The Perils of Mining Anthracite: Regulation, Technology and Safety, 1870-1945

Mark Aldrich
Professor of Economics, Smith College

The anthracite coal industry played a central role in early American industrialization, and it was equally important in Pennsylvania's economic history. Increasingly from the 1830s until it was overtaken by bituminous coal, anthracite fired the early steam engines and heated the iron furnaces that were quickening the nation's economic development. It soon became one of Pennsylvania's most important industries. By 1880 anthracite employed over 70,000 men, more than twice the number working in the bituminous sector of the industry, and far more than any Pennsylvania manufacturing industry. In Schuylkill, Luzerne, Lackawanna, and a few other counties, anthracite employed more workers than all manufacturing industries combined.[1]

But hard coal came at an enormous human cost. Before 1870, the records are spotty, but gas explosions seem to have been common. A gigantic roof fall covering fifty acres killed fourteen men in a Carbondale, Pennsylvania mine in 1846, and haulage also took a regular toll. Beginning in 1870, the reports of Pennsylvania's mine inspectors document the extraordinarily dangerous nature of anthracite mining. From 1870 to 1913, the fatality rate averaged 3.42 per thousand employees per year compared to 2.87 for Pennsylvania's bituminous miners from 1877to 1913. And since far more men mined anthracite than bituminous coal during these years, hard coal mining typically killed over 400 men a year compared to "only" about 250 in Pennsylvania's bituminous industry. In fact, in the years just before World War I, Pennsylvania anthracite accounted for a fifth of *all* coal mining fatalities nationwide. In 1916, the hard coal miners experienced a fatality rate that was 4.75 times greater than that in manufacturing. Among major occupational groups for which data are available, only railroad trainmen typically ran greater risks.[2]

In spite of the risks of anthracite mining and its importance to the Pennsylvania economy, few historians have tried to explain why it was such a deadly business. Fewer still have attempted to explain the rather considerable changes that occurred in mining technology, death rates, and safety regulation. This essay relates the changing safety of hard coal mining down to World War II to the interplay of public policy and technological change. It also demonstrates that the impact of technology on safety was more complicated than has usually been appreciated. Changes in mining methods not only impinged on risks directly, they also changed the composition of employment, sometimes increasing, sometimes diminishing the share of below-ground, dangerous jobs. From time to time, as will be seen, these compositional effects played a major

role in accounting for changes in the safety of mine work. The evolution of anthracite mining thus underlines the difficulties of regulating safety in the context of rapid technological change. It also illustrates the complex effects that such changes can have on workers' lives.[3]

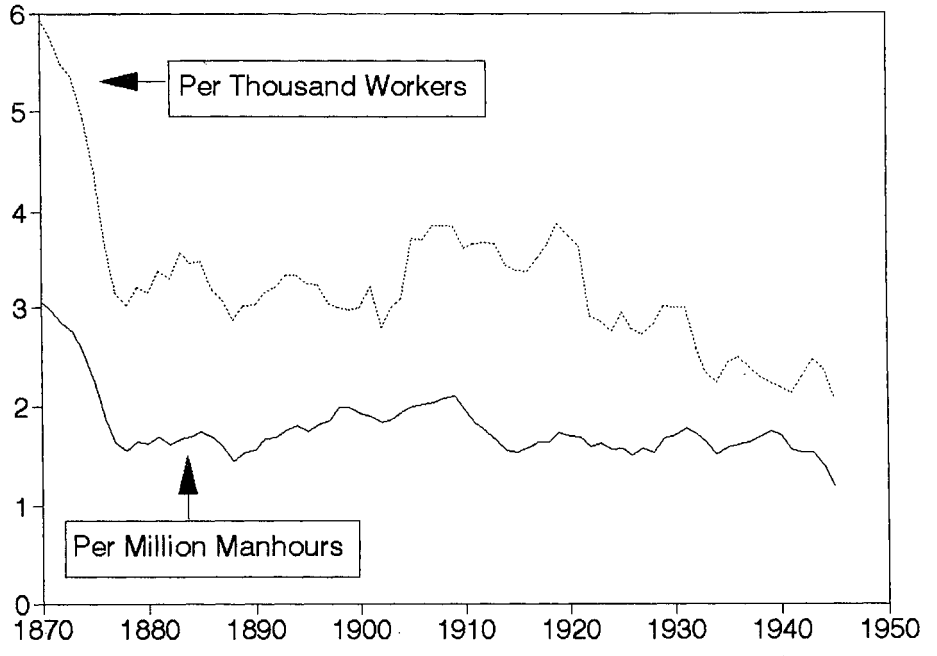
The Changing Safety of Anthracite Mining, 1870 to World War I

