Item 177 IMG 1563-1565, 5C5
1853 3-21	Atkinson resigns (hull insp.)	C7
1853 3-31	Table of masters violating new SB law.	D12
1853 3-31	Crawford resists request to replace his Whig inspector with a Democrat. Cites the reqd qualifications to enforce a complicated law. Opposition to the Law by owners and masters of SBs.	D9
1853 4-12	Alfred Guthrie, Super Insp, 8th District, to TS Guthrie. Chicago Ill. A. Guthrie needs hydro pump put into the hands of the inspectors right away. "Otherwise the want of them opens an excuse for SBs to run at high pressures." "The whole system of inspection seems to be deranged, the pressures are upon the Western rivers unlimited, many boats using as high as 175 to 200 pounds per sq inch." Wants to limit pressures even w/o pumps, but has no control over what his local inspectors do. Accidents of this type have no excuse. Only need to recognize this and have a will to fix the problem.	Vol. 2 Item no. clipped, IMG 1655-1659
1853 4-18	Boiler plate request. Paint it, not stamp it. Refused. Would require an "Act of Congress"	Corresp. Sent by Secy Treas A1
1853 4-23	Appeal from a master for refund of $100 fine. To Pres. Pierce. His pilot had walked off.	C12
1853 spring	A Guthrie appeals to TS Guthrie, don't remove me, no one has done as much good as I have. No one understands the subj as well as I do. Being removed on political grounds. I am not political, have not voted much. Crawford and myself are the only ones toiling on the act of 1852 from the beginning. Others opposed the bill. His father was a chemist who discovered percussion powder, method for making Chloroform. Credit given to others. Brother injured in war in Mexico. In 1850 I investigated SB accidents by going on boats in disguise, spent $1000 of my own money. Why not move Mr. Lewis to 9th district and leave me here? On the removal, will you give me an answer yes or no?	Vol 2 Item 256, IMG 1662-1667
1853 6-3	Typed flyer mobilizing engineers and pilots of the Eight District to protest the continued appointment of Isaac Lewis as "late appointed Supervising Inspector." Signed, "An engineer of the 8th District." Ltr from Oshkosh, Wisconsin to Hon. Jas. Guthrie, TS. Owner of Stmr *Montello* complains to TS that Lewis would not make a hydrostatic test in June of his stmr. Excuse given that there was a want of time. Owner convinced, however, that Lewis didn't know how to conduct the test. "I believe he declined to undertake such insp from ignorance and not knowing how to do it." We who have paid our insp fees and have been deemed competent by *competent* insps are now suffering for these wrongs. "We are compelled to submit to the humiliating farce of an inspection by him. Did the law ever contemplate this, or does a decent respect to the laws of the country require of us such acquiescence?	Vol. 2 Item 270 IMG 1671
1853 6-6	Newspaper account. Good results from lic. of engineers and pilots. Reforming "dissipated" intemperate individs. Opposition noted. Wait til law becomes "better understood." Crawford bases observations on report of Atkinson and Watson.	C5
1853 6-17	Crawford wants a shipment of fusible alloy. His supply of 160 has run out.	D8

Date	Description	Source
1853 6-29	Fusible alloys. "Better and cheaper" at Navy Yard, where all alloys have been manufactured. Chief Engr of Navy.	A1, full text in 4C5
1853 7-1	TD sending 50 copies of SB law to someone, probably a boat owner. Reminds the person that inspectors handle this sort of thing as a rule.	Corresp. Sent by Secy Treas 4C6
1853 7-7	Letter from 51 engineers opposing replacement of Watson. "Our reputation as engrs depends on the skill, experience, & firmness of the insp of boilers . . ."	D10
1853 7-8	Portsmouth VA inspector Davids wants to keep hydraulic pump at his business at Gosport Iron Works. Working late at night, etc.	D15
1853 7-15	Expenses. Appropriations "so small" as to negate many incidental expenses.	Answered in D14 A3
1853 8-9	Local Insps, Distr of Louisville, blame "fast men" who don't like being regulated, for agitating about method for granting licenses.	C12
1853 9-4	A. Guthrie, late supv insp, writes to President Franklin Pierce complaining of the wrong done agnst him by the hiring of incompetent Mr. Lewis to the position of supv. Insp. Mr. Lewis was profoundly ignorant of the causes of explosions, and could not start an engine aboard a steamer to save his life. Copeland fought the SB Law and is retained. Copeland would have succeeded in stopping passage of the act had the Henry Clay and Atlantic not succumbed to accidents. Copeland started the Collins line of steamers.	Vol. 2 Item 262, IMG 1668-1669
1853 9-11	Second ltr from A. Guthrie, late supv insp, to Pres. Franklin Pierce, requesting an audience to "make my explanations." Doesn't wish to annoy Pres. with more letters on the subj of steam boat inspectors. Xcribed.	Vol. 2 Item 263 IMG 1670
1853 9-16	Crawford writes Haldeman and (WW) Guthrie advising they get evidence of Hamilton's drunkenness. "Let us try and get clear of the drunkards in some way or other . . ."	C13
1853 9-21	Hamilton license revoked by Haldeman and W.W. Guthrie. "Incompetent."	C7
1853 9-22	Chief Engineer of Ward's Steamers defends Isaac Lewis, Sup Insp 8th District. Xcribed.	Vol. 2 Item 271 IMG 1672
1853 No date	LIST OF INSPECTORS 1853	1853 Proc IMG 1455
1853 10-10	Expenses. Local Inspector room rent disallowed. Several letters of this type.	A4
1853 10-12	TS Guthrie denies expense report. Wm F. Barnes, Esq., Insp of SBs, Oswego NY.	Near A3
1853 10-15	TS Guthrie to Chas Brown, Collector at Phila. Brown cannot find rooms in custom house or other public bldg for the local insps to house their instruments and conduct their business. TS advises Brown says no money available to rent rooms; advises them to put instruments in a warehouse rented recently by customs under authority of TD.	A series, misc
1853 11-16	Embree on Hamilton case. "Merely a 4th of July frolic." Hamilton's drunkenness; Hamilton is a beggar without his license; "monstrous power" of the Board; conditions upon which license is granted are not on the license; Hamilton's appeal refused; full and fair trial requested. To Crawford. Board of Supervisors not instructing local boards in such cases.	C9
1853 12	Legislation markup of 1852 Law. Not sure of exact date, but with other 12-1853 records.	D19
1853 12-1	Hamilton sues! $5000 suit against Haldeman and Guthrie, who are writing to Crawford. Is Embree involved?	C8
1853 12-2	Crawford's reply to Embree. Fears no "monstrous power" or community revolt. Hamilton had his chance, acquiesced decision of local board by default. Now he sues. Intermediaries to blame for the fluff (implying Embree).	Vol 3 C10; IMG 1422-1426

Date	Description	Source
1853 12-2	Fifty copies of SB law being forwarded by TS James Guthrie to J.A. Campbell, Super Insp, Buffalo.	Letters sent by TS, Vol 1 IMG 1419-1420, p. 38
1853 12-5	Hamilton case. Crawford writes back. "let the matter rest." Pleads innocent re: Embree involvement. Regrets loss of peace and harmony in Districts.	C8
1853 12-15	Letter from WW Guthrie copying b.crawford, responding to TD circular. Uneducated engrs gradually superseding others better qualified. Recommends hydro tests 4x per year. "Act of faith" in using steam and water guages. Guages get out of order. Better: "seeing," "feeling" of safety valves and sight of water in guage cocks. BEGINNING OF DOUBT ABOUT FUSIBLE ALLOYS. Theory advanced by "scientific men" hard to reconcile w/engineers' observations in actual operation. Boat's boiler only fair test. Recommends govt buy Evans patent and his mfg experience, make SG free.	Vol 3 IMG 1170-73, IMG 1181-87 Xcribed
1853 12-26	Newspaper account of flue collapse aboard SB Zachary Taylor. Acct by Crawford. Careening, low water, sudden rush of cold water on hot iron (old theory) blamed. Hogs careened boat.	D20
1853 12-28	Copy of correspondence from H. Hunt, U.S. Navy Yard to Com.[modore?] H. Paulding, commanding U.S. Navy Yard, Washington. Ltr originating from US Navy Yard, Washington. Responding to Bureau of Navy Yards and Docks inquiry, to which Hunt was referred to provide an answer. Tedious experiments made under direction of Mr. Ellis were of no guide as the melting points varied greatly. Some varied as high as 40 psi, showing a difference in the purity of metals.	Vol. 2 Item No. clipped, IMG 1643-1646
1854 1-2	Holding inquiries aboard boats; lack of office space.	C11
1854 1-13	Fusible alloys. Secy Navy wants Treas Dept to manufacture fusible alloys. Experimental info needed, proportions of metals used.	A1
1854 1-26	Cadwallader Evans letter to TS Guthrie. Son of Oliver Evans; Evans's qualifications; Evans's recent experiments on Fus. Alloys; wants Congress to modify law so that fus. alloys are not used in boilers where the press. of steam can act upon them. Effect of mud on the fixture in which alloys are placed.	D16
1854 1-27	J.C. Dobbin to TS Guthrie. Navy Department. Complying with TS request of 13th inst. for info on mfg of fusible alloys at Navy Yard for use by Super Insps. Forwarding ltr from chief of bureau of Navy Yards and Docks; stmt showing expenses incurred in prep of hydro pumps, alloys, etc; a report from Mr. Hunt, the engineer and machinist; a letter from Mr. Thos. Copeland covering a tabular stmt of experiments made by him with alloyed metals.	Vol. 2 Item 149, IMG 1647-1648
1854 2-7	BOOTH JOINS. Fusible alloys. TS Guthrie asks Booth/Mint to prepare alloys because Navy has not prepared it correctly. Mint is the only establishment connected w/Treas Dept in which there is any chemical skill. "Many lives" depend on quality alloy.	A2
1854 2-8	Booth to TS Guthrie. Phila. In reply to your favor of yesterday, I am willing to superintend the mfg of the alloy you mention. If your purpose is for us to experiment on the proportions of metals, then there is ample space here is in Mint bldg. But if alloy to be mfgd largely, then not enough space. Need a separate bldg close by for that business. Mentions his duties at the Mint as providing “superintendence and direction.”	Vol. 2 Item 157, IMG 1650

