

# Urban Conflagrations in the United States

by

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## Introduction

From earliest colonial times until the early part of the twentieth century, American cities suffered devastating fires known as conflagrations. In towns as modest as Bisbee, Arizona, and Plymouth, New Hampshire,<sup>1</sup> and as impressive as New York, Boston, Baltimore, Denver, and Chicago,<sup>2</sup> urban conflagrations destroyed more U.S. property over this period than any other natural phenomenon.<sup>3</sup> Moreover, such fires were often not one-time events but occurred repeatedly: Boston was severely damaged by fires in 1653, 1679, 1711, 1760, 1824, 1825, 1835, and 1872. Plymouth, New Hampshire, lost major buildings or groups of buildings in 1862, 1895, 1909, 1910, 1914, 1917, 1930, 1932, and 1948. The mining town of Bisbee burned almost completely in 1885, 1907, and 1908. Five conflagrations destroyed a major part of a large metropolis: New York in 1835, Chicago in 1871, Boston in 1872, Baltimore in 1904, and San Francisco in 1906.

These fires grew in destructive power in parallel with the coming of the Industrial Revolution to the United States in the early 19th century. Cities and towns were no longer collections of merchant buildings and private residences of modest height. Massive factories moved in, and along with them warehouses, multi-story tenements for the mostly-immigrant labor force, and great houses of commerce and banking.<sup>4</sup> Compare: the Boston fire of 1760 destroyed 174 dwellings and 175 warehouses and shops with losses of about \$100,000; fire in the same city in 1872

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<sup>1</sup>For Bisbee, see Bailey, Lynn R., *Bisbee. Queen of the Copper Camps*, Tucson:Westernlore (1983); for Plymouth, see Speare, Eva, *Twenty Decades in Plymouth, New Hampshire*, Plymouth: Plymouth Historical Society (1962).

<sup>2</sup>For Chicago, see Colbert, Elias and Chamberlin, Everett, *Chicago and the Great Conflagration*, Cincinnati: C.F. Vent. (1871); Sheahan, James, and Upton, George, *The Great Conflagration of Chicago: Its Past, Present, and Future*, Chicago: Union (1871); Goodspeed, Rev. E.J., *History of the Great Fires of Chicago and the West*, New York: Goodspeed (1871); and Fowler, William, *Fighting Fire: the Great Fires of History*, Hartford: Dustin, Gilman (1873). For Boston, see Fowler (1873); Conwell, Russell, *History of the Great Fire in Boston*, Boston: Russell (1873); Sammarco, Anthony Mitchell, *The Great Boston Fire of 1872*, Dover: Arcadia (1997); and Schorow, Stephanie, *Boston on Fire: A History of Fires and Firefighting in Boston*, Beverly: Commonwealth Editions (2003). For New York, see Fowler (1873); Corbett, Glenn, and Cannon, Donald, *Historic Fires of New York City*, Charleston SC: Arcadia (2006). For Denver, see Kreck, Dick, *Denver in Flames*, Golden: Fulcrum (2000). For Baltimore, see Peterson, Peter B., *The Great Baltimore Fire*, Baltimore: Maryland Historical Society (2005); Williams, Harold, *Baltimore Afire*, Baltimore: Schneidereith (1954/1979).

<sup>3</sup>Conflagrations are the subject of a substantial body of historical and technical literature, beginning with the pre-1900 works cited in Note 2 and leading up to Peter Charles Hoffer's 2006 work *Seven Fires: The Urban Infernos that Reshaped America*. Perhaps the most comprehensive technical discussion of the subject appeared in a 1949 treatise entitled *Fire in Buildings*, authored by two prominent British fire safety experts of the time, Eric Bird and Stanley Docking. Chapter XII of the treatise is entitled "Conflagration Hazard," written with the advantage of knowledge gained during World War II. Social impacts of conflagrations are addressed in Rosen, Christine Meisner, *The Limits of Power: Great Fires and the Process of City Growth in America*, New York: Cambridge University Press (1986). The aftermath of the Great Chicago Fire is explored in Sawislak, Karen, *Smouldering City: Chicagoans and the Great Fire, 1871-1874*, Chicago: University of Chicago Press (1994).

<sup>4</sup>See Bryan, John, and Picard, Raymond., *Managing Fire Services*, Washington D.C.: International City Management Association (1979), p. 11 ff.; Weaver, John C., and de Lottinville, Peter, "The Conflagration and the City: Disaster and Progress in British North America during the Nineteenth Century," *Social History* XIII. No.26 (1980); Frost, L.E. and Jones, E.L., "The Fire Gap and the Greater Durability of Nineteenth Century Cities," *Planning Perspectives* 4 (Sept. 1989), p. 333-347.

destroyed 776 buildings in the heart of the city's commercial sector, with losses of \$75 million in 1872 dollars, or \$1.350 billion in 2004 dollars.<sup>5</sup>

By the mid-1920s, however, these city-consuming fires had abated. While large, multi-building fires continued to cause great damage on occasion<sup>6</sup>, the vast infernos leveling hundreds or thousands of structures did not recur. In this article I will identify the technological and social causes of conflagrations in U.S. cities and the technological and social changes which eventually eliminated this once-feared event.

## **The Risk of Uncontrolled Fires**

Whether or not an urban fire spreads out of control and envelops large sections of a city is dependent on a number of factors, each of which is changing in time along with changes in the city itself. An early settlement might have been situated close to a source of water, creating generally humid conditions and providing adequate water supply for rudimentary firefighting. Fifty years later, this settlement may have grown outwards miles from its origin, may have been subdivided into multiple political units, and may have changed from a mere trading post to a manufacturing center. During this period, the available combustible loading and the number of ignition sources may have multiplied many times while the fixed supply of water remained barely adequate for drinking and cooking.<sup>7</sup> Exacerbating matters, local climatology may have shifted from a damp period to one of drought. On the other hand, these increased hazards may have been opposed by larger and better equipped volunteer fire brigades, improved fire alarms and signals, and greater use of brick, iron and concrete in construction.

Comparing the risk of an uncontrolled fire in these two situations is not a simple matter. What we do know, of course, is that as American cities grew from settlement size to metropolis size, the size of the largest fires grew in proportion, leading to conflagrations of astounding proportions.<sup>8</sup> Since it is obvious that such fires were not desirable, they must be regarded as an unintended consequence of technological progress. In this case, however, the unintended consequence was not caused by any particular device or machine, but by a synergism among certain technological conditions created during the growth of American cities. A technological system of great power and complexity was ultimately required to defeat this disastrous unintended consequence. This system, however, was not designed by anyone nor is it actually maintained by anyone. Only the individual elements, both human and artifactual, are produced, owned, and maintained.

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<sup>5</sup>National Fire Protection Association (NFPA), *25 Largest Fire Losses in U.S. History*, NFPA website. In this reference the Great Fire of Chicago's 2004 dollar-loss was \$168 million. (Sometimes this number is given as \$200 million.)

<sup>6</sup>The Boston suburb of Chelsea was heavily damaged as late as 1973, see Hanson, Henry, "Conflagration Rages Through Chelsea Mass," *Fire Engineering* (Dec. 1973), *Boston Herald*, October 21, 1973, *Chelsea Record* October 28, 1998; downtown Fargo, North Dakota, nearly burned during the great flood of 1997, see Grand Forks Herald, *Come Hell and High Water* (1997); in November of 2005, a number of contiguous historic structures in downtown Annapolis, Maryland, were gutted by fire, see Watts, Jack, *Fire Safety in Historic Buildings*, National Trust for Historic Preservation (2008).

<sup>7</sup>This pattern of American settlement and urbanization is documented in Wade, Richard C., *The Urban Frontier: The Rise of Western Cities 1790-1830*, Cambridge: Harvard University Press (1959).

<sup>8</sup>This growth in the period 1790-1840 was astonishingly rapid. In that period, New York grew from 33,000 to 349,000; Philadelphia from 44,000 to 220,000; Boston from 18,000 to 118,000; and Baltimore from 13,000 to 102,000. Pred, Allan, *Urban Growth and the Circulation of Information 1790-1840*, Cambridge: Harvard (1973), Table 2.1, pp. 12-13. Pred shows that in the period 1840-1860, the new western cities exploded in population: for example, Chicago from 4,500 to 112,000, St. Louis from 16,000 to 165,000, San Francisco from 975 to 57,000.