The risks of anthracite mining derived from many causes. Typically half of all miners died from falls of roof and coal. While a few of these — like Carbondale — were spectacular, involving many lives and much of the mine, most were less sensational, as was the death of David Edwards, a miner, who was killed instantly by a fall of coal when he failed to set a post on January 9, 1877. In the faulted and pitching seams, haulage was also dangerous, and mine cages and cars sometimes got away, leading to many fatalities. Anthracite mining also required far more blasting than did the winning of bituminous coal — with correspondingly greater risks. And as the mines became deeper, most of them gave off at least some methane, which is explosive in concentrations exceeding five percent. It might be ignited by explosives, or an electric spark, or the miner's pipe, if he smoked. Open flame lamps were also a routine cause of explosions, such as the one that killed four men on April 12, 1876 in the Nesquehoning mine, near Hazleton.[4]

Although anthracite mining remained a dangerous business from start to finish, its risks were by no means unchanging, as figure 1 reveals. The dangers of mining, as measured by fatalities per thousand workers, appear to have improved dramatically for about ten years after 1870, and then worsened until the decade before World War I. From a low of 2.85 per thousand in 1880, the fatality rate rose about 48 percent to a peak of 4.23 per thousand in 1907. When the data are expressed per million manhours, to control for changes in the number of hours worked, the results appear similar. Again, risks declined until about 1880 and then rose about 53 percent to a peak in 1908. Why, by either measure, did the safety of hard coal mining first improve for a decade and then, apparently, deteriorate for thirty years?

While Pennsylvania's early mine laws are easy to criticize, they led to marked improvements in mine safety after 1870. The miners, aided from time to time by the mining press, had been petitioning the legislature for a safety code since the 1850s. In 1858, the *Miners' Journal* reproduced a British mining law of 1855 and urged passage of a similar measure. That same year a bill calling for improved ventilation was submitted to the legislature, where it died — throttled, apparently by operator opposition. Finally, lobbying efforts by the miners' union, the Workingmen's Benevolent Association, paid off. On April 12,1869, Pennsylvania became the first state to regulate mine safety. The law of 1869 applied only to anthracite mines in Schuylkill County. It established state mine inspection, and required that the inspector pass an examination on his qualifications.

Figure 1
Anthracite Coal Fatality Rates Per Thousand Workers and Per Million Manhours, 1870-1945



Source: W. W. Adams, "Coal Mine Accidents in the United States, 1942," U.S. Bureau of Mines *Bulletin* 442 (Washington, 1944), Seth Reese, "Injury Experience in Coal Mining, 1949," Bureau of Mines *Bulletin* 525 (Washington, 1953), and calculations by the author.

The law also required an "adequate amount of ventilation," and mandated that ventilating furnaces should be constructed to "prevent ignition of coal." A fire boss was required who was to test for gas (figure 2) and he and the mine boss were generally charged with the safety of the mine. There were also a number of other general safety requirements. The emphasis on ventilation and the concern with gas reflected both earlier British laws and recent American experience, for as mine depth rose, gas explosions had become more common.

On September 6, 1869, a bit less than five months after the new law was passed, the Avondale mine shaft caught fire from the sparks of its ventilating furnace. Since it was a single shaft opening, most of those inside were trapped. In all, 110 died. Avondale was located in Luzerne County and so it was not subject to the 1869 law which might have prevented the tragedy, had its provisions been applicable and enforced. A second opening would also have saved the men.

Courtesy National Archives, R.G. 70.

Figure 2. The Fire Boss Testing For Gas with a Safety Lamp

In 1870, with the press in an uproar and miners' petitions pouring in, the legislature strengthened the safety code. The new law authorized the employment of six inspectors and covered all anthracite mines. The regulations now required mine maps and mandated double entries. They also required hoisting to be done by a competent engineer, set safety requirements for the cages miners used to descend to the work, and regulated the number of men allowed in a cage.[5]

As noted, the primary dangers of anthracite mining included roof falls, haulage, and gas explosions. The new laws probably reduced deaths from haulage and explosions. They may have had a broader impact as well, for inspectors routinely commented on and urged operators to improve a wide variety of conditions.

The annual reports of Pennsylvania's mine inspectors from 1870 on provide an invaluable source of information on anthracite mining methods, safety and accidents, and enforcement of the law. The inspectors were broadly knowledgeable, for they came from the industry and were required to pass a competency test. Although inspectors sometimes complained of their difficulties in

enforcing the new laws, their reports also note successful prosecutions from time to time. Many inspectors also acknowledged that most companies tried to comply, and they attributed improvements in safety to the law's operation.