Date	Description	Source
1854 2-15	Booth to TS Guthrie. Phila. Booth has recd papers from TS as to alloys. But they contain nothing definite as to proportions of metals composing the various alloys. Unless more certain info can be collected from previous experiments, many more small experiments will be reqd. Question also must be resolved re successive fusions altering the fusing points thru repeated heatings. Booth admits he made a hasty conclusion on the subj a few years since. That he should not sacrifice the care of an engineer for fus alloy that was not entirely reliable. Has changed his mind since; we cannot employ too many precautions to prevent the dreadful loss of life by explosions.	Vol. 2 Item 152, IMG 1651-1654
1854 2-24	Fusible alloys. Guthrie refers Booth to C. Evans' pamphlet on fusible alloys.	A2
1854 2-27	Booth to TS Guthrie. Phila. Booth will use his laboratory to experiment on, and manufacture, alloy to save expenses of a location. Shall I forward bills for metals and apparatus to the TS? Has examined the FI experiments, plus those of Rudberg, but there are no alloy proportions for given temps as documents sent by TS require. Will institute experiments to determine this. Notes problem of "absolute reliability" due to separation of components; not sure how this can be overcome.	Vol. 2 Item 38, IMG 1586-1587
1854 3-4	Booth to TS Guthrie, Phila. Heard from TS on 3-1, with Evans' pamphlet. TS has referred to a document that contains a report of Sup Insp for last year. Doc sent contains no report. The only point of interest to me is the number of steamers built in the U.S. Some mistake in forwarding? Now engaged in collecting all data of past experience in relation to fus metal so as to shape my experiments. Has just ordered a small amt of Pb, Sn, Bismuth. Has authorized a business here to import by stmr about 500 lb of grain tin. Other metals can be obtained here.	Vol. 2 Item 39, IMG1588-1589
1854 3	Reindeer flue collapse this month. Embree interviewed; see 1854 10-7. 38 dead.	Proc 10-10-1854
1854 3-7	Wm Burnett, Local Insp of boilers, invents an improved arrangement of fusible plugs. JFI, Vol 57, 1854, p. 300.	JFI 1854
1854 4-5	Fusible alloys. Guthrie asks Booth for report of experiments.	A4
1854 4-6	Booth to TS Guthrie. Phila. To carry out TS request to prepare fus metal, Booth has ordered several metals, but did not recv bismuth until lately. Furnace just completed. At TS suggestion, Booth has consulted with Super Insp from NY, who informed Booth of the mtg in Washington. Subj of fus alloy will engage the Board's special attention. They ("the Supervisors generally") of opinion that if alloy not used in form that excludes pressure of steam, it is worse than useless. In mean time have made some prelim experiments, some alloys have fused at proper points, others I fear will require many experiments to obtain reliable quality.	Vol. 2 Item 40, IMG 1590-1591
1854 4-7	Letter fr J. Booth (scribed) to TS stating that he has corresp. with Prof Alexander on subj of the alloys re: Evans' patent. We both agree that the substance of Evans' Patent is contained in the plan for preventing explosions suggested by Prof. Bache of Washington, in 1832. Prof Alexander even prefers Bache's to Evans's, and to an improvement that Booth suggested in order to reset the apparatus. Should we consult Prof. Bache? Also Prof Alexander of Baltimore, should I procure his opinions and presence in Washington? This would be done to secure sound decisions by the Board of Super Insp "on a subject of such moment."	Vol 3 IMG 1180. [?] Also? Vol. 2, Item 41, IMG 1592

Date	Description	Source
1854 4-7	Proceedings dtd 4-7-1854, held in Washington City. See p. 90. What Ross uses to define method for use of alloys. (Does not mention Evans' SGs). Supervising inspectors link alloys to SGs in general. Board resolution?	Proc. 1854, pp. 11, 84-91, 2C4
1854 4-11	Booth to TS Guthrie. Lebanon, Lebanon Co. Pa. As present mtg of super insp in Washington may lead to a modification of the SB law as relates to use of fus metal, you may want to communicate the following views to the Board: (1) different phases of melting alloys allow great range in temps, and thus pressures. (2) If Evans or analogous method be adopted (and I can conceive of no others applicable), assume that the practical fus point be that at which iron passes through alloy, but a limiting range of many pounds pressure should be allowed because of want of exactness even in this fusing point. (3) Am looking for at least one alloy of proper composition that will give a more determinant fusing point for the pressures most needed, i.e., dangerous higher pressures. (4) I have examined several sets of tables showing the correspondence between temp and pressure, and found them quite variable.	Vol 2 4C2, item 42; also IMG 1593-1595
1854 4-17	Haldeman and W. W. Guthrie charge Embree w/interference, resulted in $5000 suit against us. Hamilton stories - caused great loss of life running into steam boats, shooting at pilot, etc.	C14
No date	Newspaper acct. Exoneration of Haldeman and Guthrie in Hamilton suit.	D28
1854 4-19	Petition of SB insps [prob loc insps], engine builders, and other citizens of Pittsburg represent the importance of Evans SG and praying for the purchase of the patent right, make same free to the public, referred to the Commerce Committee.	Gov docs GD 10
1854 4-28	Booth to TS Guthrie. Phila. Have made a large no. of experiments, can prepare many fus alloy w/ pressures less than 130# above ordinary atmospheric pressure. I am not at all satisfied with any proportion of metals composing alloys to express pressures above 130#, it being difficult to determine their melting point within 10 to 30 deg of temp. Probable that I shall have to contrive new alloy for the higher pressures.	Vol 2 4C3, item 43; also IMG 1596-1597
1854 5-1	Mr. Chase (a senator) presents a petition of SB officers and engineers at Cincinnati, praying that measures may be taken to make Evans SG free to the public, by the purchase of his patent right or otherwise, referred to the Comm on Commerce.	Gov docs GD 9
1854 5-1	By Mr. Disney: two petitions of citizens, SB inspectors and prac engineers of Cincinnati, in relation to the public utility and importance of Evans SGs, referred to the Comm on Commerce.	Gov docs GD 8
1854 5-1	Fusible alloys. Fusible alloys must be used on principle of Evans SGs (to Booth). Booth requests a table of press./temp but Board has no knowledge of one.	A4
1854 5-1	Embree castigated by SB engineers on Embree's procedure for selecting engrs. No oath, no examination, etc.	D4
1854 5-5	Booth to TS Guthrie. Phila. The further I progress in my experiments, the more I realize it is essential for me to experiment directly with the Evans apparatus ("which the Board of Supervisors has adopted") to determine practical fusing points of alloys. Describes his experiments drawing tubes with thermometers out of molten lead/tin. Table showing relations of proportions of metals to temp observed. Fusible states are labeled in table: "perfect fluidity," "pasty state," "rather stiff," "solid," and "drew the pipe." The best alloy (for consistency) is the 4th in the table, and it is the alloy usually quoted as showing the reliability of the fus alloys. Ratio 7 tin to 4 lead. [Note written on wrapper: "Try and get apparatus for Booth and write Director to permit Morfit to experiment under his direction until his service is required at Assay Office." Gouge's signature and the date are on the wrapper.]	Vol 2 4C4, item 44; also IMG 1598-1601

Date	Description	Source
1854 5-10	Evans Safety Guards. Several being sent to Booth for experiments w/fusible alloys.	A5
1854 5-16	J.C. Dobbins to TS Guthrie. Navy Department. Chief of Bureau of the Navy Yards and Docks has been instructed to comply with request contained in your ltr of 15th inst re disposition of the hydrostatic pump remaining at the Wash Navy Yard, to send it to Louisville KY. No address is contained in your letter.	Vol. 2 Item 150, IMG 1649
1854 5-23	Embree cites Local Board of St. Louis criticism of effect of Evans SGs as presently mfg'd. Fear of Evans's monopoly. Power of his patent, poor mfg. Failure of SGs would make more $$ for Evans. Letter also points to possibility that Evans SGs haven't been decreed to be used on all boats yet. Inquires if Booth has succeeded in making alloys more reliable. Embree wants words "alloyed metals" removed from Law.	D5
1854 5-24	Singleton. Complaint against Embree for hiring inspectors from a distance. Loc. Insp Singleton, St. Louis, writes his nephew at Treas Dept.	C10
1854 6-5	Evans informed to complete safety guards for sending to Booth for experiments.	A5
1854 6-9	Cad. Evans to TS Guthrie. Pittsburgh. Long ltr. TS has apparently complained that SGs sent by Evans to Booth were not "complete in all respects." But Evans said he was limited to NTE $100 and therefore did not send his most expensive SG. He notes correspondence with Booth, dates.	Vol 2 Item 116, IMG 1635-1642
1854 8	Gouge's notes, first part written in Aug 1854, see 2-21-1855 entry.	
1854 8-7	Evans safety guards. To Booth. Is Evans' Patent necessary? Trials of fusible alloys cannot be made at Navy Yard quickly enough. Booth to buy a boiler to make the tests himself.	A5
1854 8-14	Fusible alloys. Shipment pending experiments. If not prepared correctly, would be "worse than useless"	A3
1854 8-14	TS to P.I. Barzize, Collector at Yorktown VA. Re Stmr Gladiator, law specifies the districts for which loc insp are to be appointed, and mode of their designation. TD has no power in these things.	A series, misc
1854 8-23	Est. of expenses. Louisville. Hyd pump - difficult to maintain for testing old boilers (hi pressure reqd).	C12
1854 9-8	M. Gouge's ltr to Peter G. Washington, Esq., Asst TS. Phila. to Wash D.C. Marked PRIVATE. Gouge's 'piracy' of printed law pamphlet. Boston publisher. Booth wants some of Evans's alloy--get some "in a private way" via Benj. Crawford.	Box 1 Item 22 IMG 1510-1514
1854 9-25	Fusible alloys. Wheeling Assoc. of Engrs complain it is unsafe. References Kentucky inspectors. A "perfect failure and imposition on Steam Boat money." Asks for repeal of the fusible alloy portion of the Law. Engrs prefer steam gauge, water gauge w/safety valve and try cocks.	C13
1854 10-2	Booth has prepared a dwg of boiler. Cost $400. Evans safety guards plus fusible alloys.	A6
1854 10-2	Secy of St. Louis Assoc. of SB Engineers introductory letter on the report on fusible alloys. "unanimous expression and sentiment of . . . 280 SB Engineers."	D17
1854 10-2	"A Report on Fusible Alloys and Safety Guards Made to and Adopted by the Saint Louis Assoc. of SB Engineers." Transcribed in full, in Red book with IMG 1149.	D18, IMG 1149-68
1854 10-5	Inspection details of SB "George Page." "Gives us more trouble than any other owner."	D14
1854 10-7	Embree comments (Sci. Am.) on *Timour No. 2* explosion. Sci American.	Gov docs GD 21