Fire is a complex chemical reaction and even today remains a challenge for analysis on a large scale. However, the thermodynamics of fires and modes of spread are well understood and calculable. Once ignition of a combustible material has occurred, the exothermicity of the chemical reaction begins to generate heat energy. This energy spreads to surrounding bodies by means of conduction (direct physical contact), convection (generally movement of air and hot gases), and radiation (absorption by nearby surfaces).<sup>9</sup> Once any combustible material in the vicinity reaches its ignition temperature in the ambient conditions, it too will ignite and begin to generate heat energy.<sup>10</sup>

This cycle may proceed very slowly, as in the case of a smoldering fire gradually spreading through moderately combustible materials such as discarded tires. On the other hand, if significant quantities of easily combustible materials are concentrated in a small area, the cycle may be so rapid that persons in the area have no chance to escape. In certain cases, hot gases released by burning materials may themselves ignite in a phenomenon called flashover. When this happens, intense heat is generated almost instantaneously, with the usual result of even greater fire spread. While flashover normally occurs in a closed space, a similar phenomenon may occur when an extremely intense fire releases clouds of smoke and gas containing incompletely burned material.<sup>11</sup> These pockets may ignite like floating bombs after traveling some distance from the point of origin. In general, fires will continue to spread until they are suppressed by (a) artificial means (firefighting), (b) natural means (rainfall), (c) lack of contiguous combustibles, or (d) consumption of all combustible materials.<sup>12</sup>

An urban setting by definition means clusters of buildings relatively close to one another. “Close” may mean actually adjoining, as when long blocks of interconnected structures are erected, or it may mean at least close enough that one building can be easily seen from another. In the former case, connected structures, all three mechanisms of fire spread may be operative once ignition occurs in any location. If there are no fire walls dividing the structures, heat may be transferred by direct conduction within the buildings, making suppression from the outside all but impossible. The presence of a firewall (such as a continuous brick wall) may prevent direct conduction of heat and direct spread along connected combustibles such as support beams, walls, and roofs. But unless the firewall is of adequate thickness and is fully sealed, the wall itself may become hot enough to ignite materials on the non-burning side.

In the case of well-separated buildings, heat transfer by conduction is eliminated, as is spread by continuity of combustible materials.<sup>13</sup> Convection and radiation remain potent means by which the energy of the fire can be transmitted. Once the fire becomes large enough, however, a fourth spread mechanism may become important: sparks and larger pieces of burning material carried on a prevailing wind or even propelled by the air currents generated by the fire itself. In generally dry conditions and in the presence of a prevailing wind, this mechanism is a wild card that can cause fires to leap from one burning building to another blocks away. As we will see, this fire spread mechanism is capable of defeating the most determined and capable of firefighting efforts.

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<sup>9</sup>See Drysdale, D., *Fire Dynamics*, New York: Wiley (1999), *passim*.

<sup>10</sup>National Fire Protection Association, *Fire Protection Handbook* (2006), p. 10-100 ff.; Bugbee, Percy, *Principles of Fire Protection*, Quincy: NFPA (1978); Colburn, Robert, *Fire Suppression and Detection*, New York: McGraw-Hill (1975).

<sup>11</sup>Lyons, John, *Fire*, New York: Scientific American Books (1984), p. 84 ff.

<sup>12</sup>Bugbee (1978), p. 51 ff.

<sup>13</sup>This is not strictly true. Fire could travel from building to building along wooden sidewalks, covered passageways, power cables, etc. Wooden sidewalks were in common use in the United States in the period of interest, and are occasionally mentioned as an excellent fire propagator in conflagrations. See Haywood, Charles, *General Alarm: A Dramatic Account of Fire and Fire-fighting in America*, New York: Dodd-Mead, (1967), pp. 80-81.

The effectiveness of these modes of fire spread is determined by a number of factors both intrinsic and extrinsic to urban structures. Intrinsic factors include: flammability of construction materials, structural and architectural design, height, volume and flammability of contents, and average distance between structures.<sup>14</sup> Extrinsic factors include: meteorological conditions at the time of ignition and for days or weeks before, availability of water supplies and adequate pressure for suppression, time between fire initiation and the commencement of suppression activities, and the use (or non-use) of fire breaks by destruction of buildings. The interaction among these factors can be illustrated by a few simple cases. In Case 1, a wood frame structure surrounded by other wood frame structures catches fire on a humid day with calm winds. By the time of fire brigade response, the first structure is totally engulfed in flame and several adjoining structures have ignited. Water supply is adequate and pressure from the mains and from pumps drives hose streams to the roofs of the structures. Calm winds and high humidity reduce the likelihood of fire leap to more distant areas. A determined and timely fire response halts the fire with damage to a few structures.

In Case 2, a wood-frame building surrounded others of the same kind catches fire on a dry, hot, windy day. Fire brigade response is prompt, but water pressure is inadequate to reach the top of the engulfed building or the others nearby. Flaming brands are carried on the winds to the roofs of other buildings several blocks away. As the fire intensifies, radiative heating ignites the contents of buildings faced in brick or stone, and burning materials ignite wood structures or the flammable roofs of brick and stone buildings. Within an hour many buildings in a several block area are aflame and ignition is occurring at many locations downwind of the fire center. Fire brigades are forced to withdraw, water supply in the mains falls to minimal levels, and the fire now burns out of control.

During the century and a half or so of the great American conflagrations, from the statistical standpoint most urban fires could be described by Case 1. Either by reason of successful firefighting efforts, favorable meteorology, fire spread to a natural barrier such as a river, or sheer good fortune, most urban fires did not evolve into city-destroying wildfires. But when Case 2 occurred, the result was utter calamity.

A major culprit in America's fire problem was the availability of high-quality lumber at a reasonable price.<sup>15</sup> Unlike their European forebears, Americans of the time did not place a high value on the outward appearance of a structure (except for certain culturally significant such as churches and city halls); speed and economy of construction were stressed above all. While the American economy turned downward for a time after the Revolution, by 1800 a broad and rapid commercial expansion was underway. In the major cities of the East, construction of warehouses, trading centers, mercantiles, train stations, and housing was proceeding apace in 1800 and the decades to follow. Urban development of this kind was also rapidly spreading westward to Chicago, Kansas City, Denver, Seattle, San Francisco, and a dozen other cities destined to rival their east coast progenitors. As urban structures grew larger and taller, frameworks of iron replaced wood, but this offered no additional protection from fire.

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<sup>14</sup>Bird and Docking (1949), p. 98 ff.

<sup>15</sup>Bryan and Picard (1979), p. 17.

While many of the developed nations of Europe had exhausted forest reserves by the start of the 19th century, in the United States, the almost limitless availability of inexpensive, virgin-forest wood tended to discourage the use of brick, stone, and marble in the construction of dwellings, shops, factories, and warehouses.<sup>16</sup> Even though wood was widely used prior to coal's ascendance as a source of heat and power, the supply was so great that— unlike the case in Great Britain— its use as a building material was unrestricted. While old-forest states in the east such as Vermont were essentially denuded of trees by 1850,<sup>17</sup> America's westward expansion opened up access to forests that seemed inexhaustible. Railroads, rivers and canals made transportation of huge quantities of timber cost effective. The plentiful supply of lumber at reasonable cost led to wood being used in nearly all U.S. building construction.<sup>18</sup> Even where more imposing structures such as city halls and banks were faced in stone or brick, the interior framing, floors, walls, roof, and windows would be made of wood, and such structures were typically filled with carpets and upholstered furniture.<sup>19</sup>

Prior to the coming of the electric streetcar and later the automobile, horses were kept in urban areas in tremendous numbers, with the attendant need for wood-frame barns filled with straw and hay.<sup>20</sup> As factories became more prevalent in cities, warehouses in large numbers were constructed to hold both raw materials and finished goods awaiting transport. These buildings were filled with combustible materials and, even if the exterior walls were brick, the contents would catch fire easily when the walls grew overheated. Finally, wood has the unfortunate characteristic that its kindling temperature is sensitive to heat and humidity.<sup>21</sup> Extended stretches of low humidity and lack of rain dried out every bit of combustible material: walls, roofs, sidewalks, hay, scraps, storage, etc.

Even the design of buildings was problematic. The development of “joisted construction” in the 19th century allowed buildings to be built more rapidly and with less wood than older designs using heavy timbers and mortised joints.<sup>22</sup> But the use of joists enhances the spread of fire inside a building by providing more open space and smaller support beams that will fail rapidly. As to the use of brick exteriors, Paul Lyons remarks, “Brick buildings with the interior filled with wood-joisted construction were not much better . . . the effect was something like a stove filled with kindling wood.”<sup>23</sup>

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<sup>16</sup>Bird and Docking (1949), p. 25 ff.

<sup>17</sup>Albers, Jan, *Hands on the Land: A History of the Vermont Landscape*, Cambridge: MIT Press (2000).

<sup>18</sup>“Cities of wood like colonial Boston or antebellum Pittsburgh or much of post-Civil War Chicago were in effect artificial forests . . . with wooden shingles or thatch for roofing, soot-filled hearths and chimneys for wood or coal fires, they invited fire. The hay and straw in their barns was highly combustible, and the candles and wick lamps used in night lighting courted accidental fires.” Hoffer (2006), p. 9.

<sup>19</sup>Wermiel, Sara, *The Fireproof Building*, Baltimore: Johns Hopkins (2000), p. 37 ff. For more general discussions of building materials in the 18<sup>th</sup> and 19<sup>th</sup> centuries in the United States, see Gelerntner, Mark, *A History of American Architecture: Buildings in Their Cultural and Technological Context*, Hanover: University Press of New England (1999), and Randall, Frank and John, *The History of Development of Building Construction in Chicago*, Urbana: University of Illinois Press (1999).