In 1872, F. M. Schmultzer, inspector of the Pottsville district, claimed that "the law has wrought a wonderful change both in the condition and character of the collieries and the people, far above expectation." That same year, John Eltringham, inspector of the Ashland district, agreed, claiming that "the condition of the mines and mine ventilation is greatly improved, and is upon the part of all managers and mine bosses receiving encouraging attention." Two years later Eltringham also reported "a decided improvement" in mining conditions. In 1875, Inspector William Hemingway found "a large number of our operators desirous of making the necessary and safe improvements," while the next year Inspector Samual Gay detected "decided improvement" in ventilation" in his district, although he groused that a grand jury had ignored his bills. In 1877 Gay had better luck in court. He reported a successful suit against a foreman who was fined and given thirty days in jail for repeatedly failing to test for gas. In 1882 Inspector Gwilym Williams might have spoken for all his colleagues when he claimed that "vast improvements have been made, not only in ventilation, but in all the practical parts of the perilous industry of coal mining."[6]

While such claims are obviously self-serving, they deserve to be taken seriously. For one thing, as figure 1 reveals, they are consistent with the data, which show improving safety during these years. For another, most inspectors brought real expertise to their jobs. The same inspectors who claimed that safety was improving were quite capable of criticism when they thought the facts warranted it. Thus in 1877, Samuel Gay, inspector of the second Schuylkill district, thought there had been a "decided improvement" in ventilation. But he also excoriated the miners for taking chances that "might properly be called suicide," and complained that a grand jury had ignored his efforts to indict a foreman. The inspectors' views were also supported by the editors of *Colliery Engineer,* one of the nation's leading mining periodicals. In 1888, they called Pennsylvania's laws the "best in America." While this was certainly a modest standard of comparison, two years later they claimed there had been a "wonderful improvement in the collieries in respect to . . . safety as compared with their condition before the passage of the first Anthracite Mining Ventilation Law in 1870." The improvement was even "more marked since the enactment of the new Mine Law of 1885."[7]

But if the mining law had wrought such "wonderful improvements," why then did safety apparently steadily deteriorate from the 1880s on? The inspectors claimed that changes in underground mining were increasing its riskiness. Thus in 1879, T. M. Williams alleged that compared to a dozen years ago, the mines in his district were "many times more dangerous, being so

much deeper and more extensive." In 1888 inspector G. M. Williams made the same point, claiming that "the perils of mining coal increase each year with the extension of the working and with the depth." Inspectors also maintained that the influx of new immigrants who were inexperienced and spoke little English also worsened the risks of mining. Inspector H. McDonald thought that the most important difference between British and American anthracite mine safety was "in the workmen." He asserted that two-thirds of the miners and laborers did not speak English. In 1910, Pennsylvania's longtime chief mine inspector James Roderick concurred. "The occupation [anthracite mining], unquestionably is much more hazardous than it was twenty years ago." He blamed the dangers on "the difficulties encountered in mining the deeper veins and the employment of ignorant and inexperienced men from . . . Southern Europe."[8]

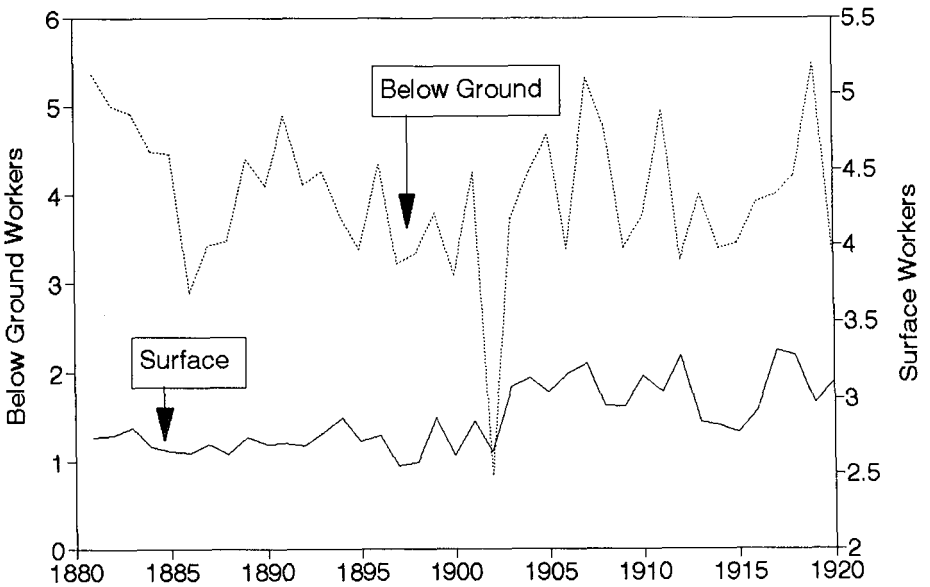
Certainly mine workers were increasingly new immigrants. In 1907, the U.S. Immigration Commission cited one probably typical large anthracite producer, 72 percent of whose employees were recent immigrants. And as the inspectors claimed, the mines were getting both deeper and larger during these years. Around Wilkes-Barre, average mine depth doubled — from 170 to 341 feet — between the 1870s and 1897, while the average work force per mine rose from about 100 to 500 men. In the western middle field around Shamokin, depth increased from 223 to 518 feet and mine size also increased sharply. The average depth of mining in Lackawanna County rose from 229 feet to 281 feet over the same period, and in every other field both mine size and depth increased sharply.[9]