Date	Description	Source
1854 10-19	Letter on behalf of Jane Evans fr D. Benson to W. M. Gouge. Pittsburgh. Jane Evans interested in writing a contract w/govt for $1 per lb of alloy. She intends mfg SGs in her own name. When C. Evans was sick, she superintended the weighing and mixing. The gentleman appointed by Govt to mfg alloys has resigned [Navy Yard or Booth?]. No one else appointed in his stead. Several new steamers left this port w/o SGs. Please write and advise Mrs. Evans.	Box 1 IMG 1472-1474
1854 10-21	EVANS DIES. Prof. John Locke to TS Guthrie, Cincinnati. Altho there are enemies to Evans SG, I think it excellent. Have myself examined it, experimented with it, and it's good. Capt Haldeman is also in favor of it. He thinks its applic the most essential part of the SB law. Regret that SG has been almost nullified by govt ceasing to furnish the alloy to inspectors. Evans' workmen have the necessary experience to make alloy. To make alloy fuse at proper temp is the soul of the invention. Evans succeeded in doing this, for I verified the results by rigid experiments. Locke is "late prof of chymis in the Med. Coll. of Ohio."	Vol 2 IMG 1660-1661, Item 119.
1854 10-28	Evans safety guards under consideration by Board of Sup Insps. No promises (to Booth)	A6
1854 11-1	J. Curry, local inspector, New Orleans, ltr to TS Ja Guthrie. *Timour No. 2*. Absurd theories no engr should claim - in testimony. Refers to Super Insp Resolution of 4-7-1854 re applying alloy "in a suitable manner" in a tube. Steamer in his district using plugs - no good. Regrets report of St. Louis engrs.--doesn't deserve a passing notice. Convinced w/Evans SGs no explosion can happen if left free to act. Has in past 12 mos. revoked licenses of 12 engrs mostly for loading safety valves or fastening down Evans SGs or other devices.	Vol 3 IMG 1188-91
1854 No Date	To Pres of U.S. from pilots & engrs. Inconvenience of going to St. Louis to get licenses. 20 signatures.	Vol 3 IMG 1192-93
1854 No date	Pamphlet: "A Stmt of Experiments upon the Temp of Steam, the Opns of the Common Safety Valve, and upon Govt Alloys: with a Descript. Of Newly Invented Saf Valves, &c." by Cad Evans.	Vol 3 IMG 1194-1229, Reshots in IMG 1674-1678
1854 No date.	Mistaken reshots of Evan's A Stmt of Experiments upon the Temp of Steam, etc. Different edition? Pages don't line up.	Spineless Vol 1852-60, IMG 1439-1445
1854 11-7	Suggested amendments to SB bill; bill too verbose. Also, remove "fus. Alloy" Recd at TS 11-7-1854. Jos. Swager [Loc insp hulls 6th District, Louisville, under Shallcross] to TS James Guthrie. Recommends org changes--eliminate super bd, call members of loc bds under a presiding person of scientific attainments. Super Bd too expensive. Fus alloy has "utterly and entirely failed." SB engrs assoc to weigh in on subj of fus alloys. Collision and signal matters. Pilot rules. Price of pilots and engrs lic renewals.	Vol 3 IMG 1174-79
1854 11-11	Process service to offenders for revocation of licenses is stymied due to no fees for service authorized in the Law. Inspectors have no official seal. Embree.	D6
1855		
1855 1-1	Steamer Kent - illegible. Something pertaining to annual license issue.	D29
1855 2-21	Gouge's notes ON FUSIBLE ALLOYS. Copied on Dino 4-6-05. Xcribed. Six dbl sided legal pgs - blue. Item 75 -- not labeled, but found just ahead of Item 76. <u>FIRST PART OF NOTES (FROM 8-1854)</u>: Justifies fusible alloy iaw scientists' opinions. History of difficulties of introducing alloys. Long, detailed letter. <u>SECOND PART OF NOTES 2-21-1855:</u> Events have occurred since last notes. Evans has died, widow inherited his secret of mfg alloy; Super Bd in meeting in Oct 1854 did not rescind resolution on f.a., but left it to local boards to apply as they saw fit; Booth has made reports of progress but not reported	Box 1 Item 75 5C1 IMG __?

Date	Description	Source
	(1855 2-21 CONT) alloy ready for use. Evans SGs most useful contrivance, but no fair experiment can be made of law of 1852 unless they be generally adopted. See text for quote, p. 6. If Booth can't succeed, then jane evans is only route open. Prof Smith could test alloys.	
1855 2-22	Booth to TS Guthrie. Phila. Commencing the preparation & testing of the alloys. Procured small test boiler 3 weeks since, but trouble getting insurance for it. Insurers afraid boiler would explode [ironic] and burn down bldg. Finally got ins, apparently, and is using boiler and a small apparatus. Working to improve the character (reliability) of the alloy thru experiment. Attached table of fusing pts. Enclosing invoice of Morris Co. for test boiler (see IMG 1143 for the bill). Booth pd for intro of water into room himself. Furnace set up, obtaining casting pot, marking punches, fuel, and cast iron molds. Booth worried about pleasing TD re: mfg speed. Could use more persons, but TD wants economy.	Box 1? Item 77 IMG 1140-1142
1855 2-22 ?	Morris Co. invoice for Booth's small test boiler. Date too hard to read, but came w/ Booth's 2-22-1855 ltr (see IMG 1140-1142 of same date).	Box 1? Item 78 IMG 1143
1855 2-22 ?	"Results of Experiments on Fusible Alloys," Booth's table of fusing points, derived from his experiments.	Box 1? Item 78 IMG 1144
1855 3-13	Booth to TS Guthrie. Phila. Continuing the mfg & test of fus alloys "as fast as I can prepare them," using 3-4 persons. Testing in 50-lb batches, three batches per day. Testing method--tests first and last alloy, then stamps them. Uses Mint's "shoe moulds." Just recd ltr from Shallcross re: apparatus. Doesn't know how to answer him re: apparatus. Explores other apparatus besides Evans SG, e.g., Bache's. Recommends TD investigate legal issues w/making govt SGs. Booth would pkg one w/each batch of alloy [cheaper than Evans SG, presumably]. Alloys need 1 page instrucs. Tube must touch flues. Put alloys in kegs so they can be rolled along.	Box 1? Item 83 IMG 1135-1138
1855 3-17	Evans safety guards. Booth had asked for legal opinion. Did Bache's mode infringe on Evans' patent?	A6
1855 3-20	Booth to TS Guthrie. Phila. Just recd 3 orders for alloys. Most have come from inspectors as Booth wants TS to certify them "as issuing from a proper source." Wants to procure circular of instructions also.	Box 1? Item 84 IMG 1139
1855 3-31	Shallcross and Crawford to TS Guthrie. Alloys about to be distributed by Booth. We wish to postpone use of them in our districts, with your sanction, until Booth completes his studies of the different apparatus. Govt alloys we have recd before now have been defective. xcribed.	Vol 6 IMG 1685-1686, Item 162
1855 4-10	Evans's Patent renewal application for his SG - 1852. True copy of letters patent from the U.S. Patent Office (w/red seal) (Orig dtd 11-23-1852). Attached are Patent Office docs wrt to the patent. These describe Evans' excessive zeal in advertising and pushing the SGs upon the community, which have resulted in the difficulties he has had to contend with in introducing his invention. The patent office corresp. is transcribed.	Spineless vol 1852-60 IMG 1395-1413, Item 16
1855 4-16	Connecticut inspector discusses small pressure of hydro. pump provided for hydro. test of large SBs. Pay per day cited.	D27
1855 5-1	Ltr from Atty General's Office to TS james Guthrie. Compared Evans and Bache's patents. No interference between the patents. Evans's language too general and sweeping to make his patent exclusive. Other devices are okay. Bache's device may be mfg'd without infringement.	Spineless vol 1852-60 IMG 1388-1394, Item 19
1855 5-19	"Know nothing" politics intrude on choice of replacement local inspector at New Orleans. Insists on statement of political position of all applicants.	D26
1855 5-26	Local Inspectors, NY, want to spend $10 for a new tap to connect hydro pump to boilers. Using "Croton water." (New aqueduct to NYC).	D31

Date	Description	Source
1855 6-2	Complaint of arbitrary power of inspectors in NY district agnst Edward Barnay. He denied license, refused appeal. "I submit . . . Whether a citizen must be compelled to fold his arms & go to the poor house merely because an inspector chooses to persecute him." [Xcribed.]	Vol. ? IMG 1682-1684
1855 6-6	Booth to TS Guthrie. Phila. The Evans SG model I have is fine; no need to get another model spoken of in Prof. Locke's comm. Conclusions thus far--simple plugs of fus alloy may be used for 110-160 lb pressure. Alludes to "favorable opinion expressed in regard to the new alloys we have issued." I am well satisfied of the reliability of "every pound" of alloy we have distributed. Others can now test the accuracy of alloys in relation to the pressure expressed on them."	Box 1 Item 100 IMG 1515
1855 7	Louisville KY - Payment of witness claims. U.S. Marshals etc. Difficult to read.	D32
1855 7-12	Early ltr of Crawford's, where he supported Dickey/Watson's travel claims before the TS. Shows contrast before/after Fanny Fern controversy. See also 3C1, 8-30-1858.	Vol 6, 3C2, p. 172
1855 7-14	Booth to TS Guthrie. Phila. Reply to Guthrie's 7-11-1855 comm. Have experimented on forms of apparatus (SGs) sufficiently to know that Evans SG is not the only way to go. Bache's method, slightly modified, works. Haven't had time to work on mechanism because I have been studying the chemistry ("my devotion to chemical pursuits to the neglect of mechanical.")	Box 1, Item 101, IMG 1516-1517 Also IMG 1145-1146 (dupe shots)
1855 7-18	Booth to TS Guthrie. Phila. Just recd comm from J. P. Morris of Phil, boilermaker. Made Booth's experimental boiler. Do not need their boiler as the small apparatus I use in the tests is superior. Suggest using sale proceeds to finance experiments on fus alloys. Will have report ready in 10 days, xmit to TD.	Box 1 Item 102 IMG 1518
1855 7-23	Jane Evans ltr to TS James Guthrie. Fus. alloy for past 3 mos. has been made by Prof. Booth. Yet, SB inspectors here at Pittsburgh, St. Louis, Cincinnati, fail in their duties by not mandating SGs on boats. Went to Phila last week to see Booth about this. Will you straighten out the inspectors, direct them to follow the law? I have already lost $2000 because these men do not procure and apply the alloy. Ltr xcribed.	Box 1 Item 104 IMG 1475-1476; also as IMG 1519 (dupe shots)
1855 7-29	Dashiel (?) writing (to whom?) Hard to read. Capt Embree not inspecting stmrs. Boat containing mail and business will be delayed unless you (TS?) provide some relief. Ltr xcribed, but difficult to make out due to camera blurring.	Box 6? IMG 1691-1692, Item 81
1855 7-30	Adams pkg receipt. Booth to Embree--4 boxes [200 pcs] of fus alloy.	Box 1 Item 106 IMG 1522
1855 8-9	Booth to TS Guthrie. Phila. Booth xmits various docs in relation to fus alloys. (1) report on forms of apparatus, plus dwgs. Have long since ordered an apparatus similar to Fig. 1; (2) a dupe receipt for 4 boxes of alloy shipped to insp at St. Louis 10 days ago; (3) receipts for work on fus alloys, incl Carleton's for boxes to ship alloys and those of Hunter, Morgan, Garrett, & Wm. Rogers.	Box 1 Item 104 IMG 1519
1855 8-23	Booth to TS Guthrie. Phila. Responding to TS comm on Booth's report recently recd at TD. Would have provided more detail on plugs, but experience by insps in their use rendered this unnecessary. My experience with them is only theoretical. Anticipating printing of the report. Prefers to meet w/ Benj Crawford [on the subj of the pending public release of my report]. Has had prior "short intercourse" w/Crawford--was impressed w/his intelligence and experience.	Box 1 Item 107 IMG 1523-1524
1855 8-27	Fusible alloys. Plugs. Diffuse information thru report. TD to Booth.	A7