<sup>20</sup>Whether or not Mrs. Murphy's cow actually kicked over a lantern, there is no dispute that the Great Fire of Chicago originated in the Murphy's hay-filled barn. See Chicago fire accounts, note 3 above.

<sup>21</sup>Bugbee (1978), p. 74; Weaver and DeLottinville (1980), p. 421.

<sup>22</sup>Hoffer (2006), p. 117.

<sup>23</sup>Lyons (1985), p. 35.

Nineteenth century Americans were well aware of the combustibility of their cities.<sup>24</sup> And while cities such as Boston, New York, and Washington had adopted regulations governing the thickness of walls and the materials to be used in the exposed portions of buildings, no other great city had taken any such measures. American cities and towns were, in brief, great piles of dry wood, hay, carpets, furniture, paint, and lumber, literally awaiting a spark to set it all on fire.

In the settlements of colonial America, structures tended to be clustered close together. There were good reasons for this, of course: easy access to the sea or river, defense against attack, nearness to a place of business, worship, or theater, etc. With commercial expansion, property values in large cities rose, and rose most rapidly in areas near the port, river, or railroad nexus. This increase naturally encouraged the maximum use of every available square foot. But the streets in these areas had been laid out in pre-industrial colonial times, hence huge wood-frame buildings hulked over the narrow street, which was generally jammed with pedestrians, horses, carriages, wagons, and vendors. Fire beginning in one building had very little distance to travel to another. Certain designs also tended to encourage fire spread. In Boston, for example, the mansard roof became popular for reasons of style and ability to withstand snowfall.<sup>25</sup> Mansard roofs were constructed entirely of wood, and were used to cap buildings of brick and stone that otherwise might have resisted fire in some degree.<sup>26</sup>

In the course of the 19th century, occasional but spotty progress was made towards alleviating the worst of the crowding. This was accomplished in the main by the clearing out of old buildings and shanties, straightening of curved streets, and widening of narrow streets. These actions permitted fire companies to reach a fire more quickly, made it more likely that they could direct a hose stream at upper sections of a building (after steam power was available), and made the transmission of fire across streets at least somewhat less likely. As cities expanded, there was a trend towards less crowding in areas further from the center, yet older commercial districts remained densely packed. And even where streets were widened, taller buildings were built whose roofs remained beyond the reach of firefighters' pumps.

### **America's Cities in 1800**

It would not be an exaggeration to say that American cities in 1800 were awash in ignition sources. Flame in one form or another was everywhere: candles, fireplaces, heating stoves, cooking stoves, oil lanterns, foundries, smithies, and so on. Lanterns were carried into stables filled with hay. Homes and businesses were heated by combustion of wood or coal. Domestic lighting was provided by candles and oil lamps, and later by gas lamps, themselves an ignition source. Smoking was common, especially of cigars that would smolder long after being tossed away. By mid-century, steam-powered trains spewing sparks entered into the heart of cities. Stationary steam engines fired by wood and coal became common power sources in factories and machine shops.

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<sup>24</sup>The July 1873 issue of the *North American Review* offered an article entitled "Fires and Fire Departments." Published the year after the terrible fires of Boston and Chicago, author James Bugbee takes note that "large cities in this country have grown up without any restrictions in the construction of buildings." Scan of entire article is available at: <http://cdl.library.cornell.edu/cgi-bin/moa/moa-cgi?notisid=ABQ7578-0117-6> (verified May 1, 2009).

<sup>25</sup>Schorow (2003), p.78-80.

<sup>26</sup>Ibid.

The understanding of ignition sources was considerable even in colonial America, and was relatively comprehensive by the mid-19th century.<sup>27</sup> Citizens and city governments were also aware of the danger of fire. City and town ordinances dating back to the earliest colonial villages promised certain and severe punishment for carelessness with fire.<sup>28</sup> Arson was generally punishable by death, so severe could be the consequences.<sup>29</sup> The fundamental problem was neither arson nor extreme carelessness, but the simple fact that ignition sources were in constant proximity with highly flammable materials. Under these circumstances, fires were bound to be prevalent, and they were.<sup>30</sup>

The technology of firefighting in the colonial period was not much changed from the Middle Ages or even from ancient times. Larger cities and towns might possess human-powered “fire engines” capable of throwing a significant volume of water several stories high. When the nearest water supply (generally a well or cistern) was some distance from the fire, as was generally the case, engine companies would form a chain and each pumper would pump the water to the next. In the face of a blaze that had already spread to several buildings, such chains of hand-worked pumps could not do much more than gain time for residents to flee. By 1800, the human-powered fire pump, drawn to the fire by teams of highly-trained horses, had reached the limits of its development. These pumps ranged from small ones operated by a four or six men, to huge affairs with two decks of pumpers numbering 40 or more in all. The largest of these engines was capable of projecting a small column of water a considerable distance vertically and horizontally (100 and 200 feet respectively), but only so long as its human operators could maintain a furious pace under often-horrendous conditions of heat or cold.<sup>31</sup>

Other tools available to early firefighters included hooks to pull off roofs or pull down walls of structures near the fire to prevent further spread. At times blasting powder was used, generally at great risk to the firefighters. Ladders were brought to the fire to save victims trapped on upper floors of buildings already on fire. Fire axes could be used to help cut down structures, open up roofs, or access buildings to save occupants or deliver blasting powder. Alarms in the pre-electric era were generally church bells or other bells mounted to the fire houses. This method had the distinct disadvantage that while one might know there was a fire somewhere, its exact location had to be learned by other means.

Fire alarms were extremely important in helping firefighters to get to a fire before it burned out of control. Every effort had been made, by 1800, to improve the use of bells and other sonic alarms. As steam power became available, steam whistles could also be used. In larger cities with multiple fire districts, bells or whistles might sound a certain number of times to signal the location. But this was unreliable: if a bell rang eleven times, what if the nearest fire captain heard only ten and sent his teams in the wrong direction?

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<sup>27</sup>Joseph Bird's *Protection Against Fire*, published in 1873, identifies and describes a wide variety of ignition sources: oil lamps and candles, fireplaces, stoves, smoking, steam and hot water heating systems. He was also aware of the danger of spontaneous combustion of caused by oil-soaked sawdust, cotton, hemp. By this time turpentine and kerosene were in common use, and Bird knew that they could be ignited easily by a spark or open flame. Bird (1873), pp. 17-36.

<sup>28</sup>Schorow (2003), p. 191 ff.

<sup>29</sup>Ibid.

<sup>30</sup>Dennis Smith recounts a story in which Swedish visitors to New York in the 1840s could go out on almost any night and be entertained by a fire somewhere in the city. Smith, Dennis, *History of Firefighting in America*, New York: Dial Press, (1978), p. 45.

<sup>31</sup>See King, William T., *History of the American Steam Fire-Engine* (1896/2001); Tamarin (1971); Green-Hughes, Evan, *A History of Firefighting*, Ashbourne: Moorland Publishing (1979).

One ineluctable fact was known from the very beginning: you need water, lots of it, to fight fires. Colonial settlements in America often had been located deliberately near sources of clean water, but with time and expanding populations, these water sources were exhausted and polluted.<sup>32</sup> Moreover, a water supply perfectly adequate for drinking and bathing may be grossly undersized and underpressured for firefighting even on a limited scale.<sup>33</sup> In general, municipal water systems constructed in the early 19th century were sized to supply potable water.<sup>34</sup> They were probably sufficient to fill reservoirs used for firefighting when water was drawn by buckets or hand-pumpers. Thirty and forty years later, however, these systems were leaking and the pipes were narrowed by rust and scale. Such reservoirs as did exist could not be refilled to match the vastly increased pumping power and endurance of steam engines.

Water supply and pressure problems plagued fire departments which were otherwise well-equipped with pumpers and hose.<sup>35</sup> In 1800, not a single major American city possessed a reliable municipal water system providing adequate volume (and purity) for drinking, washing, and firefighting. Philadelphia became the first in 1801, due largely to the indefatigable efforts of Benjamin Latrobe.<sup>36</sup> Boston and New York were decades behind. The lack of a pressurized system meant that in these cities, water for firefighting had to be drawn up from wells or drained from cisterns in order for the pumps of the day to function.<sup>37</sup>

An inadequate water supply was Boston's misfortune in the great fire of 1872: the water mains provided enough drinking water, but could not begin to supply the fire department's fleet of steam pumpers.<sup>38</sup> Boston was not alone in this predicament. The Seattle fire chief reported in 1888 that the city's water system could not be relied on in the event of an "extensive conflagration."<sup>39</sup> In June of the following year, the city burned down, and the *Seattle Daily Press* commented: "There were numbers of willing firemen, but from the first the water was at a provoking low pressure. The firemen fought mightily, but vainly."<sup>40</sup>

Many of the great conflagrations in American cities<sup>41</sup> occurred in highly unfavorable weather conditions: low humidity, lack of rain for an extended period, and a strong wind at the time of

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<sup>32</sup>American Public Works Association, *History of Public Works in the United States* (1976), pp. 217-235.