The difficulty with this story, which blames the deterioration of safety on a decline in the quality of the miners or worsening underground conditions, is that the fatality rate for below-ground workers was improving slightly over these years, even as non-English speaking miners were flooding in and the mines themselves were increasing in size and depth. Probably these modest gains in the face of such adversity resulted from improvements in the mining laws, which were tightened in 1885, 1889, and 1891 as a result of recommendations from inspectors and lobbying by the miners.

Figure 3 presents fatality rates per thousand employees separately for surface and underground workers from 1881 (the first year for which they are available) to 1920. As can be seen, the apparent worsening of mine safety during these years had nothing to do with underground risks. In fact, the fatality rate for underground workers fell slightly after 1881 to the mid-1890s and then rose a bit; during 1911-1920 it averaged about three percent less than it had been in the 1880s.

The explanation for this odd state of affairs is straight forward. The overall fatality rate for anthracite miners was an average of the rates for surface and below-ground men weighted by the share of employees in each category. As

Figure 3
Anthracite Coal Fatality Rates Per Thousand Workers, Inside and Outside Employees, 1881-1920



Source: Pennsylvania Department of Mines, *Annual Report, Anthracite* 1921 Table 19.

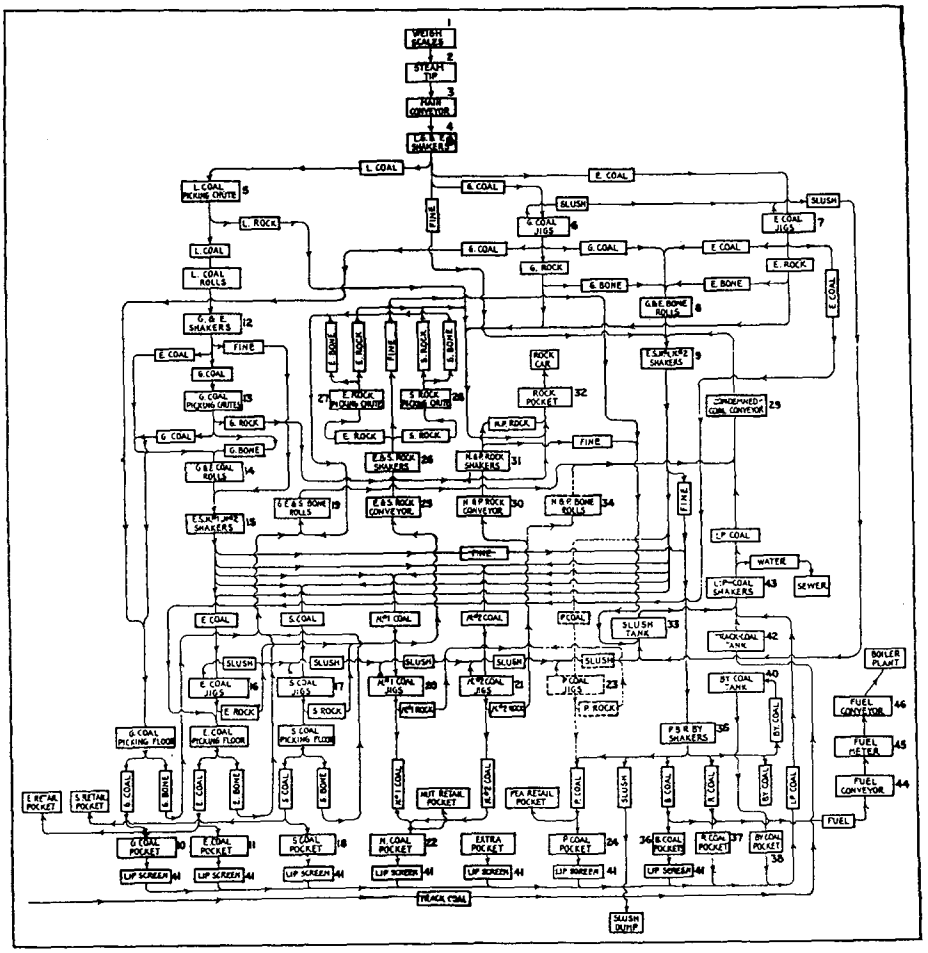
figure 3 demonstrates, surface work was far less dangerous than employment below ground. Thus it would be possible for the overall fatality rate to rise even though the rate for both surface and below ground men fell — if the share of below-ground employment were to rise sufficiently.