Date	Description	Source
1855 8-30	Booth to TS Guthrie. Phila. Booth xmitting an order for 125 lb of fus alloys to Nashville Dist. Local Insp. Booth wishes to proceed to Pittsburgh to visit Crawford on the "hitherto use of the fusible plug" and to inspect "apparatus now or formerly in use."	Box 1 Item 108 IMG 1525-1526
1855 9-22	Booth to TS Guthrie on Mint letterhead. Phila. Enclosed is an order for fus alloys from loc insp of Wheeling VA. Booth has put the report and dwgs in the hands of the printers. Met w/Crawford--useful meeting. As a consequence, has added a dwg of best form for a plug, plus descriptive comments on plug in report.	Box 1 Item 112 IMG 1527
1855 8 (but distrib in 9?)	J. Booth, published pamphlet, "Report on Apparatus for the Use of Fus Alloys in Steam Boilers." Inventions w/circular movement (Evan's SGs); vertical movement (Bache's nippers); and lateral movement. Problem of rust on such machines; segregatory tendencies of fus alloys. Artwork not in pamphlet, but can be found in Proceedings, 1855, p. 56	Box 1 - White Box 2C3
1855 8 (but distrib in 9?)	Booth report from Aug 1855, including dwgs. (Report incl in Proceedings). (Dupe of Booth's pamphlet). Fus alloys and machines for using them, etc. Only 7 pp of Proc. Proc. Held 10-10-1855 in St. Louis. See also 2C3, IMG 1447 (artwork reshot - fus alloys, alloy in a cup), 2C5.	Proc 1855 pp. 50-57 of Proc., 2C5
1855 9-10	Boiler insp Barnes submits his travel expenses. 10 trips, $150.60. Oswego NY.	Box 6? IMG 1688-1689, Items 139, 140
1855 10-1	Booth to TS Cobb. Mint letterhead. 300 lbs of alloy have been xmitted to their respective destinations. Past quarter's bills. Ladles for melting alloy being made.	Box 1 Item 113 IMG 1528
1855 10	Boiler fraud - types of crimes.	Proc 1855 IMG 1457
1855 10-10	Proceedings of Fourth Annual Mtg on subj of Booth's report. Issue of plugs exposed to pressure of steam. Distribution of his report to Local Boards. Supers prefer SGs to plugs of tin.	Vol 4 IMG 1235-37, pp 42-43
1855 10-12	Booth to TS Guthrie. Phila. Order recd from loc insp of Phila for fus alloys: 100 lb, 70 lb, 60 lb press. Sent by mail today. 225 copies of report. Wishes to lay before the Bd of Supers the whole subj of "forms of apparatus [that] may be advantageously employed." Trusts their experience to determine the best form. Distrib report to super & loc insps, also to machinists of steam engines. See what the latter think; object being "to elicit . . . inventions or improvements of apparatus for using fus alloy." Send also a copy to Bache of Coast Survey, "for I availed myself of a suggestion of his for the vertical movement."	Box 1 Item 118 IMG 1530-1531
1855 11-2	Fusible alloys. To Booth. 500 copies of a plate re: report.	A7
No date	Newspaper article (no date, but prob 1855 or 1856). Congress bought by special interests, drags feet; touts value of fusible alloys. Combine forms to thwart law. Article based on interview w/Crawford. Banca Tin--see 1856 Proceedings, p. 29. Super insp advocate changing 9th section that stipulates the method for using fus alloys. Text of change to law shown. Now use fus plugs or rivets of pure tin.	Proc 1856 D35
1855 11-15?	Booth to TS Guthrie. Phila. Fuzzy, hard to read. Dwg of apparatus alluded to not yet "effaced from the stone." Refers to request of Mr. Lucas. Bill for printing submitted. 500 plates.	Box 1 Item 120 IMG 1532

Date	Description	Source
1856		
1856 3-24	Adams pkg receipt. To local inspectors, New Orleans. Booth ships out alloy.	Vol. 6? IMG 1690
1856 4-9	Dickey & Watson letter recd by Board of Super. Insp. P. 16, 1856 Proceedings. No further action deemed necessary. This was anticipated by the Board.	Proc. 1856
1856 7-1	Booth admits he doubted the utility of fusible alloys when commencing their preparation. Now reliable, don't abandon them.	Vol 6 D24; p. 149
1856 11	Gouge's notes on fusible alloys. Gouge takes strong issue with McCord's stmts discovered by Gouge in a newspaper letter. McCord is insp of boilers at St. Louis, writing to Embree, ltr dtd 9-30-2856. Experiments on fus alloy on SB *Reindeer* validate SG. Gouge indignant that McCord derives his office and salary from the law, but would have the Bd suspend its operation! "We shall have a beautiful govt indeed if each subordinate officer enforces the laws, or leaves them unenforceable, according to his own practical views of their expediency." Etc. Monopoly issue - "I have never heard such an outcry" with other patent inventions used on SBs. Evans' patent will expire shortly, but blocks of tin, which will do away with the use of SG, is intended to be permanent. In supporting fus alloy applied in suitable manner, I am in company with many of our most distinguished men of science, steam engine builders, and our most able engineers and other SB officers. Long, detailed letter.	Vol 6, Item 64 IMG 1693-1711
1856 11-19	Booth ships alloys to Louisville KY. Indicates each piece weighs a little over a pound. One box = approx 55 or 56 lb. Adams Express receipts all throughout this section of the correspondence. Means Booth was shipping fus alloys out to all districts at this time.	Vol 6 D22; p.155
1856 11 & 12	Booth shipments of fusible alloy in late 1856 (11-1856/12-1856). New Orleans, 2 boxes (100 pcs); Mobile AL, 5 cases (boxes?); Louisville, 2 boxes (100 pcs); Cincinnati, 1 box (50 pcs). Typed note only, Adams' Express receipts sprinkled throughout Vol 6.	Vol 6 C15
1856 12	Booth ships alloys to New Orleans, Mobile, Louisville, and Cincinnati.	Vol 6 3C3
1856 12-1	Booth (on U.S. Mint stationery) sends 50 pieces of fusible alloy to Cincinnati.	D23
1856 12-1	Package express receipt - 2 boxes. Refer to D23.	D25
1856 12-23	Hydro pump broken. Need to place it on wheels. Request also a half cord of firewood to heat the office. Curran/Farlow from Baltimore, Local Inspectors.	D30
1856 11	Summary of shipments in nov and dec 1856. New Orleans: 2 boxes, 100 pcs; Mobile AL: 5 cases (boxes?); Louisville: 2 boxes (100 pcs); Cincinnati: 1 box (50 pcs). [More accounts are spread out throughout Vol. 6].	Vol 6
1857		
1857 1-7	Remonstrance of citizens [engrs?] of the US navigating the Ohio and Miss. Rivers, against the ninth section of the 1852 bill, praying the govt to purchase and make free "Evans' SG.	Gov docs GD 5
1857 1-12	Booth to TS. Guthrie. Phila. Laments that he "has recd orders a second time from only a few loc insps." Fears that "previously existing prejudices remain agnst their utility." Was himself "formerly prejudiced . . . now impressed with their value." Combined remedies (I.e., fus alloys and tin plugs) better than nothing. Wishes to convey his opinion that use of tin plugs should not dispense w/ employment of fus alloy since their objects are different.	Box 1 Item 121 2C1, IMG 1533-1534; also IMG 1147-1148 (dupe shots)

Date	Description	Source
1857 1-26	Mr. Bigler presents memorial of Jane Evans, widow and executrix of late Cad. Evans, remonstrating agnst the enactment of any law by which the use of plugs or rivets of pure tin may be reqd in the construction of engines for steam vessels instead of the SG now in use, referred to the Comm on Commerce.	Gov docs GD 6
1857 1-31	Mr. Bigler presented 3 memorials of citizens [engrs?] engaged in navigation upon the ohio and Miss rivers and in construction of steam vessels, praying that Congress will make an appropriation to purchase the right to use Evans SG, referred to the Comm on Commerce.	Gov docs GD 7
1857 3-3	R.T. Queen's 2-9-1858 copy of arbitrator's stmt of Crawford's debt owed Queen. $4,505 real estate at 6% int. $1,400 with int in full of negroes. See related IMG 1498 2-8-1859.	Box 1 Item 333 IMG 1499
1857 9-4	Miss. River pilots have combined - unlawful conspiracy. Abuse of licenses. Inattention to proper duties by combiners.	B3
1857 9-9	Inspector of Hulls busy running a steam boat. Also, the boiler inspector "incompetent" (Chas. Gilmore) as judged by a no. of engrs/pilots. New Orleans.	B2
1857 10-20	C.W. Copeland (Super. Insp NY) charged w/corruption. Involves Steamer *Niagara*.	B3
1857 No Date	LIST OF INSPECTORS 1857	1857 Proc IMG 1448
1857 11-3	Alabama Engrs conspire to monopolize employment of engrs. Like Miss. R. Case in 1857. "revoke lic. of ringleaders." Extortion of exorbitant compensation for services charged.	B4
1857 11-9	Expenses. TS Cobb orders Dickey and Watson to sell carpet.	A3
1857 11-30	News clipping - W.R. Jackson's Patent Detachable Safety Deck Saloon Cabin. From US Mining Journal, RR & Financial Advertiser, Vol X, New York.	Spineless vol 1852-60 IMG 1414, pp 123-124
1857 12-8	Inspection certificate, Steamer *Eliza Battle*. Mobile, Alabama. This boat burned to the waterline.	Vol 5? IMG 1271
1857 12-15	Calif. Local Inspector engaged as agent for several insurance cos. and not paying attention to duties.	B5
1857 12-24	Unspecified charges against Local Inspector in Phila. Note concludes in margin re: Republicans/Democrats.	D33
1858		
1858 1-3	D. Lynch [a SB capt, I think] newspaper article, *Pitts Daily Evening Reporter*, letter to editor, 1-14-1858 issue. Lynch would not endorse Crawford's Democracy. Crawford reported I was an applicant for Super Insp, which Crawford has held for 6-7 yrs. False! Also said I made great exertions at Wash. City as Dickey's replacement as hull insp. Crawford not experienced in SBs--made wood patterns for sand castings. Crawford acts like a Dem but really is a Whig. Watson a Whig also. Crawford had $600 worth of SB blanks printed by a Whig printer when Dem printers were available. [with Dickey papers - he is applic for super insp]. Crawford hadn't even voted, unless after 1856, at which time he began supporting Democrat position.	Box 1 Item 324 IMG 1493-1495
1858 1-13	Loc Insp T.J. Haldeman to TS Cobb. Cincinnati. Efforts are being made to remove Crawford as sup insp. Capt Ross vying for position, is an applicant--but he doesn't have the technical knowledge of steam. Sup insp are reqd to inspect boats in their districts where there are no local boards. Must carry hydrostatic pump, solve steam pressure calculations, etc. Ross a good pilot and master, but no engineer. Bad choice. Recommendations often are by personal friends but tell us nothing of qualifications.	Box 1 Item 202 IMG 1576-1578