<sup>33</sup>This problem is explored for the city of Cornwall, Ontario, in Stein, Jeremy, "Annihilating Space and Time: The Modernization of Fire-Fighting in Late Nineteenth Century Cornwall, Ontario," *Urban History Review* 24:2 (March 1996), pp. 3-11.

<sup>34</sup>Koeppel, Gerard, *Water for Gotham*, Princeton: Princeton University Press (2000); Blake, Nelson M, *Water for the Cities*, Syracuse: Syracuse University Press (1956); American Public Works (1976), p. 217 ff.

<sup>35</sup>See Anderson, Letty, "Hard Choices: Supplying Water to New England Towns," *Journal of Interdisciplinary History* XV: 2 (Autumn 1984), pp. 211-234. Anderson's analysis focuses on New England but she provides a broad overview of the water supply problem in the United States beginning in the 18th century.

<sup>36</sup>Manfred (1956), p. 20 ff; see also Gilpin, Thomas, *Fairmount Dam and Water Works*, Historical Society of Pennsylvania (1913); American Public Works (1976), p. 218.

<sup>37</sup>*Ibid.*

<sup>38</sup>Schorow (2003), p. 80; Jacobson, Charles David, *Ties that Bind: Economic and Political Dilemmas of Urban Utility Networks, 1800-1990*, Pittsburgh: University of Pittsburgh Press (2000), p. 45.

<sup>39</sup>Reported in Jacobson, p. 65.

<sup>40</sup>*Seattle Daily Press*, June 7, 1889.

<sup>41</sup>The comparable experience of Canadians is documented in Smith, J. Grove, *Fire Waste in Canada*, Ottawa: Commission of Conservation (1918). Smith reports that the city of St. John was substantially destroyed by fire in 1877, Ottawa in 1900, and Toronto in 1904, the same year as the Great Fire of Baltimore. He discusses the phenomenon of conflagrations at pp. 103-106, where his technical conclusions are fully in accord with those I set forth in the text.

ignition.<sup>42</sup> These conditions would increase the flammability of already highly-combustible materials, deplete already marginal water supplies, and fan minor blazes into major ones before any action could be taken. In this sense, the exact timing of the great conflagrations can be correlated with meteorological conditions.

### **Technological and Urban Change, 1800 to 1870**

In the seven decades spanning 1800 to 1870, the United States underwent astonishing changes. Anyone living at both times must have been staggered at the transformation of the country. In 1800, overland travel was slow, arduous, and dangerous; in 1870, high-speed railroads could cross the nation in a few days.<sup>43</sup> In 1800, the geographic population center of the nation was in Howard County, Maryland, near Baltimore; by 1870 it had shifted westward to Ohio.<sup>44</sup> Waves of immigrants surged into the country from Europe and Asia. The Civil War destroyed the slave-based economy of the South yet stimulated the industrial economy of the North. The population of Chicago rose from a few thousand in 1837 (the year of its charter) to 300,000 in 1870.<sup>45</sup>

The great technological change of the age was the harnessing of steam power. The capacity to convert chemical energy into mechanical energy via steam made possible the factories and railroads of America's industrial revolution. From a civilization based on the power of horses, the United States became a nation of engines rated in hundreds and thousands of horsepower. Steam engines raised water for the cities to drink and bathe in, drove river boats up and down the Mississippi, and increasingly replaced sailing vessels on the high seas. Other technological changes, though not as important as steam power, nonetheless altered the lives of people in homes and factories. Gas for light and cooking grew in popularity; most major cities and many private residences had access to gas supplies by 1870.<sup>46</sup> In cities, horse-drawn trolleys competed for the streets with wagons and carriages. Steam-powered elevators made possible the building of higher and higher structures in major cities.<sup>47</sup>

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<sup>42</sup>Conflagrations merit a brief appendix in the textbook by Robert Colburn: *Fire Suppression and Detection*, New York: McGraw-Hill (1975). Colburn defines a conflagration as any fire "that communicates to adjoining properties, extending beyond a potential firebreak such as a street or an open area, and involving a goodly number of buildings." He then reproduces a table from the National Fire Protection Handbook (for 1975) listing the contributing causes for conflagrations when defined in this way. Unfortunately, the table begins with the period 1901-1925 when such fires were on the wane, but it is nonetheless useful for this study in the causes it identifies. The dominant factors are those I have already discussed, though it is not clear exactly what is meant by "inadequate public protection" as distinct from "ineffective firefighting."

<sup>43</sup>See Schivelbusch, Wolfgang, *The Railway Journey: Trains and Travel in the 19th Century*, New York: Urizon (1977). See also Davidson, Janet and Sweeney, Michael, *On the Move: Transportation and the American Story*, Washington D.C.: National Geographic (2004), Chapter 3, "The National Economy Gets a Backbone." In most cases one could travel from coast to coast in four days. In "Fastest of Fast Trains" the *New York Times* reported on October 13, 1889, that the Canadian Pacific would run from St. John, New Brunswick, to Port Moody, British Columbia, in four days time using 14 locomotives in relays. *New York Times*, Oct 13, 1889, p. 5.

<sup>44</sup> U.S. Census Bureau, <http://www.census.gov/population/censusdata/popctr.pdf>.

<sup>45</sup>Sheahan and Upton (1873), p. 50; see online population chart provided by DePaul University at <http://condor.depaul.edu/~history/chicago/population.html>.

<sup>46</sup>Rose, Mark, *Cities of Heat and Light: Domesticating Gas and Electricity in Urban America*, University Park: Pennsylvania State University Press (1995).

<sup>47</sup>U.S. Patent Number 31,128, issued to Elisha G. Otis January 15, 1861, "Hoisting Apparatus." Images available on the United States Patent Office Database, [www.uspto.gov](http://www.uspto.gov).

The risk of fire had abated little in this period. While the forerunners of skyscrapers in cities were fronted with stone and brick, their contents remained highly flammable and exposed items such as windows and roofs were made of wood. Gas lighting tended to reduce the risk of fire from candles and lanterns, but it required great care to be used safely.<sup>48</sup> Fires and explosions from the use of gas were all too common and sometimes extraordinarily destructive. The core industrial areas of cities remained tightly packed, and now were often surrounded by miles of poorly-constructed tenement houses occupied by immigrants working in the factories. Warehouses and factories rose by the thousands as America industrialized.<sup>49</sup> Factories were powered by steam engines whose boilers were heated by wood and coal fires. It is therefore not surprising that conflagrations struck Boston in 1824, 1825, 1835, and New York (to devastating effect) in 1835. Major fires also began to plague expanding cities to the west: Denver was nearly reduced to ashes in 1863.

There were three technological changes, however, working in the opposite direction. In major cities such as Philadelphia, New York, Boston, Chicago, and San Francisco, the municipal water supply was greatly improved.<sup>50</sup> Philadelphia's steam-powered system of drawing water from the Schuylkill River began operations as early as 1801, thanks to the unremitting efforts and engineering brilliance of Benjamin Latrobe.<sup>51</sup> New York's Croton Aqueduct began pouring water into polluted Manhattan in 1842, unfortunately seven years too late to battle the horrendous conflagration of 1835.<sup>52</sup> Chicago's steam-powered system of drawing water from Lake Michigan went into operation in 1842.<sup>53</sup> Boston opened its Cochituate Aqueduct in 1848, and thereafter the city had access to excellent drinking water— but too little water for fighting fires, as will be seen below.<sup>54</sup>

The invention of the telegraph system by Samuel B. Morse in 1844 led almost immediately to its use in fire alarm systems.<sup>55</sup> Boston and New York installed early versions of telegraphic alarms in 1851, and other American cities quickly followed suit.<sup>56</sup> By 1870, the process of converting from bells and fire watchers in towers to a network of telegraphic alarm boxes was well along, though not completed before the turn of the century. Where such systems operated, however, they often provided a critical time advantage to fire companies, allowing suppression of fires that otherwise might have exploded out of control.

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<sup>48</sup>Bird (1873), pp. 9-12.

<sup>49</sup>See, for example, Pred, Allan, *Urban Growth and City Systems in the United States 1840-1860*, Cambridge: Harvard (1980); also Pred's *Urban Growth and the Circulation of Information 1790-1840*, Cambridge: Harvard (1973); Monkkonen, Eric, *America Becomes Urban: The Development of U.S. Cities and Towns 1780-1980*, Berkeley: University of California Press (1988).

<sup>50</sup>For Seattle, see Kneels, Barton Harvey, "The Early History of San Francisco's Water Supply," unpublished thesis, University of California at Berkeley (1948), cited in Jacobson (2000).

<sup>51</sup>Armstrong, Ellis, *History of Public Works in the United States 1776-1976*, Chicago: American Public Works Association (1976); Blake (1956), Chapter 2, "The Ingenuity of Benjamin Latrobe"; also Gilpin (1913).