That was not quite what happened. In fact, the surface fatality rate rose by 48 percent from an average of 1.20 per thousand employees in 1881-1890 to 1.77 in the period 1911-1920. At the same time, the share of underground employment also rose sharply, from about 62 percent of all anthracite employment in the decade of the 1880s to 72 percent, accounting for about two-thirds of the increase in the overall fatality rate. From 1911-1920, the "typical" anthracite worker who labored below ground experienced less risk than had the typical worker a generation earlier even though the overall fatality rate for all anthracite workers was higher. The rising fatality rate resulted not because underground work was becoming more dangerous but rather because surface work was growing both more dangerous and relatively less common. Both results stemmed from technological changes in surface work.[10]

Beginning in the 1880s, a host of technological improvements was introduced to improve the above-ground handling of anthracite to cut costs and enhance product quality. Steam engines increased in horsepower, and electric power was introduced. Breakers grew in size, and larger mine cars along with

storage hoppers and spiral chutes were introduced to feed them coal. The 1880s also saw the introduction of shaking screens to sort the coal by sizes, while mechanical pickers were employed to remove impurities. Washeries were introduced, some relying on the different specific gravities of coal and impurities, and others using forced air to clean the coal. Hydroseparators were also employed to de-water and thus recover the fine coal. By 1919 anthracite mines used 6.1 horsepower per worker compared to only 3.9 for bituminous mines. The above-ground workings had become large, mechanized, continuous-flow factories. The breaker at the Pennsylvania Coal Co. (figure 4) exemplifies the state of technology at this time. It employed a host of rollers, shakers, chutes, jigs, conveyers, and washeries to break, separate, clean, screen and transport the coal and to remove the waste products.[11]

Figure 4
Flow Chart of Breaker, Pennsylvania Coal Co., 1920



Dever C. Ashmead, "Advances in the Preparation of Anthracite," American Institute of Mining Engineers *Transactions*, 66 (1920).

These changes sharply raised the productivity of surface workers, reducing the need for slate picking and other relatively safe activities. The technology of underground work improved only modestly and it was offset by the mining of thinner seams at greater depth and so productivity changed little. Thus in Lackawanna county, the average width of seams mined fell from nearly seven feet in the 1870s to about five in 1897. The productivity of inside men stagnated at a bit less than two tons a day, while outside productivity increased from 5.7 to 8.5 tons over the same period. Around Nanticoke, seam thickness declined from about eleven to eight feet in the nineteenth century, causing the productivity of inside labor to decline even as the output of outside employees increased sharply. Similar changes characterized the other districts as well. The net effect of these differences in productivity growth was to raise the share of underground workers in total employment.[12]

At the same time, mechanization also worsened the risks of surface workers. By World War I, two-thirds of the fatalities from above ground work resulted from mine cars, machinery, falls from heights, electricity, and boiler explosions (figure 5). Thus, between 1880 and World War I, technological change increased anthracite fatality rates for two interconnected reasons. It made surface work more dangerous, but because it also increased the relative productivity of surface workers, it reduced their share of mining employment while raising that of underground work. Since underground jobs remained

Courtesy National Archives, R.G. 70.

Figure 5. A Tipple Accident at the Patterson Mine that Killed Nine Men, July 30, 1915

comparatively dangerous, this shift in employment composition also raised the fatality rate.[13]

This story of technological change and mine safety downplays the importance of labor struggle in shaping accident rates. The miners, it is true, were largely responsible for Pennsylvania's laws of 1869 and 1870 and were active participants in revision in 1885 and 1891. They were also successful in 1889 in getting a state board composed of experienced miners to certify all anthracite miners who were required to have at least two years of experience in anthracite collieries. The law probably had little impact, for official corruption ensured that certificates were freely available for a price, and a secondary market soon developed.[14]

In the 1890s, the miners also began to clamor for the direct election of inspectors, for few miners had been able to qualify. In addition, there were claims that appointed officials were corrupt. They achieved direct election in 1901 thereby, in the words of Chief Inspector Roderick, throwing the job into a "vortex of political intrigue." Seven of his best inspectors promptly resigned. Later Roderick claimed that his worst fears had been confirmed. Inspectors who examined mine foremen for certification had begun to pass nearly every candidate for fear of political reprisals from the miners. In 1907, Roderick claimed that one board had certified ninety-two of ninety-five applicants.[15]