Date	Description	Source
1858 1-20	*Fanny Fern* explodes, report of details of explosion. See also 10-15-1858 entry below. In Proc. 1858, p. 7. Super censures local board, TS rules in favor of super insp. Actual report by Super Insp is on pp. 61-62, blames assistant engineer's "negligence or incompetence." Asst engr was on duty at the time.	Proc. 1858 No Shot; see 4C1
1858 4-7	James Guthrie concerned he is not being renewed as local inspector (political patronage perhaps). Writes Guthrie that he's a loyal Democrat and won't support Black Republicans/Nation.	D36
1858 5-10	Loc insp. New Orleans to Collector Hatch. Complaints against loc insp due to them not prosecuting Ferry Stmr *Trenton* for employing negro engineers. Matter investigated by Capt Pitfield, who vindicated loc insp actions.	Vol 5 IMG 1325-1326, p. 166
1858 5-20	Orig ltr, Capt Thos Rogers affidavit agnst D&W. Blames carelessness of King for explosion of *Fanny Fern*. "D&W did not make sufficient inquiry concerning said affair." Green notary seal on ltr.	Box 1 p. 225 No shot, xcript, or copy.
1858 5-31	Receipt for credit. Penalty paid by Jacob Poe for violation of SB Act.	D34
1858 6-10	Ltr fr D&W to TS Cobb re: Capt. Rogers.	Box 1
1858 6-27	Crawford writes that charges have been made by Capt Rogers against his inspectors. Also a petition is being circulated to replace Crawford. Talk is about of reorganizing the Board of Supervising inspectors, and Crawford wishes to be notified of any meeting in Washington upcoming.	D39
1858 6	TD Notes - draft of ltr (date?) TD to Benj Crawford re problems w Debora Dashiel etc. "The stmt of shortcomings of B Crawford have no bearing on the F Fern Case." "For their neglect of duty in not revoking both licenses [King/Miller for arbitrarily carrying press. too high], the Secy removed D&W."	Box 1 p.263 No shot, xcript, or copy
1859 6-29	John R. Davidson to TS, New Orleans. Lost a friend in explosion of Stmr <u>Pennsylvania</u>. Mode of licensing engrs by recommendation vs. examination has rendered filling of engr positions beyond endurance. Wishes an investigation made.	Vol 5 IMG 1323-1324, no pg no. (clipped)
1858 6-29	Supporters of Crawford to TS Cobb. Scheme concocted (see also 5C4) by enemies of Crawford to support other candidates for Sup. Insp. No feeling among people for removal of Crawford. We have no desire for his removal--he a good and efficient offcr.	Box 1 Item 138 5C2
1858 6-30	Crawford to TS Cobb. Crawford sued by Edward Warner, has had suit "for 2 or 3 years standing." Crawford lost case, thinking of appealing case to Supreme Court per attorney's advice. Debora Dashiel memo - Crawford doesn't know her. Warner's charges agnst Crawford for extrav living and abundant means in wife's name. But Crawford says she hasn't any money.	Box 1 p. 218
1858 7-1	T. J. Haldeman, loc insp Cincinnati, to TS Cobb. Regrets efforts to remove Crawford. Crawford a loyal democrat; is surprised David Lynch (spelled 'Linch') said Crawford was not a Buchanan man. Apparently Crawford pd Lynch for convention expenses.	Box 1 Item 141 5C3
1858 7-1	Mayor of Pitts affidavit fwded to TD (name is Shrum?). Deposes D&W; they testify that Crawford told them they could "take their time" to write their report. Date of mtg 6-4-1858. Crawford since rushed them. Has mayor's seal.	Box 1 No shot, xcript, or copy.
1858 7-14	Embree replaced. Political change.	B5
1858 7-22	Chas. Thaler to John B. Guthrie (Asst TS?) re: Crawford - "No man in the Country is more able to elucidate [the SB Law]. He had so much to do w/Law's inception; he its virtual author. Crawford has practical skill and theoretical knowledge, a man of integrity and justice. He is worthy due to not only knowledge but also his 'quasi-judicial discrimination.' Don't take out one whom the public trusts and replace him w/an untried man. Friends of Crawford misled by agitators for his job--gave the impression to friends that inspectors are to be routinely overturned, thus they supported others. False rumors being spread.	Box 1 Item 140 5C4, See also 5C2.

Date	Description	Source
1858 7-27	Leonard Harbaugh, Engr, to TS Cobb, from Cincinnati. Industry practice on Ohio R. is injuring shippers. Practice is combining Carpenter and 2nd engineer stations. "Strykers" are beginners. Engr must leave his post if strike an object in river, or fill it with an inexperienced Stryker. Cause of accidents, re: neglect of his engine.	Vol 5 IMG 1320-1322, p. 189
1858 8-17	Dickey and Watson. Official act of removal noted. Full letter in IMG 1418; not a good copy, but legible.	Letters sent by TS, Vol 1 B5; IMG 1418
1858 8-19	Miller license revocation - TS doesn't like it. Crawford wants to come to Wash. and explain his decision to TS personally.	D37
1858 no date	Newspaper acct. Local inspectors Dickey and Watson dismissed from office in connection with explosion of Fanny Fern. No date.	D40
1858 8-27	Crawford to Mr. Ela (TD). "D&W seem to take it pretty hard being removed from office." Everyone surprised at Watson [heaping odium on Crawford]. Secy would be pleased at how his decision gives satisfaction. Newspaper article from *Cincinnati Gazette*. Enclosed.	Vol 5 IMG 1318-1319, p. 197
1858 8-30	Dickey/Watson answer Crawford's charges re travel improprieties. Typed excerpt from ltr into keyboard.	Vol 5 3C1, p. 198
1858 9-3	Crawford points finger at Watson for falsified travel expense report.	D38
1858 9-8	Warner's original 1855 ltr to Crawford. New Brighton [PA?]. Pay up at least the interest on my claim immed or I shall lay proofs of my stmt before the TS. You have no appeals [i.e., to supreme court]; you are misleading TS. TS said if I substantiate my case [about your indebtedness] then he will "turn the rascal out."	Box 1 Item 221 5C7
1858 9-10	Dickey and Watson controversy. Their "Vindication" pamphlet. Fanny Fern Explosion. Shameful deception of the super Insp. Crawford. King/Miller. King never tried the middle boiler. Evans SG on these boilers. Title: "A Vindication of the Action of the Late Loc inspectors at Pittsburgh in the Case of the Explosion of the Steamer Fanny Fern; with the evidence and Correspondence." Pittsburgh, 1858. See IMG 1328-1387 for full pamphlet. Notes need to be compiled in a separate doc for this pamphlet; however, one interesting note is the feud between D&W's experts and the govt experts (see IMG 1386).	Spineless Vol 1852-60 C1, C2, C3; full doc in IMG 1328-1387; reshot pages as IMG 1461-1470
1858 9	"Shortcomings of Benj Crawford, Esq." Not shot or typed. Compiled by TD, is a list of charges from D&W's "Vindication" by page no. Charges are numbered 1 thru 26; also under heading "Violations of Law, Evasion of Duty, Ignorance, etc." there are 9 more charges.	Box 1 p. 225 No shot, xcript, or copy.
1858 9-24	Crawford to Edward Warner. Pittsburgh. [Warner case tried in Spring 1857. Crawford lost judgment in Allegheny County PA District Ct.] Stat of Lim, writ of error, Supreme Ct. Crawford didn't have funds to pursue writ of error at this time. [Background: Case is about a $900 loan Warner made to Crawford that Crawford has not repaid. Warner has witnesses that Crawford lives extravagantly, and has his wealth in his wife's name. Crawford denies this. Warren had said TS said about the case that if Crawford guilty, then "I will throw the rascal out."] You can't disprove facts in my [6-30-1857?] ltr to TS.	Box 1 Item 220 5C6
1858 10-1	Crawford to TS Cobb. Pittsburgh. Xmitting Warner's letter threatening Crawford if he refuses his demands, plus assorted papers. Lawyer has advised Crawford of his right to redress thru Supreme Court. Crawford claims he suffered "great loss" in Warner matter.	Box 1 Item 222 IMG 1584
1858 10-4	"Draft of internal letter to Crawford." Auth unknown. Response to Crawford's letter of 10-1-1858 [?] and papers relating to the judgment of Mrs. Dashiel agnst him. TS will not investigate [her charges of moral delinquency/unfitness]. No proof.	Box 1 Item 223 IMG 1581-1582

Date	Description	Source
1858 10-?	TD side of Fanny Fern case - auth unknown. The "Shortcomings" of B. Crawford have no bearing on the Fanny Fern case. Engrs had habitually exceeded pressure allowed. Loc insp D&W totally disregarded this, and this is the reason TS removed D&W. Crawford censured for restoring Miller.	Box 1 Item 223 (concl) IMG 1583
1858 10-18	LIST OF INSPECTORS 1858	Box 1 Item 204 IMG 1449
1858 10?	Note - "These are testimonials in favor of appt of John S. Dickey one of the local board and removed by the Secy; to be appointed Super Insp in favor of B. Crawford." To His Excellency James Buchanan, Pres. of the United States."	Box 1 Item 178 IMG 1562
1858 10?	SB engineers' petition to Pres James Buchanan. Engrs urge Pres to remove Crawford from office. He "never had any experience . . .whatever . . . on board SBs." "Entirely unfit to fill the office of Super Insp. Signed Andrew Watson, James Atkinson, and 33 others.	Box 1 Item 180 IMG 1566-1567
1858 10?	No date, but among other 10-1858 items. Engine builders and engrs, to Pres Buchanan. Crawford is neither a practical man or a mechanic, and is "totally incompetent." Urge his removal and a "speedy change." Singed by Robt E. Rogers + 47 others.	Box 1 Item 181 IMG 1568-1569
1858 10	Crawford tried strenuously to abolish use of Evans SGs. Failed due to Mrs. Evans' patent.	Ross's letter?
1858 10-14	Proceedings of Seventh Annual mtg of the Bd of Super insp at Buffalo NY. P. 61-62 [Seems to vindicate D&W.] *Fanny Fern*. See also B5, 8-17-1858.	Vol 4 Proc. 1858, IMG 1232-34
1858 10-15	Resolved, special committee of 5 members of Super Bd appointed to investigate facts of *Fanny Fern* explosion of 1-1858. Members - Ross, Lewis, Pitfield, Burnett, Shallcross. Investig necessary because Loc Insp never filed a report, they being dismissed. Mtg at Buffalo NY. See also 10-14-1858 for result.	Proc. 1858 No shot; p. 7-8
1858 10-18	Crawford reports "signal failures" of fusible alloys in Proc. Resolution of board; committee on machinery to look into rescinding resol. of 4-13-1854.	1858 Proc pp. 12-13 of Proc., IMG 1459
1858 10-18	Crawford's resolution in Proc. To investigate "rescinding resolution in regard to fusible alloys passed by the Bd on 4-13-1854."	Proc. 1858 pp. 12-13, IMG 1459
1858 10-19	Report by special committee re: *Fanny Fern* accident, pp. 23-25. Ross's committee blames King for disaster, exonerates and even praises Miller for saving victims by throwing planks to them.	Proc. 1858 See 2C6 for penciled extracts.
1858 10-26	Super Insps evaluate Reeder's Safety Valve. It is an indicator of pressure, i.e., does not guard against low water. This valve is a modification to Reeder's valve presented to this Bd in 1856. SI's don't like the modified one either. Valve won't react until water is 2 in. below tops of the flues.	Proc. 1858 No shot. pp. 73-77
1858 11-12	John Shannon to Pres Buchanan. Testimonial in favor of his political friend Capt. John S. Dickey. Dickey a true Democrat and "has not been tinctured in the least w/any of the political heresies, or isms of the times."	Box 1 Item 185 IMG 1574
1858 11-17	Fusible alloys. Booth. Treasury will reluctantly pay room rent on lab. Alloys haven't been made for "some time past."	A7
1858 11-18	John Caruthers (friend of Dickey's) to Pres Buchanan. Beaver County PA. My neighbor is best qualified man for the job of super insp. Consistent democrat. If you appt him to office, "you will promote the best interests of Democracy."	Box 1 Item 183 IMG 1572