<sup>52</sup>Blake (1956), Chapter 8, "New York Builds Its Aquaduct"; also Galusha, Diane, *Liquid Assets: A History of New York City's Water System*, Fleischmanns: Purple Mountain Press (1999).

<sup>53</sup>Blake (1956), p. 266; Armstrong (1976), p. 226.

<sup>54</sup>An early study of system demand for fire appeared in Siems, V. Bernard, and Biser, D. Benton, "Fire Protection Requirements in Distribution System Design," *Journal of the American Water Works Association* (January 1924).

<sup>55</sup>Schorow (2000), p. 48 ff. provides a detailed narrative of the origins of telegraphic fire alarms. The definitive work on alarm designs is probably Roncallo, Paul, *History of the Fire Alarm And Police Telegraph*, Evansville: M.T. Publishing (2005). Of interest for its 1898 perspective is Hill, Charles T., *Fighting a Fire*, New York: Century (1898), p. 62 ff. Hill gives details about how alarms of that period worked that would be hard to find in later accounts.

<sup>56</sup>Roncallo (2005). For a contemporary account and description, see Bugbee (1873).

The third great advance of the 19th century was the rapid replacement of hand-cranked water pumps with portable steam engine pumps.<sup>57</sup> The first such pump demonstrated in America (following British developments) was built by Moses Latta of Cincinnati, Ohio, in 1852. It was impracticably large and heavy (22,000 pounds) but in initial tests it was able to throw as many as six 1-1/2" hose streams simultaneously as far as 225 feet, thus offering a replacement for as many as six hand-pumpers requiring 20-30 men each.<sup>58</sup> Within a few years, steam pumpers of equal power but weighing a third or a fourth as much were being built by many companies in the United States. These engines could make up steam in 5 minutes and could be drawn by teams of two or four horses at high speed.<sup>59</sup> Most importantly, provided fuel was available they could pump hour after hour without fatigue.<sup>60</sup> Changeover to all-steam pumper systems was slowed somewhat by both cost and the resistance of volunteer fire departments, whose members were directly threatened by the steamers.<sup>61</sup> By 1870, the conversion process was far along but not yet complete. Nonetheless, by this date all major U.S. cities possessed anywhere from 10 to 30 steam pumpers, and even a small town might have one. Coupled with an adequate supply of water, steam pumpers gave fire companies at least a chance of halting a major blaze by massing of pumpers in a single location.

By way of brief summary, then, progress had been made. By 1870, there was perhaps an increasing confidence in the country that major fires could be contained, their damage limited, based on the faster alarms, better water supplies, and far greater pumping power. This confidence was to prove unfounded.

### **The Disastrous Two Years**

*The terrible conflagration in Chicago will long be remembered as one of the prominent events of the nineteenth century. In the evening of Sunday, October 8, 1871, a stable took fire, and within twenty-four hours thereafter the flames had swept over an area of more than twenty-one hundred acres, destroying nearly three hundred human lives, reducing seventeen thousand five hundred buildings to ashes, rendering one hundred thousand persons homeless, and sweeping out of existence two hundred million dollars' worth of property.*<sup>62</sup>

By the year 1871, Chicago was a great mercantile city. Favored as both a rail hub and a port on Lake Michigan, its growth had been nothing less than astonishing. In two decades from 1850 to 1870, its population had increased by a factor of 10, from 30,000 to 300,000. The commercial district covered more than five square miles of densely-packed, large structures. While some of the newer structures were faced with brick or stone and had iron frameworks, the majority were wood-frame, shingled-roofed homes, warehouses, stables, hotels, boarding houses, and mercantiles. All told, there were in 1870 a total of 48,867 brick buildings, 44,274 of wood and 914 of stone or iron.<sup>63</sup>

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<sup>57</sup>Bryan and Picard (1979), p. 24 ff.

<sup>58</sup>Ibid.

<sup>59</sup>Bryan and Picard (1979); also sources in note 428.

<sup>60</sup>For the technology of steam pumpers, see King (2001/1896).

<sup>61</sup>Lyons (1985), pp. 42-51; Bryan and Picard (1979), pp. 34-36.

<sup>62</sup>Colbert and Chamberlain (1871), p. 9.

<sup>63</sup>The information in this and the following paragraph is condensed from Colbert and Chamberlain (1871), pp. 2-62; Hoffer (2006), pp. 110-116; Fowler (1873), Chapter I; Sheahan, James, and Upton, George (1871); and Andreas, A.T., *History of Chicago from the Earliest Period to the Present Time*, Chicago: Andreas (1889), Vol. 3.

As a progressive city, Chicago had neglected neither its water supply nor its fire department. As recently as 1869, Chicago had put into operation a new water system, drawing water into a steam-powered pumping station from several miles out in Lake Michigan. The fire department had passed the halfway point of converting from volunteers to professionals; by 1871, 185 professional firefighters were on the city's payroll. The department had at its disposal 16 steam pumpers, 54 hose carts, four hook and ladder trucks, and 48,000 feet of hose. The first telegraphic fire alarm had been installed in 1867, though the system by no means covered the city in 1871. A fire bell atop the courthouse signaled fires by district; it was manned at all times with a lookout.

Late summer and fall of 1871 had brought an extended drought to the great plains of the United States. Rainfall during the summer had been 28% of normal.<sup>64</sup> By October, everything wooden in Chicago was bone dry. In the week prior to the Great Fire, the resources of the fire department were called upon daily: 30 major fires in the week from September 30 to October 6. On October 7, a fire erupted in the boiler room of the Lull-Holmes Planing Mill and due to the strong southerly winds it spread out of control. Only an heroic effort by the entire fire department halted the fire at Adams Street to the north. This fire had been a full-fledged conflagration, consuming sixteen square blocks of buildings. It might have become known as the "Great Fire of Chicago" but for the events of the following day.

On the evening of Sunday, October 8, before the fire department could refurbish damaged engines and carts, rest its horses, and replace the 30 men injured in the huge fire of the 7th, another fire was reported in the vicinity of 137 DeKoven Street on the city's east side, a few blocks from the lake. Strong winds from the southwest quickly spread this far beyond the capacity of the reduced fire department to stop it.<sup>65</sup> By the time it was eventually suppressed by rain 24 hours later, the fire had destroyed 2,000 acres of property, 17,500 buildings, rendered some 100,000 persons homeless, and caused \$200 million in damage in the currency of the time.<sup>66</sup>

Among the oldest of major American cities, Boston had a long record of damaging fires: 1653, 1679, 1711, 1760, 1824, 1825, and 1835.<sup>67</sup> By the mid-18th century, Boston had made some upgrades to its water supply system, which was generally adequate for fresh drinking water. It was a leader among cities in installing telegraphic fire alarms.<sup>68</sup> By 1865, the city had installed no less than 73 pull stations in the inner city and surrounding areas. It had a large fire department on paper: 472 members in 1870.<sup>69</sup> But this number was deceiving; of these, only 85 were paid professionals fully trained to handle the steam engines. Of such engines, Boston again looked comparable to Chicago on paper: 21 engines, along with ten hose and seven ladder companies.<sup>70</sup> But unlike Chicago, whose 16 steam engines were located near the city center and were mostly of high capacity, Boston kept

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<sup>64</sup>Lyons (1976), p. 83.

<sup>65</sup>Minute by minute, eyewitness accounts can be read in Colburt and Chamberlain (1871), Goodspeed (1871), and Sheahan and Upton (1871). These books provide detailed maps of the fire's progress through the city. A letter providing another eyewitness account is reprinted in Woody, Robert H., "A Description of the Chicago Fire of 1871," *Mississippi Valley Historical Review* 33:4, pp. 607-616 (March 1947).

<sup>66</sup>An excellent online resource on the fire and its human and material consequences is "The Great Chicago Fire and the Web of Memory," maintained by the Chicago Public Library: <http://www.chicagohs.org/fire/index.html>. Another assessment, issued long after the event, is *The Great Chicago Fire*, published by the Chicago Historical Society in 1946.

<sup>67</sup>Schorow (2003), Chapter 1, "Built to Burn."

<sup>68</sup>Ibid.

<sup>69</sup>Lyons (1976), p. 89 ff.

<sup>70</sup>Sammarco (1997), p.7.

only six inside the boundaries of the ancient city, and some of the engines in surrounding areas were of very low capacity.