The United Mine Workers (UMW) became a major presence in the anthracite camps with the great strike of 1902. Yet the union seems to have had modest effects on company safety policy. Mine accident rates were not an issue in the strike itself, or in the great strike of 1920 — except as arguments for higher wages. Anthracite safety was seldom discussed in the UMW *Journal* —although that publication occasionally drew attention to the dangers of non-union mines. Nor was safety an important issue at the meetings of the anthracite Tri-District Conventions and neither they nor *Anthracite Tri-District News* reveal any dissatisfaction with the mine laws. In 1930 Secretary of Mines Walter Glasgow explained to the U.S. Bureau of Mines that "organized labor in [the anthracite] field appears to been entirely satisfied with the 1891 law and has always opposed any changes, regardless of their nature."[16]

At the local level, the union did play a modest role in enforcement of safety laws, however. Locals sometimes participated in accident investigations with representatives of the company and the Department of Mines, and they routinely passed on to the department miners' allegations of safety violations. All such complaints were investigated. Some men wrote of their concerns directly to the department instead of going through the union local, but most who did so remained anonymous for they feared reprisal from the company. Hence the union functioned both as a voice for the men and as a continuous check on company practices.[17]

The Inter-war Years: Anthracite Mine Safety 1920 - 1940

The two decades after 1920 brought momentous changes to the anthracite industry. The United Mine Workers consolidated their hold over employment. Production fluctuated at about 90 million tons a year until 1923 when it began to fall. At the end of World War II, output averaged a third less than it had a quarter century earlier. Employment followed the downward trend in production, declining about 55 percent to 74,000 men in 1945 from 160,000 in the mid-1920s. And since the mines typically worked fewer days with the industry in decline, hours of labor fell even faster than employment. Under the press of contraction, profits also declined, and some collieries fell into bankruptcy.[18]

Technological change continued apace during the inter-war years. An important difference with the earlier period was the speeding up of underground as well as surface productivity, however. The profit squeeze after 1922 encouraged a host of efforts to economize on labor and save costs. Susquehanna Collieries introduced a new entry system that reduced the need for maintenance workers, and all the mines increased their use of electric drills and trolleys. Scrapers (a kind of drag) were introduced that could efficiently remove coal from thin seams. At Hudson Coal, the first scrapers made their debut in 1916, and by 1928 they accounted for about 14 percent of the company's output. Price-Pancost Coal employed underground mechanical shovels to move rock. That company also introduced conveyors in 1923, and within a decade, they brought out 90 percent of its tonnage. Other mines introduced gravity chutes, rotary dumps, face conveyors, and pit car loaders to save underground labor. By the end of the 1930s, 28 percent of all anthracite was mechanically loaded. Companies installed roller bearings on mine cars that increased the number a motorman could haul, and they introduced automatic control of pumps and doors, ending the need to man them. Such improvements mimicked the improvement of above-ground work, and the impact of such rapid but balanced technical change was to end for a time the long term increase in the share of underground employment.[19]

The industry also experienced a momentous regulatory change. In 1916, Pennsylvania implemented its workmen's compensation law, raising the cost of accidents. Fatalities which had previously cost a few hundred dollars now set employers back $2,000 to $3,000, while lost eyes, hands and feet cost $1,500 to $2,000 each.[20]

Even before this financial jab to the bottom line most of the large producers had taken at least some safety measures. The original mine first aid organization was founded by Dr. Matthew Shields in 1900, at the Delaware and Hudson's Jermyn Colliery. Although as Shields laconically observed, "the company was appealed to but gave no encouragement," first aid soon spread throughout the anthracite districts — encouraged, no doubt, by the 1901 law

requiring the mines to provide emergency hospitals. Companies also began to stress safety education (in 1912, the Delaware, Lackawanna and Western published a book in five languages on the prevention of accidents in its mines), and they tried to encourage the spread of electric cap lamps.[21]

The rising cost of accidents that resulted from workmen's compensation legislation encouraged additional company safety work. Yet most such efforts seem to have been ineffectual. Hudson Coal was a large anthracite producer whose activities shed much light on the difficulties of improving mine safety. While the company had not been interested enough in safety in 1899 to support Dr. Matthew Shields' proposed first aid program, by the early 1920s it had a safety department and code of safety rules. In 1922 it began the systematic study of "work at the face" — an effort to develop the "one best way" to set roof timbers, drill, blast, and perform all the other tasks associated with mining anthracite. The object was both to reduce costs and improve safety. The results were codified into a set of rules and the company launched a campaign including "work at the face" dinners where miners were treated to chicken and all the fixings and subjected to a company speaker who eulogized the advantages of the new approach. This proved a hard sell, in part — as the company soon discovered — because its approach was not always "the best." Conditions varied so greatly from one part of the mine to another, that the company's techniques were sometimes inferior to those being practiced by individual miners. Convincing the men to follow company safety rules must have been difficult when it was clear that they sometimes knew more about mining efficiently than the company did.[22]

The miners' predilection to ignore company safety rules was no doubt reinforced by the casual attitude of the officials toward safety. An investigation into the death of Stephen Visit, who was killed in Hudson's Jermyn mine by a speeding coal trip on November 8, 1927, yielded the following interesting exchange between the inspector and the company transport foreman:

Question: "Did you ever question this motor runner about that [speeding]?"