Date	Description	Source
1858 11-20	Joseph Irvin to Pres Buchanan. Rochester, Beaver City, PA. Childhood friend of Dickey's recommends him as super insp. Democrat, a good moral character, popular with all, etc. "Never doubting an ultimate triumph."	Box 1 Item 184 IMG 1573
1858 12-8	Ross replaces Embree (gov docs). Embree "removed."	Gov Docs GD1
1858 12-9	Bill to put on hydro pump.	D50
1858 12-13	Engrs oust super insp Crawford, exert pressure on TD. Jas P. Barr to TS Cobb. Pittsburg ("Office Daily Post"). Efforts to "push aside" Benj Crawford. Doubts "whispered" by one or two men in Pitts. as to his democracy and unfitness for office. Crawford "never a brawling politician," but exacted the envy of others. It is proper that in his current position, he NOT be a politician. These be "covert but systematic" efforts to unseat him. Let me bring "a cloud of witnesses" to attest to Crawford's [democracy and confidence]. Counter "the tongue of slander."	Box 1 Item 204 IMG 1579-1580
1858 12-22	James Lundgraft [sp?] to Hon P.C. Shannon, Pittsburgh. Crawford supported Lundgraft as Inspector of Hulls, but then withdrew his support in favor of a Mr. Grace. Capt. Rogers a witness. Xcribed ltr.	Box 1 Item 200 IMG 1575
1859		
1859 no date	Feedwater heating inventions a big deal in 1859. Heater urged on technical community in order to keep boiler iron from being stressed from sudden temp changes due to cold feedwater being introduced into hot boiler. See Proc. pp. 36-38.	Proc. 1859 pp. 36-38
1859 no date	Snowden (inventor of feedwater heater) is listed as a loc insp of machinery and boilers, 7th District.	Proc. 1859 Appendix, no page no.
1859 no date	More on boiler iron fraud. Witnesses won't come forth due to "odium which would attach to them as informers."	Proc. 1859 pp. 40-42
1859 1-3	Booth's "Analysis of the Corresp bet the U.S. Treasury Dept & J.C. Booth in Relation to Fus Alloys." Portion of a large corresp bet Booth & TD. Booth's list is in response to inquiries raised by TD's letter of 11-17-1858.	Box 1 Item 125 IMG 1542-1544
1859 1-3	Booth to TS Cobb. Phila. In resp to request in TD letter dtd 11-17-1858. Facts in regard to rent of premises used to mfg alloys (TD wants to know why it should pay rent during period of inactivity). Chronol. list of corresp follows. Booth offers facts "in simple justice to myself," not in "vaunting spirit." Does govt want to stop work and discontinue rent of $300 for lower part? Please advise.	Box 1 Item 126 IMG 1545-1551
1859 1-11	Mr. Hastings (late collector of port) of IMG 1493-95 attests to convers bet. Lynch, Crawford and himself one yr earlier. To Lynch from Stewart. Allegheny City PA.	Box 1 Item 330 IMG 1496
1859 1-12	N. McAlarayne to Maj David lynch. Crawford appeared interested in Dems after election of 1856. Lynch would not endorse Crawford's Democracy.	Box 1 Item 337 IMG 1497
1859 1-26	Loc Insp Davids to TS Cobb, Norfolk VA. Investigating puddled iron. "Much of my time is spent away from home." Covers a large area - NC, Virginia.	Vol 5 IMG 1316-1317, p. 234
1859 2-5	A friend of John S. Dickey's to Pres [Buchanan] recommending Dickey to office of sup insp. Wash. City. Dickey is a hardworking and consistent Democrat. Good character, unblemished.	Box 1 Item 182 IMG 1570-1571
1859 2-8	R. T. Queen ltr. Crawford accused of "skipping bail" on a bad loan held by Queen. Crawford was in jail 2 days. Promised to pay if let out, but did not. "A more dishonest, dishonourable, and ungrateful man lives not out of a penitentiary." See copy of Queen/Crawford arbitrator's stmt IMG 1499 (3-3-1857)	Box 1 Item 332 IMG 1498

Date	Description	Source
1859 2-9	D. Lynch's name on a wrapper. "Notes relative to the within publication . . . please read."	Box 1 No Item No.? IMG 1509
1859 2-9	Affidavits showing "the baseness and want of moral honesty of [John B. Guthrie's] pet Crawford." Also, Crawford borrowed money ($400) from one Edward Warren. Letter clipped--money not pd back? J. Guthrie "used . . . Crawford as a catspaw and procured a certificate of my pecuniary embarrassment."	Box 1 IMG 1492
1859 2-9	Crawford boarded at Isaac Beers's house. Crawford stated he was poor, and never paid his rent. Crawford "shamefully violated" his promises. Now avoids Beers's communications.	Box 1, Item 334 IMG 1500
1859 2-10	Affidavit affirming truth of Beers's stmt about Crawford's shameful behavior re debt owed. See IMG 1500 (2-9-1859)	Box 1 Item ? IMG 1501
1859 3	Newspaper acct, date clipped off. Explosion of SB *Princess* (March 1859? Hunter). Passengers considered her very safe until this. Spirit of law vs. letter discussion. Newspaper acct in among 1859 papers. [Note: from Proc. 1859, Princess exploded 2-27-1859, p. 25, and also pp. 54-55]	D48, IMG 1458
1859 3-12	Loc insps J.O. McLean and John C. Marsh to Capt; O.A. Pitfield. Loc insp have taken testimony in *Princess* explosion. She had Evans SG on ea boiler. No info that any of them fused before the explosion. They were of the large model working with wts and chains. Also they want to see the boilers that were on the *Princess* before they make any decision on the case.	Vol 5 IMG 1315, No item no. given
1859 3-16	Crawford to TS Cobb. Engr Wm. Buffington charged with interfering w/SGs. *Panola* - boat that exploded. "First case of this kind under law of 1852." Wishes to go to St. Louis to collect evidence. [See Proc. 1859, shot 3-30]. Conviction in Crawford's 7th District, fined $200 as misdemeanor. Penalty laid out in law, could have been sentenced to 18 mos. prison also, but apparently was not.]	Vol 5 IMG 1313, p. 262
1859 4-1	Transmittal Hon TS Cobb to Crawford. Papers w/charges made agnst Crawford. Provide explanations.	Box 1 Item 342 IMG 1505-1506 (1506 a dupe)
1859 4-4	Sworn statement of George Oglesby reports engineers are tying up Evans SGs. Reported it to Dickey and Watson, nothing happened. Reported it to current local insps., and they are taking care of it.	D49
1859 4-6	Booth to TS Cobb. Phila. Receipt for rent of premises employed for prep of fus alloys. Lease ends on 6-30. Wishes to be relieved of the charge of the fus alloys since they are an unnecessary expenditure and a Supervisor has informed me that alloys are no longer to be used ("it has been determined").	Box 1 Item 122 IMG 1535-1536
1859 4-8	T.J. Haldeman to Gouge, from Cincinnati. Shallcross is prime mover in "ridiculous" idea of substituting block tin for fus. alloy. Salaries of loc bd. Booth's experiments on a boat here - something wrong. TS conclusions incorrect. Relationship of heat to press. re: alloys, where to place the alloy on the flue matters. Astonished at explosion of *Princess,* which had the large and approved Evans SGs. Thinks the SGs were tied down, but explosion damage too extensive to ever know. Has seen a no. of boats w/SGs tied down but never able to get proof as to whom. Can't prosecute w/o proof. Crawford recently charged engrs in his district with fastening down SGs [*Panola*]. If he can only prove it, it may serve as a warning to others. Haldeman injured - fell into hold of a SB.	Vol 5 IMG 1309-1312

Date	Description	Source
1859 4-11	T.J. Haldeman to TS Cobb. Cincinnati insp office. In April 1857, SBs *Northern Light* and *Alaska*, Haldeman inspected (with W.W. Guthrie, now deceased). Found to have cast iron steam pipes instead of wrought iron.	Box 1 Item 344 IMG 1558-1561
1859 4-11	Booth to TS Cobb. Phila. Booth's acct of the stock in premises (at the Mint), in response to TS's query of 4-7-1859. Lists a small boiler and 1502 lb fus alloy, among other items. Will furnish detailed list of alloy distributed over the yrs. ("I have kept a minute account.") He also states that "no orders have been recd by me since the fall of 1856." Notes a renewal order by Pittsburgh super insp for 900 lb of alloy. "This is by far the heaviest order we have recd."	Box 1 Item 123 IMG 1537-1540
1859 4-16	Crawford re charges by David Lynch. Legs of pipe connecting boiler w/steam pipe. Made of copper, not inferior matls. No violation of 1852 law. Haldeman his backup (see also IMG 1561, 4-11-1859). Law quoted incorrectly by Lynch. Copper permitted. Crawford quotes law. I did not neglect attending to the matter. Second charge refuted: passageway to upper deck in case of accident--D&W have certified passageways are adequate. Small sternwheel boats are sometimes too crowded with gear. Leave this to loc insp as no general rule can be laid down by sup insp that would apply to all boats. Rogers (Crawford's critic) was a disappointed applicant for hull insp after resignation of Capt Atkinson. Atkinson angry w/ Crawford--not on speaking terms. Atkinson apparently also one of Crawford's recent critics. *Fulton City* disaster--lost Nov 1858. Paper submitted by Crawford on this disaster exonerates Crawford wrt Lynch's charges.	Box 1 Item 343 IMG 1502-1504 picked up agn at IMG 1552-1557
1859 5-3	Booth's forensic techniques used to prove melting points of alloy aboard *Panola*, Wm. Buffington Case. Appears to have been quoted in an 1862 internal report by TD. [see second entry at "1861-1862"]	Box 4, Item 123 IMG 1241-1243
1859 No date	No date, but among spring 1859 records. "Shortcomings of Benjamin Crawford, Esq." A laundry list of accusations put together by TD, arranged by page number from D&W's "Vindication." See IMG 1328, 9-10-1858. Crawford's double dealing, etc. Violation of law, evasions of duty, ignorance, etc. Corruption - Crawford instructs loc insps to reject unpatented lifeboats when he owed the agent of the patented article a sum of money (see pp. 45-53 of 'Vindication.' for particulars).	Box 1 Item 338 IMG 1507-1508
1859 5-16	Pittsburgh Gazette "River News" column. Allegations have been made that many members of the board of SB Inspectors for Western Waters are incompetent. "Assure me that a certification of safety shall mean that."	Box 1 IMG 1477
1859 5-26	"Marine" writes to The Phila. Press newspaper, Pittsburg corresp section. He knows a capt on Ohio & Miss. Rivers who tells him that the laws are "almost entirely disregarded on our Western Waters." Not a single SB comes up to the stds of law of 1852. Matters of minor importance are strictly obeyed, but precautions agnst accidents "are almost uniformly disregarded." Crawford quick to remove D&W over <u>Fanny Fern</u> debacle; she blew up in Jan 1858. 13 instances of boats lacking chains, rods, addl steering app as reqd by law; boats certified! Complaints made to Pres Buchanan, but he refuses to act re honest and competent sup insp. "God save us from an unjust [administration] if this be just." TS no help either. [Penciled note: "The leading Democrats here are working hard agnst the state ticket and National administration. Pennsylvania [is] good for 75,000 opposition majority. [1860 election approaching].	Box 1 IMG 1483-1484