Boston had failed to improve upon a water supply system designed mainly for providing potable water.<sup>71</sup> Of particular interest is the struggle between John Damrell, an experienced firefighter whose technical expertise led him into the position of chief engineer for the City of Boston, and the Cochituate Water Board. Damrell tried throughout the 1860s to explain that the old cast iron water pipes were heavily encrusted with rust and that Boston's vintage fire hydrants were defective, with the result that the system could not possibly keep up with the demand of the new, powerful steam pumpers.<sup>72</sup> Examination of the Boston mayoral addresses beginning in 1851 shows that Damrell had a tough sell to make. In his inaugural address of 1851, Mayor Bigelow comments proudly:

There are 980 hydrants so located and arranged throughout the City as to furnish in every quarter, when necessary, an instant and inexhaustible supply of water for the extinguishment of fires.<sup>73</sup>

This boast may well have been true in 1851, when the fire department's 14 engine companies used human-powered mechanical pumps. In 1860, Mayor Lincoln lays claim to six steam pumpers and predicts that "a short time will elapse, I trust, before we shall have an entire steam department."<sup>74</sup> The problem, of course, was that while the fire department rapidly converted to steam pumpers, the water supply lines beneath the streets were left untouched. The city's water mains were but four inches in diameter, and the branch lines feeding hydrants a mere three inches— far too small to supply more than one large steam pumper at a time, if that. And as Damrell had pointed out, the pipes were also rusted on the inside, further lowering flow and increasing friction losses.<sup>75</sup>

Two further risk factors threatened the city, neither appreciated until after the fact. Boston's commercial district by 1870 contained many multi-story structures faced with brick or granite, supposedly a lesson learned from the city's many previous conflagrations.<sup>76</sup> However, many of the same buildings were topped with an ornate mansard roof, trimmed in wood and faced in highly-flammable wood shingles.<sup>77</sup> And in an era before self-propelled steam pumpers, Boston's fire department (like all others of the time) relied on well-trained teams of horses.<sup>78</sup> In November of 1870, the horse population of the entire city had been struck by equine flu, generally not fatal but incapacitating while it lasted.<sup>79</sup> There were no horses available to pull the massive steam engines over cobblestone and brick streets.<sup>80</sup>

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<sup>71</sup>Described in Lyons (1976), pp. 90-91; Schorow (2003), *passim*.

<sup>72</sup>Brayley, Arthur, *History of the Boston Fire Department*, Boston: Dale (1889); City of Boston, *Report of the Commissioners to Investigate the Fire*, Boston: Rockwell and Churchill (1873); Conwell, Russell, *History of the Great Fire in Boston*, Boston: Russell (1873), Chapter XIII.

<sup>73</sup>City of Boston (1894), p. 402.

<sup>74</sup>City of Boston (1896), p. 212.

<sup>75</sup> *Ibid*.

<sup>76</sup>The great height of the buildings alone was a problem. Even steam pumpers could barely drive water above 100 feet straight up, and then only with adequate water supply. The *Boston Daily Globe's* editors blamed the conflagration on wooden construction, height of structures, mansard roofs, and poor water supply. (November 12, 1872 issue)

<sup>77</sup>Schorow (2003), pp. 78-79.

<sup>78</sup>Brayley (1889), Chapter XI.

<sup>79</sup>*Ibid*.

<sup>80</sup>Eyewitness accounts state the firefighters dragged the heavy engines to the fire by hand— but this would have been (footnote continued on following page)

On Saturday evening of November 9, 1872, fire alarms announced a major blaze in a granite-faced six-story dry goods warehouse.<sup>81</sup> The nearest engine company responded as best it could lacking horses, but in the confusion failed to turn in a general alarm, thus delaying other companies. Without horses, all the massive steam pumpers had to be pulled by hand, but eventually most reached the fire, now completely out of control. The demand of the steam engines was far too great, and as Damrell had predicted, the water supply failed.<sup>82</sup> Aid requested by telegraph from surrounding communities arrived, only to find that their hose couplings were incompatible with Boston's antique hydrants. Though the wind was not strong at the time, it was more than adequate to carry burning brands from one roof to the next. Buildings burned from the top down on the inside, whatever their facing material. The city's grossly undersized water mains failed almost immediately. Eighteen hours later, a massed force of steam pumpers finally halted the blaze by drawing water from tidal reservoirs. The destruction: a square mile of the city's finest buildings, 776 large structures in all, at a cost of \$75 million in 1872 dollars.<sup>83</sup>

These two immense blazes,<sup>84</sup> coming as they did in an era which had begun to feel more confident of its firefighting capabilities, laid bare the fatal weaknesses still to be corrected: crowding of buildings, combustible construction, water supplies (in some cases), speed of response and accuracy of alarms, and reliance on the horse to pull the engines. Pitted against a single building on fire, several steam pumpers of the time could mount an effective attack. But a fire spreading in a high wind or from rooftop to rooftop remained an unconquered adversary.

### **Learning the Lessons**

Following the two great fires in Chicago and Boston, it was apparent to all that a city could not be protected by firefighting and alarms alone.<sup>85</sup> At least some of the remaining risk factors had to be overcome and other parts of the system strengthened still further. As I have already noted, steam pumpers were on the rise by mid-century, a trend that led to the elimination of hand-pumpers within a few more decades.<sup>86</sup> By century's end, all large urban fire departments had gone to "steam" and were professionalized.<sup>87</sup> Some steamers were even self-propelled, but this did not prove much of an advantage given the time lost in getting up enough steam to drive the engine. The next great advance was the power, light weight, and the instant starting capacity of gasoline engines. Internal combustion pumps came along in parallel with the development of the automobile, and by 1910

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slow and exhausting work. See Conwell (1873), p. 48; also Murdock, Harold, *Letters Describing the Great Fire*, Boston: Rockwell & Churchill (1873).

<sup>81</sup>Ibid.

<sup>82</sup>Testimony of Charles Damrell, Fire Chief, *Report of the Commissioners* (1873), p. 108 ff.

<sup>83</sup>NFPA, note 3.

<sup>84</sup> In addition to the two great conflagrations I discuss in this article, a forest wildfire in 1871 consumed the rural Wisconsin town of Peshtigo. It occurred on the *same night* as the Great Fire of Chicago, not entirely a coincidence because of the shared common cause of extended dry weather and high winds. This horrific fire claimed somewhere between 1,200 and 2,400 lives, far more than the Chicago blaze. Unlike Chicago's massive force of fire companies and pumpers (which were ultimately unavailing), Peshtigo possessed a single, horse-drawn steam pumper for fighting fires in the local sawmill. I do not discuss this fire in the text because Peshtigo was a small rural town, consumed not by an urban blaze but by a wildfire that even 21<sup>st</sup> century firefighting power would fail to halt.

<sup>85</sup>Haywood (1967) is especially good at listing the technological and social "lessons learned" after each conflagration. See also Rosen (1986) and Sawislak (1994).

<sup>86</sup>Bryan and Picard (1979), p. 29 ff.

<sup>87</sup>Ibid.

engines became powerful enough to drive the vehicle as well. The age of the horse-drawn fire engine had also drawn to a close. A gasoline engine pumper could race out of the firehouse with only seconds delay, and deliver multiple hose streams on a fire a few minutes later. Firefighters could also make use of devices to direct water streams from a high point, first from a ladder and later from a specially-built water tower.

Following the disaster at Boston, many cities with undersized water systems (or too few hydrants) invested in upgraded systems capable of supplying the steam pumpers. In the Baltimore conflagration of 1904, it became painfully evident once again that each city having its own hydrant coupling design and threading would no longer do. Within one year, the National Fire Protection Association announced a standard hydrant thread size and pitch.<sup>88</sup>

It was generally understood, however, that the critical problem was the crowding together of highly flammable structures. No force of steam pumpers could combat a wind-driven blaze leaping across seven-story buildings, spreading flame from block to block over the heads of fire companies. What was still needed were buildings so constructed that they did not tend to propagate fires even under the more dire meteorological conditions. Many so-called “fireproof” or “fire resistive” buildings had already been constructed in Chicago and Boston by the time of the great fires. While these structures could not withstand the intensity of the blaze, they did not contribute much to the propagation of the fire.<sup>89</sup>

This same conclusion was drawn after one of the last great conflagrations, the Baltimore fire of 1904. In its consequences, this fire rivaled the Chicago and Boston blazes: total losses \$100 million and eighty square blocks of valuable commercial real estate.<sup>90</sup> The fire began in the basement of a “fireproof building,” shot up an unprotected elevator shaft, exploded out of the roof, and ignited multiple blazes in surrounding buildings. In the resulting 36-hour fire, many other fireproof buildings were gutted— but they remained standing.<sup>91</sup> It became clear that a city constructed entirely of such buildings would be far more resistive to conflagrations. Modern building codes for commercial and industrial structures include many requirements derived from hard experience.<sup>92</sup>

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<sup>88</sup>Yet a 2004 study concluded that “100 years after the Great Baltimore fire many of the major cities in the United States do not have national standard hydrants. Although all hydrants use standard pipe diameter and thread combination, the sizes are not always in agreement with the national standard for hydrant connections. Almost all hydrants have national standard hose line connections (smaller diameter outlet). Most major cities do not have national standard pumper connections (larger diameter outlet). Today, it is common for fire engines to carry adaptors that make connections with all hydrants in areas where equipment may be used.” National Institute of Standards and Technology, “Major U.S. Cities Using National Standard Fire Hydrants, One Century After the Great Baltimore Fire.” NIST-IR-7158 (2004)

<sup>89</sup>See especially the post-fire photographs in Williams (1954) and Peterson (2004).