Answer: "The only discipline I ever gave him was for losing time."

Question. "Is it a fact that . . . you pay more attention to the production from the motor than its speed?"

Answer: "No sir."

After an explosion killed four men in the company's Eddy Creek mine on September 29, 1927, mine officials used compressed air to disperse the gas — a clear violation of the mine law. "I was amazed to see this demonstration of incompetence," the inspector reported. The aftermath of this explosion revealed at least one payoff to the company's safety program, however. After receiving an unctuous letter from a company vice president elaborating Hudson's safety work, the department decided not to prosecute it for viola-

tions of the mine laws.[23]

As General Manager Cadwallader Evans later noted, "the safety program we had been carrying on was one more on paper than in our hearts and minds." This was true not only of the foremen and superintendents "but more important still, . . . of the general manager and vice president," he admitted. In the late 1920s, stung by the company's rising fatality rate, Evans determined to improve conditions. His efforts reveal that he was well-versed in the literature and accomplishments of the safety movement. He read U.S. Bureau of Mines publications, corresponded with safety men in the bituminous sector, and was familiar with the work of U.S. Steel, the copper producer Phelps Dodge, and the railroads, and he was determined to duplicate their successes at Hudson.[24]

Evans's approach emphasized supervision. He seemed disinclined either to make expensive safety investments or to confront many of the established practices and customs that impeded safety work. In 1927, when a miner was crushed because he failed to block the wheels of a mine car, Evans blasted his superintendents: "such accidents as these are the result of long continued failure to observe simple elementary rules of safety." Yet the next year Evans rejected the suggestion of a state inspector that he adopt systematic cross timbering. "Such a blanket order would cost our company hundreds of thousands of dollars a year," Evans claimed, and he thought it bore little prospect of any payoff.

Hudson was also slow to adopt some of the newer safety technologies. Since its inception in 1910, the U.S. Bureau of Mines had advocated blasting only with "permissible" explosives that would not ignite gas or coal dust, and by the late 1920s, many mines employed the new procedures. Hudson was not among them: on May 25, 1928, a blast of black powder ignited gas in its Baltimore No. 5 mine, in Wilkes Barre, killing ten men.

In May, 1929, in a staff meeting with his superintendents, Evans continued to hammer at supervision, bluntly blaming accidents on the "continued carelessness of our officials and their disregard for our rules." Evans told of a section foreman who when disciplined for violating a safety rule could not even understand why he was being punished. Such attitudes led to sloppy habits. According to the rules, foremen were to instruct new men in safety; in practice they were often simply told to be careful. In 1928, only 335 men out of a work force of nearly 18,000 had received any form of punishment for safety violation. The disinclination to enforce or follow rules may have resulted because, as one superintendent bluntly informed Evans, "there are so many things that are to be found out of line that it is difficult for the mine foreman or section foreman to decide the seriousness of the conditions." Foreman may also have been reluctant to enforce regulations that many of them thought were whimsical. For example, the failure to use a safety lamp led to dismissal while more serious offenses resulted only in suspension.[25]

Little was accomplished in 1929. To raise the safety consciousness of his operating officials, Evans made foremen fill out their own accident reports, and safety rules were revised so the punishment more nearly fit the offense — the failure to employ a safety lamp now led to suspension rather than dismissal. At the urging of the state Department of Mines, the company also tried to persuade miners to blast with electric batteries but that proved as hard a sell as the "one best way," because the men bought their own blasting materials and the local union balked at the cost of batteries and fuses. In early 1930, with the company losing money, Evans reminded his superintendents that the fifty fatalities in 1929 had cost $250,000 in workmen's compensation payments to families. He also recounted a conversation with the general manager of Consolidation Coal who had told him that the problem was with his officials. In February, Evans hired an outside consultant who concurred in this assessment and reported as well that some mines lacked first aid equipment and safety lamps! Evans' own safety department even favored the "radical" idea of using safety lamps where there were tests for gas, but costs were once again a problem as was the fear that the state inspector might then ban firing with fuses altogether.[26]

Evans also noted that a U. S. Bureau of Mines publication stressed the value of instructing new men. He observed that at Phelps Dodge this was done by the superintendents. This prompted an outcry; he was informed that annual labor turnover of 200 percent made such a procedure impossible. As a compromise Evans required superintendents to be present for the instruction. The company also published safety rankings of section foremen. In September, 1930, first aid classes were again begun for both men and managers. These efforts continued throughout the 1930s, with Evans hammering away at the failures of his subordinates. In 1937, Hudson also tried to encourage safety consciousness among the men by publishing a company paper "The Safety Commentator." In 1938 it started a "Safety Key Men" program to reward those who avoided accidents.[27]