Date	Description	Source
1859 6-1	"Engineer" responds to Marine. Auth is prob. Crawford--same writing style. Not all complete (some clipped), but most is here. 'Engineer' defends sup. insp. agnst charges. Marine defended D&W in *Fanny Fern* accident but it backfired in Wash. City. Charges agnst super insp did indeed go to TS, but super insp defended self. TS saw the truth of the matter. Marines' charges absurd and baseless. SB capt mentioned by Marine was applicant for office of inspector.	Box 1 IMG 1485-1489
1859 6-2	William Haslitt to the newspaper (says "for the Pittsburgh Post." Pseudonym "Engineer" singled me out re: my dissatisfaction w/how inspectors are made here (Phila.). "Engineer" is Crawford, he argues. Hazlitt was one of the applicants for inspector. I deny that I wrote to the press. My denial will cause Crawford to "bob around" to find who real author is. Mentions accident aboard the *Fulton City*; passageways too narrow. "Marine" was speaking truth, Crawford evades his criticisms. "Marine" reveals Crawford's fabrications. *Col. Crossman* explodes, burns - no steering gear.	Box 1 IMG 1478-1482 (start at 1479)
1859 6-13	Booth to Wm. M. Gouge. Phila. TD wants Booth to use up Navy Yard alloys, but Booth says cost of analyzing them to ascertain how to modify them to make them useful is too expensive--would take months. Agrees w/Gouge that these Navy Yard alloys should not be distrib to Western Waters as is--dangerous. Suggests selling them to Eastern stereotype founders.	Box 1 Item 124 IMG 1541
1859 7-7	Booth says one man is making the alloys. Slow but trustworthy. Purchases tin from Trotter Co. Lab charge is forwarded (for making alloys). US vs. Buffington case. Buffington loaded the safety valve on SB Panola (see also 3-16-1859 entry). Fusing points from that boat were off. Calls attention to problem: ladle is defective. Requests authority to make custom ladles for the purpose. Will improve reliability of the alloys. [Trotter Co. is now Nathan Trotter Co., Exton, PA, founded 1789 (near Philadelphia).]	D47
1859 7-11	Booth to TS, Philadelphia. NY Times article well written on subj of bursting/exploding boilers. Problems w electrical theory of explosions - not sure, would need to be tested. Test boiler, experiments a great risk to Booth's life. Should be done in large yard of a machine shop.	Vol 5 IMG 1305-1308, p. 318
1859 7-12	Crawford writes TS that Booth's new iron ladle design is probably a good idea. Cost of ladles.	Vol 5 D41, IMG 1303-1304, p. 319
1859 9-12	Loc insp Haldeman discusses Evans safety guards and how they are rendered useless when boiler has crud in it. Discusses *Princess* explosion. Speculates on electrical theory, other baseless theories. Talks of Booth as authority. Best source on explosions is Evans. Want of water is the real culprit.	D46
1859 9-21	Robert Hood sworn statement. He appeals to TS about his job as Engineer under Super. Insp. Ross. Ross won't let him get on a boat. My power is absolute. Kids hungry for bread. No date. Capt. Kountz, Captain and owner of boats. He was called "Commodore." Later expanded into railroads.	Vol 5 D44-45, also IMG 1291-1293, p. 370
1859 9-21	Statement under oath of Daniel D. Bloys. Convers with Capt. Ross.	Vol 5 IMG 1294-1296, p. 372
1859 No date	LIST OF INSPECTORS 1859	1859 Proc IMG 1450
1859 10?	*Princess* explosion report.	1859 Proc pp. 54-55 of Proc, IMG 1458

Date	Description	Source
1859 no date	"Synopsis of papers filed in behalf of J.S. Dickey." Dickey is gunning for Crawford's job. SB engrs call for Crawford's removal--he not a mechanic and not exper on SBs. Call him "wholly incompetent." Offcrs of SB *Chariot* defend D&W--injustice done them. Offcrs of SB *Potomac* state same re: SB *Fanny Fern*. Crawford was the only culpable person. Same w/other boat - *Rockett*--McScan--Crawford is "insincere and deceptive." Etc.	Box 1 Item 327 IMG 1490-1491
1859 10-13	Statement by Samuel Carlin re convers with Capt. Ross.	Vol 5 IMG 1297-1298, p. 374
1859 No Date	Engr prosecuted for loading the safety valves and fastening down his SGs. Engr said alloy fused at less than indicated temp. Booth tested it and contradicted this. Engr plead guilty, paid fine. Was this *Panola*? Probably.	Proc 1859 IMG 1446
1859 11	Copeland tries to abolish SGs. Failed due to Mrs. Evans' patent, same as before.	Ross letter?
1859 11-19	Ltr from a Mr. Davis. Another anti-Ross complaint. Detroit MI. This time wrt Capt Kountz affair. Kountz is complainant, represented by Davis [?] Davis is submitting affidavit complaining about Ross's conduct.	Spineless vol 1852-60 IMG 1415-1416
1859 11-26	Super Insp Augustus Walker, 9th Dist., Buffalo, to TS Cobb wrt letter of 19th inst. "I fully concur with the views and sentiments set forth in your communication."	Vol 5 IMG 1302, p. 380
1859 12-8	Ross defends against attacks. May have said that guards were no good. Failure of SGs. Even the Super. Insp's have been pushing to eliminate them from use. Nothing in the Law re: Evans' SGs--But see A4, link bet. Evans SGs & fusible alloy (1854 5-1).	D43
1859 12-19	Evans safety guard. TS chastises Super Insp Chas. Ross, St. Louis, for opining against using the guards. "Run the damn thing full of lead." Violation of law of 1852.	B7
1859 12-21	Super Insp John S. Brown, Balto, to TS re TS ltr dtd 19th inst. re Capt. Ross. Fus alloys give us no trouble, we have few hi-press. boats in our district. However, we are duty bound to enforce the law regardless.	Vol 5 IMG 1299, p. 375
1859 12-24	John Shallcross, Super Insp 6th District, to TS Cobb re: Charles Ross charges. Bd of Super Insp have no power to change any provision in the law - I agree with you. Evans SG is best mode of using the alloy now known. Objections by engrs are numerous, but problem is imperfect mfg by patentee. SG and alloy will not be a true and reliable indicator. "But for this purpose the engrs have the steam guage and safety valves."	Vol 5 IMG 1280-1281, Item 377
1859 12-24	Chas. W. Copeland, Super Insp, 2nd Dist, NY, to TS Cobb re: Ross charges. Formerly, a member of the Bd [unnamed] had a difference of opinion on the alloys, overruled by majority. Alloys a source of trouble and anxiety to me. Constant complaints that alloy did not act successfully. Doubts that alloy works any better due to exclusion of pressure than with it. Will volunteer to aid in experiments so as to lead to a more reliable mode of using alloys.	Vol 5 IMG 1282-1285, p. 376

Date	Description	Source
1859 12-26	Benj Crawford to TS Cobb re: charges against Charles Ross. Super. Insp, loc insp, river men are all against use of SGs. Unreliable alloy the problem. Loc Insp McCord (boilers) asked the Bd to suspend provisions of law re: alloys. Super Insp. not enforcing all prov of law in their districts; makes it harder to enforce them in his district. Ross's predecessor [Embree] didn't enforce fus alloys, nor require wrought iron heads. Accidents wised up the Super Inspectors, however. Has had much difficulty in enforcing alloys. Constant complaints that alloys have fused at far less pressure than allowed by their certificates. Complaints reiterated by the loc bds on the Western Waters. I was desirous of a change in law (when boilers exploded w/Guards on them), but still I upheld the law. Prosecution of engr on the *Panola*; make an example of him. Had a beneficial effect. Scarcely a complaint now against the SGs. Booth changed my mind re SGs with his testimony in the suit. Now need to make SGs tamper proof. "I should regret to see the provision of the law re use of alloyed metals changed."	Vol 5 IMG 1272-1278, p. 379. 6-pp letter
1859 12-26	Super Insp. Wm. Burnett, Boston, to TS Howell Cobb re TS ltr of 19th inst. Little experience with SGs in this district, not hear Ross make stmts. SG's exclusive use is "demanded substantially by a resolution of the Bd passed at Washington in 1854. They can repeal it if use should prove to be improper. But I believe Bd thinks the SG effective.	Vol 5 IMG 1300-1301, p. 378
1860		
1860 2-21	Mr. Bigler presents memorial of Jane Evans, deceased, praying for renewal of C. Evans' patent, and referred to Committee on Patents, Patent Office.	Gov docs GD4
1860 3-17	Steam Boat explosion. Construction of boiler careless. "Alfred Thomas" was boat, exploded at Easton PA. Passengers were along for the trial run.	C1
1860 3-23	Mr. Burnham from Committee on Patents, to whom was referred petition of Jane B. Evans, widow of Cad. Evans, made a report accompanied by a bill HR 471 for her relief.	Gov docs, GD 3
1860 3-23	Bill for the relief of Jane Evans. Extends her patent. HJ.R. 471, 36th Congress, 1st Sess.	Gov Docs GD 2
1860 4-26	Custom Collector James McHetridge to Howell Cobb TS. Requests Super. Inspector to come inspect a boat in his district. Super insp. Said he couldn't w/o direction from TS. Requesting that direction from Cobb.	Vol 4 IMG 1230-31
1860 5-22	Super. Insp. Ross to TS Cobb. Ross's letter about the old 1838 inspectors phasing out. He discusses why Cincinnati is the last place in the country where the old 1838 law is still being enforced, even while the act of 1852 is in force. Different payment methods for inspectors, i.e., 1838 vs. 1852. [Not a fully transcribed letter]	Vol ? IMG 1679-1680
1860 6-1	Schedule of public property at local insp. Office, Detroit. Hydro pump, 14 lengths of hose.	C1
1860 10-15	Proceedings title page, LIST OF INSPECTORS, held at NYC, 1860.	1860 Proc, IMG 1434-1435, dupe of IMG 1452
1860 10-15	LIST OF INSPECTORS 1860	1860 Proc IMG 1452
1861		
1861 1-10	Booth to Philip Thomas, TS. Mobile and Pittsburg orders for fus alloys nearly completed. But in conseq of condition of Treas Dept, want me to halt? Two remaining orders.	Vol 4 IMG 1240