<sup>90</sup>Williams (1954); Hoffer (2006), p. 154 ff.

<sup>91</sup>An excellent recent treatment of the historic interaction between major fires and code development is Arnold, Jim, “Large Building Fires and Subsequent Code Changes,” Clarke County Nevada Building Division (2005). Arnold covers both the huge urban conflagrations and also building fires that resulted in major loss of life. He also provides some limited data (without identifying his sources) of conflagrations in other parts of the world.

<sup>92</sup>Sara Wermiel documents the surprisingly small role played by fire insurance companies and underwriters in achieving greater fire safety. Fire insurers liked a fair number of fires, because they encouraged business. They feared conflagrations because of so many multiple claims generated, but the insurance industry had difficulty in the latter part of the 18th century in developing a shared stance that could be imposed via rates on the insured companies. Wermiel (2000), pp. 133-137 and 173-178.

By the late 1890s, the influence of fire safety professionals had become an important driving force for change. This group included fire marshals, fire department chiefs, engineers, architects, and insurance underwriters, and took as its agenda the setting of uniform standards for building construction, fire apparatus, fire department operations and staffing, water supply needs, and control of combustibles and ignition sources. The National Fire Protection Association (NFPA), founded in 1896, by 1905 numbered hundreds of individual and institutional members, among them the Associated Factory Mutual Insurance Companies, the Factory Mutual Laboratories, and the National Electrical Contractors Association of the United States, American Water Works Association, the International Association of Fire Engineers (Fire Chiefs), the American Society of Mechanical Engineers, and the American Institute of Architects, a variety of sprinkler manufacturers and installers, and the U.S. Army Corps of Engineers.<sup>93</sup> The NFPA, which numbers some 81,000 members in 2007, was from its inception a powerful force in establishing uniform fire codes that could be adopted by cities and states throughout America.<sup>94</sup>

By 1925, all of the major sources of conflagration risk I identified above had been much reduced: electric power replaced gas lights and candles, greatly reducing the incidence of fires from lighting needs<sup>95</sup>; the vanishing of the horse as a means of transportation removed from cities highly flammable hay and stables<sup>96</sup>; new commercial buildings now included sprinkler systems that protected both the building and its occupants<sup>97</sup>; electric fire alarm systems notified central dispatching stations in seconds of the location of a fire<sup>98</sup>; fire engines and their pumps were powered by potent and reliable gasoline engines<sup>99</sup>; major cities in the United States were now served by professional fire departments<sup>100</sup>; state governments and code-setting bodies such as the

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<sup>93</sup>Source: NFPA history, found at [www.NFPA.org](http://www.NFPA.org), "Overview-History."

<sup>94</sup>The NFPA's essential mission was set forth in a speech at the first annual meeting in 1897 by Uberto Crosby, NFPA's first president: "To bring together the experience of different sections and different bodies of underwriters, to come to a mutual understanding, and, if possible, an agreement on general principles governing fire protection, to harmonize and adjust our differences so that we may go before the public with uniform rules and conditions which may appeal to their judgment is the object of this Association." See Hall, John R., "Countdown to the NFPA's Centennial – Life in 1896 America," *Fire Journal*, Quincy: NFPA (January 1995).

<sup>95</sup> See Kyvig, David E., *Daily Life in the United States 1920-1940*, Chicago: Dee (2002), p. 57: "For quite some time gas and electric utility systems waged a direct and often fierce competition. Both electricity and natural gas were viewed as expensive and novel in the early twentieth century, but their advantages over wood, coal and kerosene were widely recognized. The relative inflexibility of gas pipes, the more limited applications of the fuel, and the dangers associated with leakage put natural gas at a disadvantage in the contest . . . the percentage of gas used for illumination fell from 75 at the turn of the century to 21 by 1919." See also Rose, Mark, *Cities of Heat and Light*, University Park: PA State University Press (1995); Dillon, Maureen, *Artificial Sunshine: A Social History of Lighting*, Warrington: National Trust (2002); O'Dea, W.T., *The Social History of Lighting*, London: Routledge and Kegan Paul (1958); Bowers, Brian, *Lengthening the Day: A History of Lighting Technology*, New York: Oxford (1998).

<sup>96</sup> By 1923, the American auto industry was producing 3,700,000 cars per year and horses had vanished from the streets except as novelties. See Epstein, Ralph, *The Automobile Industry: Its Economic and Commercial Development*. Chicago: Shaw (1928). See also McShane, Clay, and Tarr, Joel, *The Horse in the City: Living Machines in the Nineteenth Century*. Baltimore: Johns-Hopkins University Press (2007).

<sup>97</sup> The first U.S. patent for an automatic fire sprinkler was issued to Henry Pamalee on August 11, 1874. (Image file can be viewed at [www.uspto.gov](http://www.uspto.gov), patent number 154076). The drive to sprinkler commercial buildings was initiated by the NFPA in 1896. See *NFPA Journal*, May/June 1995, "The Men Who Made the NFPA." See also Wermiel (2000), p. 129 ff.

<sup>98</sup> History of fire alarms in note 58 *supra*. See also Brayley, Arthur Wellington, *Complete History of the Boston Fire Department Including the Fire Alarm Service and the Protective Department*, Boston: Dale (1889), scan/download available at Google books.

<sup>99</sup> History of fire engines in note 34, *supra*. See also Calderone, John, *The History of Fire Engines*, Greenwich: Brompton Books (1997). The last horse-drawn teams appear in photographs of firefighting taken circa 1920.

<sup>100</sup> See Rabeau, Mark, *Eating Smoke: Fire in Urban America 1800-1950*, Baltimore: Johns-Hopkins (2003). Rabeau's (footnote continued on following page)

NFPA established uniform standards for building construction, fire apparatus, fire department operations and staffing, water supply needs, and control of combustibles and ignition sources.<sup>101</sup>

Taken together, these technological, social, and political forces all but eliminated the threat of city-destroying fires that had plagued the United States since earliest colonial times. Fifty years after the destruction of Chicago and Boston, U.S. cities felt confident that they were no longer at serious risk of this terrible fate.<sup>102</sup>

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Appendix One and Two provide comprehensive statistics on the rapid growth of professional firefighting after 1900.

<sup>101</sup> See <http://www.nfpa.org/assets/files/PDF/HistoryNFPACodesStandards.pdf>.

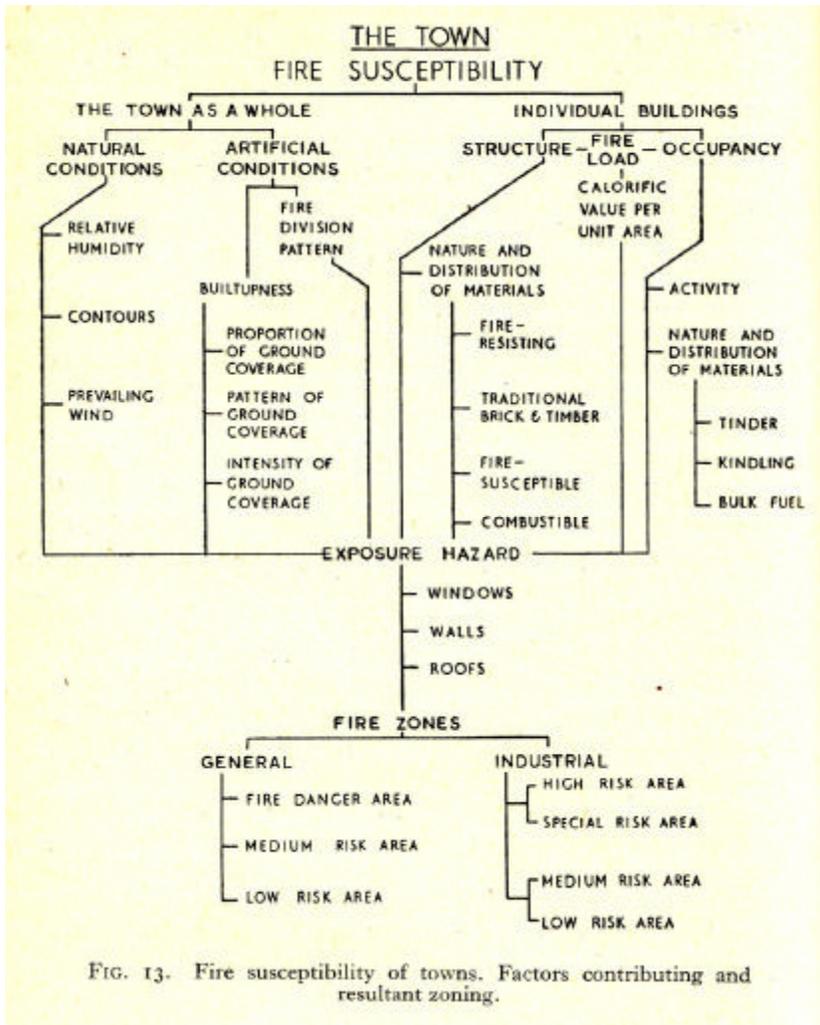
<sup>102</sup>The risk of conflagrations may be increasing, however, in industrializing nations. For China, see Guo, Tiw-Nan, and Fu, Zhi-Min, "The Fire Situation and Progress in Fire Safety Science and Technology in China," *Fire Safety Journal* 42, (2007), pp. 171-182. These authors display data showing that property damage from urban fires is currently rising exponentially in China.

## List of Figures

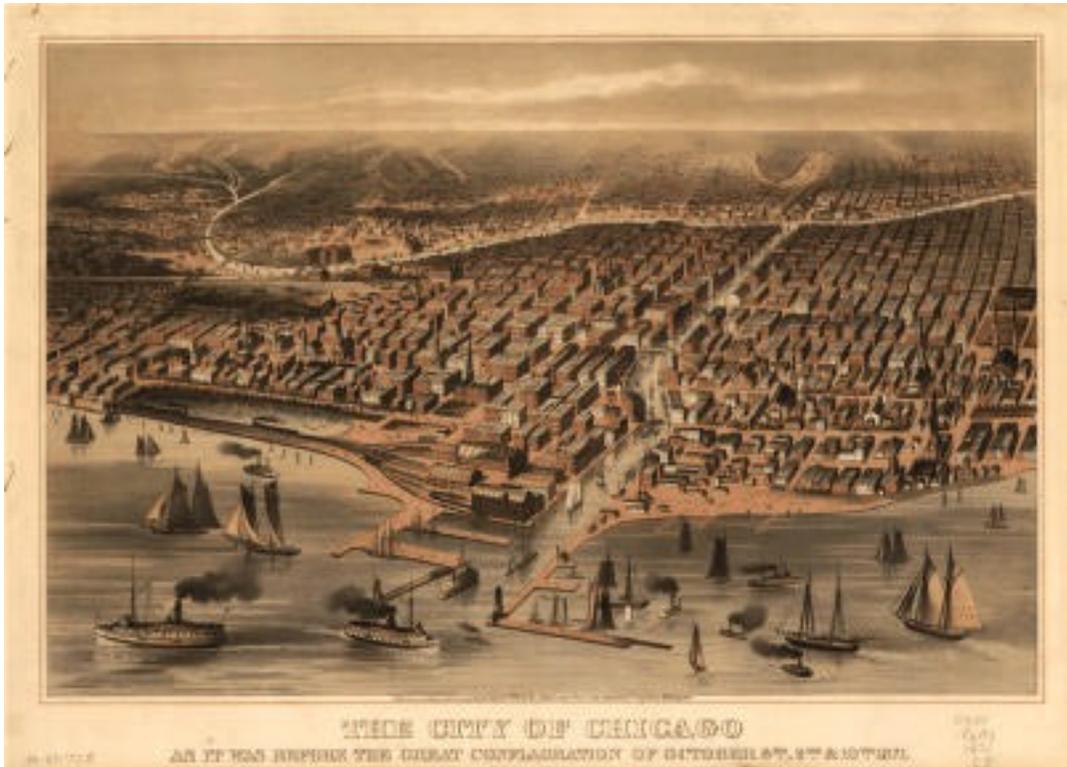
Bird and Docking Chart  
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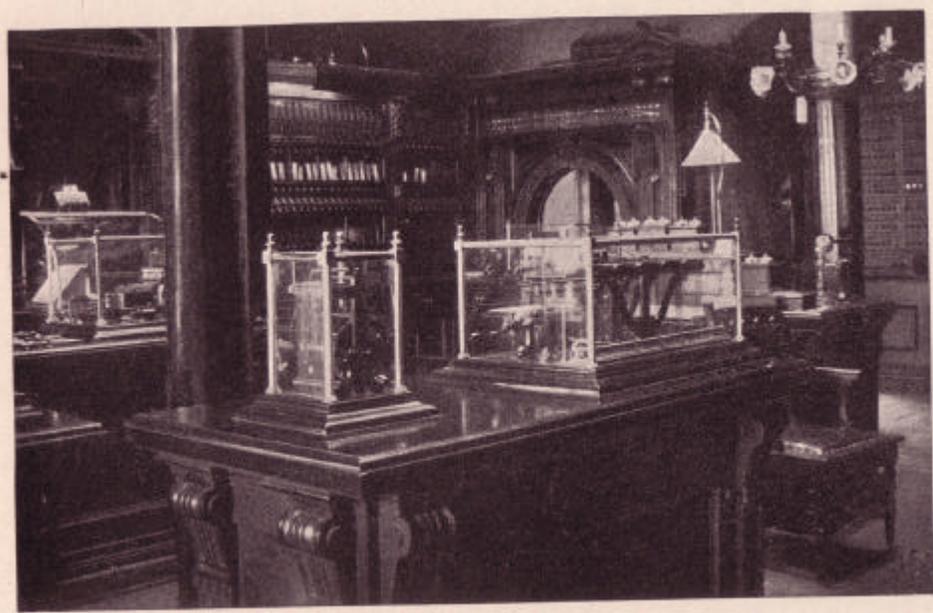
**Table A-1 Principal Factors Contributing to Conflagrations in the United States and Canada since 1900\***

| FACTOR  | NUMBER OF TIMES CONTRIBUTING |           |           |
|---|------------------------------|-----------|-----------|
|   | 1901-1925                    | 1926-1967 | 1901-1967 |
| 1. Wood-shingled roofs  | 45                           | 24        | 69        |
| 2. Wind velocity in excess of 30 miles per hour, or "high"                  | 22                           | 41        | 63        |
| 3. Inadequate water distribution system                                     | 23                           | 32        | 55        |
| 4. Lack of exposure protection  | 18                           | 29        | 47        |
| 5. Inadequate public protection   | 23                           | 24        | 47        |
| 6. Unusually hot or dry weather conditions                                  | 4                            | 23        | 27        |
| 7. Delay in giving alarm  | 5                            | 13        | 18        |
| 8. Congestion of hazardous occupancies difficult of access for firefighting | 5                            | 13        | 18        |
| 9. Delay in discovery of fire   | 4                            | 16        | 20        |
| 10. Forest or brush fire entered town                                       | 2                            | 10        | 12        |
| 11. Failure of water pumps or breakage of pipes                             | 5                            | 6         | 11        |
| 12. Ineffective fire-fighting   | 4                            | 6         | 10        |
| 13. Private fire protection failed or inadequate                            | 1                            | 9         | 10        |
| 14. Fire department at other fires  | 4                            | 3         | 7         |
| 15. Fire spread through inaccessible spaces under pier or building          | 2                            | 4         | 6         |
| 16. Severe winter conditions  | 2                            | 3         | 5         |
| 17. Earthquake, floods, hurricane, etc.                                     | 1                            | 3         | 4         |
| 18. Hose couplings or hydrant connections not standard                      | 2                            | 1         | 3         |
| 19. Cotton rags, etc., stored outside of buildings                          | 2                            | 1         | 3         |





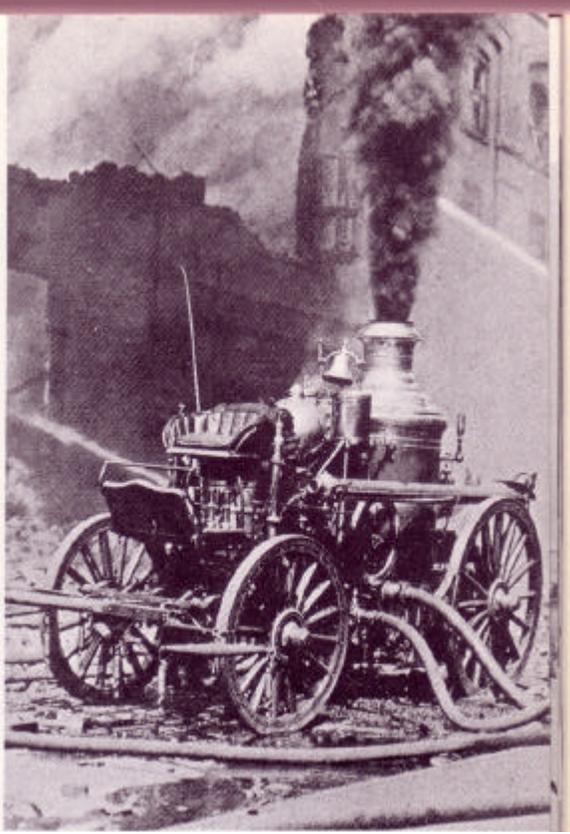




GENERAL VIEW OF THE FIRE-ALARM TELEGRAPH HEADQUARTERS.



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## 180 THE FIREPROOF BUILDING



Fig. 5-10. Baltimore after the 1904 conflagration, with fireproof buildings standing. Mississippi Wire Glass Company, *Reconnaissance of the Baltimore and Rochester Fire Districts...* (c. 1904).