Date	Description	Source
1861 1-28	To Hon W. Bigler (TS?) Law - versions - leaves use of fus alloys optional, advocates tin plugs. "In the name of suffering humanity, let's have them! [fus alloys]" Opposition to fus alloy by engineers, inspectors. Unknown author.	Vol 4 IMG 1256-60, Item 2
1861 4-29	Boiler Insp J.V. Guthrie to Benj Crawford, Super Insp Pittsburgh. Guthrie is going to war, will leave his office May 1, "to serve my country." "Sustain the govt against the traitors." Asks Crawford to attend to his loc insp duties in his absence.	Vol 4 IMG 1263, Item 17
1861 7-1	Boiler Insp J. Guthrie to TS Chase. His leave of absence will expire on July 18. Requests extension of LOA for 3 more mos. Little doing in the office, see no necess for anyone to fill his place. Crawford doing a good job as temp loc insp. If extended he can go with his regiment and "fight traitors," thinks rebels will quit.	Vol. 4 IMG 1264, Item 40
1861 7-6	TS Chase informs a local inspector that he cannot leave his duties to a deputy.	B1
1861 No date	LIST OF INSPECTORS 1861	1861 Proc IMG 1451
1861 12-19	To Enoch T. Carson, Surveyor of Customs, Cincinnati, from US Atty F. Ball. Benj crawford to act as loc insp, at least for present. Col. Guthrie at war. Mentions Haldeman and Shields.	Vol 4 IMG 1261, Item 15
1861 12-21	To TS Chase from Benj Crawford. Has been temporary Loc Insp at Cincinnati district since last May. Replacement for Col. Guthrie (who is at war). Has not been paid, the salary being sent to Guthrie. Wants Dept to pay him. References J. Guthrie letter, boiler inspector.	Vol 4 IMG 1262, Item 16
1861 or 1862	No date, but probably in 1861 or 1862. "The Fusible Alloy Used in SBs" Letter (copied). By TD internal, but quoting Jas. Booth earlier writings from 1859. Fus alloy - criticized for hardening of alloy - not functioning for intended purpose. SB Panola, Wm. Buffington. Temperatures (table), however, very consistent. Wrapper: Local Insp. Snowden (Pittsburgh) re fusible alloys. [Was the old fus alloy unreliability argument being defused so the alloys could be reintroduced? Appears so. If so, ignores Booth's later recognition that the fusing points were too low in *Panola* case. He wrote that ladles were the problem.] [See second entry made in this index - 5-3-1859.]	Vol 4, Item 123 IMG 1241-44
1862		
1862 1-1	Purge of disloyal local inspectors during Civil War	B1
1862 1-16	Crawford removed (Gov Docs). Replaced by E.M. Shield of Cincinnati. Crawford listed as a special agent in the SBIS in 1870 Proceedings.	Gov Docs, GD 16, Proc 1870
1862 1-17	Redmond J. Grace, Inspector of Hulls, Pittsburgh Loc insp of SBs - to Gouge. Mentions Booth experiments. "SG loses its character by neglect of the engrs." Believes in the efficacy of the alloys, but bitter prejudice of river men prevented its usefulness. They are jealous and conceited, view any safety device as an infringement of their rights, a slur on their own knowledge or practical skill. I worked with them on the river for 22 years and I know them well. Mentions Snowden's invention, feedwater heater.	Vol 4, p. 121 IMG 1247-49 Ltr xcribed.
1862 1-17	In among above item of Edmond Grace's. Printed Flyer - "Snowden's Improvement in Feeding Water to Steam Boilers," Patented April 3, 1860, T. Snowden. Heat feedwater to temp of that of water in boiler.	Vol 4, p. 122 IMG 1250-51
1862 1-30	Booth to TS Chase. Am forwarding order for fus. Alloys to Boston. First order recd since Booth first prepared alloys in 1854. May I go ahead and prepare order?	Vol 4, Item 132 IMG 1238-39

Date	Description	Source
1862 2-5	Petition letter asking for the removal of Loc Insp Singleton, who is aged and thus incompetent, and also a "Secesh." "He takes the oath, but that is 'moonshine' in our opinion." There are thousands such in our midst. He advocates states rights and nullification. By St. Louis citizens, signed by eight men.	Vol 4 IMG 1270, Item 183
1862 2-17	Jas. Booth ltr to TS Chase. Has forwarded to Wm Burnett such of fus alloys I have previously prepared re Law of 1853. Sent to Burnett [On wrapper]	Vol 4, Item 137 IMG 1245
1862 2-18	"Congratulatory." My heart "thrills with joy" at our Army and Navy victories. Bull Run defeat. We bowed our knees in our little basement office under the Collectors Room, in company with my local board. Glory to Army, Navy, President, Cabinet, TS Chase; Glory glory to our good and blessed God etc etc (effusive sentiments). I. Nells [sp?] - engr or pilot? Not stated.	Vol 4 IMG 1266-1267, p. 139
1862 2-20	Mrs. Crawford's letter to Secy Treas. Re: hiring Benj. Crawford as Loc Insp. Pittsburgh	Vol 4 IMG 1252-1255
1862 3-10	To TS Chase. Some pilots and engrs in charge of vessels chartered by the govt are secessionists. Can I have those men summoned before me to take the Oath of Allegiance? Signed James N. Muller Sr., Super. Insp. 3rd District.	Vol 4 IMG 1265, Item 156
1862 3-11	Oath of allegiance Civil War - reason to purge engrs/pilots.	B2
1862 5-29	A.S. Bemis - Buffalo NY to replace Augustus Walker as Supervising Inspector.	B2
1862 10-16	Proceedings title page, Civil War Loyalty Oath of 8-6-1861, held at Phila. Xcribed. Also notes special meeting at Chicago, 4-7-1862.	1862 Proc IMG 1436-1437
1862 10-16	LIST OF INSPECTORS 1862	1862 Proc IMG 1453
1862 12-22	E.M. Shield, Super. Insp, Cincinnati. Requests fus alloys No. 140, 150, a box of each. Also, complaints have been recd re: the local inspectors at Wheeling. Refers TS to Collector of Wheeling for substantiation.	Vol 4, Item 274 IMG 1246
1863		
1863 No date	LIST OF INSPECTORS 1863	1863 Proc IMG 1454
1867		
1867 no date	Annual Report, Benj Crawford, pp. 38-40 - Alloy plugs dangerous to boats operating on the Northern and Western lakes if not able to be disabled. Put it before the Super Bd. Crawford is listed as a special agent. Minority report of Guthrie: alloys found to be of no use in the past.	Proc 1867, pp. 11, 38-40 IMG 1428-1431
1868-1873		
1868 1-18	Embree's food for livestock using steam process. Sci Am New Series, Vol. 18, Issue 3, p. 44.	Gov docs GD 20
1870 1-1	Calculations for specifying the proper area for a safety valve port.	Sci. Am. Vol 22, No. 1 Gov docs GD 23
1872 2-12	A bill for the relief of Benjamin Crawford, HR 1443. Gave Crawford $10,000 for compensation of govt for use of patent steam-blower.	Gov docs, GD 19
1873 2-10	A bill for the relief of Benjamin Crawford, HR 3874. Gave Crawford $5000 for compensation for govt use of his patent steam-blower.	Gov docs GD 14

NARA Bound Volume Details

The NARA correspondence volumes are in poor condition due to age, so are not clearly marked in all cases. Below is a condition summary, to aid the researcher.

Treasury Department Records (RG 41, Correspondence to/from the TS)

Vol. ? (No volume number, no binding, volume is in two parts in large white box, no spine. Range of correspondence is 1855-1859, with some from 1853-1854 in the second part).

Vol. ? (No volume number, no spine, not marked with a date range. Contains 1858-1860 mostly. Includes *Vindication* Pamphlet of Dickey and Watson concerning the explosion of the *Fanny Fern*. Includes some 1852-1855 material).

Vol. 2, Marked 1853-1854.

Vol. 3, Marked 1852-1853 (Contains St. Louis engineers' report, 1854, and there is a large quantity of depositions concerning the explosion of the *Kate Kearney*).

Vol. 4, Marked 1861-1862.

Vol. 5, Marked 1857-1859 (Contains Carlin, Hood, and Ross statements).

Vol. 6, (No spine, not marked with a date range. Appears to contain correspondence between 1854-1856).

Commerce Committee Records, U.S. Congress (RG 46, Material of Sen. Davis's Investigation on Steam Boiler Safety)

Tray 26, Commerce Records, Folders 1 and 2. These materials are in satisfactory condition.

Bibliography

<u>Key Primary Sources:</u>

National Archives and Record Administration (NARA, Washington, D.C.) Records of the Bureau of Marine Inspection and Navigation, Record Group 41, 1774-1973; Subgroup 41.2, Headquarters Records of the Steamboat Inspection Service, 1812-1944; Sub-subgroup 41.2.3, Records of the Board of Supervising Inspectors, Journals and Proceedings, 1852-1942. Each volume of proceedings corresponds to the preceding year in review, beginning with 1853 (covering 1852). For an index of the Supervisors' material referenced by date/report in the body of this thesis, see author's index of selected letters, Appendix A. Abbreviated "Proc" in the text footnotes.

National Archives and Record Administration (NARA, Washington, D.C.) Records of the Bureau of Marine Inspection and Navigation, Record Group 41, 1774-1973; Subgroup 41.2, Headquarters Records of the Steamboat Inspection Service, 1812-1944; Sub-subgroup 41.2.1, Correspondence and Related Records (specifically labeled on the binders, "Miscellaneous Correspondence [Sent from/Received by] the Secretary of the Treasury, 1852-1862," Vols. 1-6.) For an index of correspondence referenced by date in the body of this thesis, see author's index, Appendix B. These records are indicated in the text footnotes by simple dates (e.g., 1858 12-1).

National Archives and Record Administration (NARA, Washington, D.C.) Record Group 46, Records of the Commerce Committee, Tray 26, Folders 1 of 2 and 2 of 2, 1850. Senator John Davis's records collected during the drafting of the Act of 1852. For a list of Committee's correspondence referenced by date in the body of this thesis, see author's index of selected letters, Appendix A.

Unpublished Report: *A Report on Fusible Alloys and Safety Guards Made to and Adopted by the Saint Louis Association of Steam Boat Engineers*. Part of NARA Record Group 41, "Miscellaneous Correspondence Received by the Secretary of the Treasury, 1852-1862," as listed above. Report dated October 2, 1854.

John S. Dickey and Andrew J. Watson, local inspectors at Pittsburgh: *A Vindication of the Action of the Late Local Inspectors at Pittsburgh in the Case of the Explosion of the Steamer Fanny Fern; with the Evidence and Correspondence*. Unpublished Pamphlet, 1858. Part of NARA Record Group 41, "Miscellaneous Correspondence Received by the Secretary of the Treasury, 1852-1862," as listed above.

Evans, Cadwallader: *A Treatise on the Causes of Explosions of Steam Boilers with Practical Suggestions for their Prevention to Which is Added a Description of Evans' Improved Safety Guard, or Engineers' Assistant*, 1850. In NARA RG 46, Commerce Records, Tray 26, folder 1 of 2.

Evans, Cadwallader: *A Statement of Experiments upon the Temperature of Steam, the Operations of the Common Safety Valve, and upon Government Alloys: with a Description of Newly Invented Safety Valves, &c.* Pamphlet. In NARA RG 46, Commerce Records, Tray 26, folder 1 of 2, with his 1850 Treatise.

Journal of the Franklin Institute. *Report of the Committee of the Franklin Institute of the State of Pennsylvania for the promotion of the Mechanic Arts, on the Explosions of Steam Boilers*, Parts I and II. Part I is contained in JFI Vol. XVII (new series), 1836; Part II is contained in JFI Vol. XVIII (new series), Nos. 4 and 5, 1836.

Government Documents:

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U.S. House of Representatives. Document: *On Boilers of Steamboats.* (CIS No. 209-1, H. Doc. 131, 21-2). Washington, 1830, 1831. Contains government circular template to be used in gathering information.

U.S. House of Representatives. Report: *Explosion of Boilers of Steamboats*. Report of the Select Committee (Mr. Wickliffe, author). (CIS No. 228, H. Rpt. 478, 22-1). Washington, 1831, 1832. Contains "answers to interrogatories" in response to government circulars, and a report of the Franklin Institute. Discusses new Federal initiative to provide a remedy for steam boiler explosions. A number of causes of boiler explosions are reported, and the select committee's recommendations for solving each.

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