Similar programs were adopted by other large producers. The Philadelphia and Reading published safety bulletins in Italian and Polish (figure 6) as well as English. In 1930 it began a campaign to shift to electric cap lamps. Lehigh Coal and Navigation introduced electric cap lamps and electric shot firing as early as 1913. A decade later, it undertook a systematic study of injury causation. Madeira, Hill also began an intensified safety program during the early 1920s. In 1929-1930, in response to a modification of the state mining code that required shaft workers to wear hard hats, Madeira, Hill, Lehigh and Price-Pancost began to require all men to wear such gear. Susquehanna Collieries began to employ safety inspectors in 1913. It also analyzed accidents, and maintained first aid teams and mine rescue stations. During the mid-1930s a U. S. Bureau of Mines safety car toured most of the large anthracite producers and provided nearly a half-million first aid and

Figure 6.
The Reading Appealed to its Polish Employees to Work Safely

ALL COLLIERIES BULLETIN

December 20, 1928.

Ogloszenie Wstrzymania Wypadkow No. 27

Zapadanie Sufitu Zabilo Czterech Robonikow Wjeden Tydzien

Alaska Brecha Grudzien 10

Kontraktow gornik 44 lat stary szuflowal wengel przy koncu siuta jak wengel spadl na jego i zabilo go.

Alaska Brecha Grudzien 14

Kontraktow gornik 36 lat stary swidrowal dziure w brestzie gdy kawal susita spadlo na niego i zabilo.

Tunnel Brecha Grudzien 15

Kontraktow gornik 50 lat stary suflowal wengel w siucie zeby zrobic miesctie dla propa gdy kamien spadl na glowe zabilo na miejstu.

Lincoln Brecha Grudzien 17

Kontraktow gornik 47 lat stary po wystrzelenu wrocil fejciu a zeby zerwac spodny wengel jak kamien spadl i zabilo go.

Smutny swieta dla wdow i 10 dzieci Ktokzy Cali nadzieje pokladali wtych opiekunach.

"MYJESTESMY CHLEBODAWCY NASZYCH BRACY"
W stolnie wiec pracujmy z swoim komitetem ostroznosci i ztol tracownikamy azeby zaprzestac wytadkow takowych pomiedzy nami.

KAZDY ROBOTNIK POWINIEN I MUSI BYC SWOIM WLASNYM INSPECTOREM OSTROZNOSCI

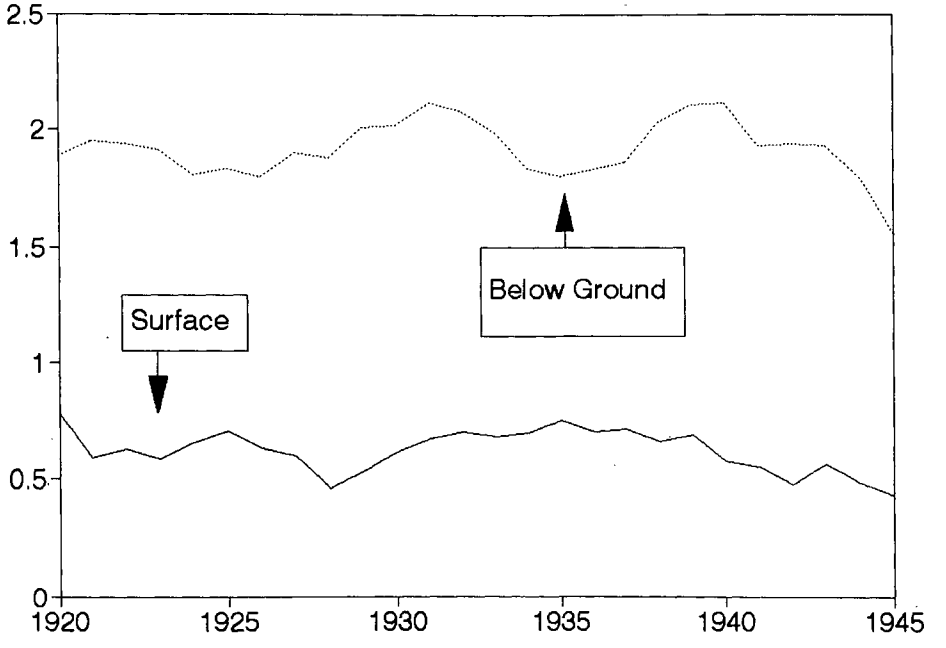
Industrial Relations Department
The Philadelphia and Reading Coal and Iron Company

Source: General Correspondence, Box 9, Department of Mines, Record Group 45, Pennsylvania Archives.

mine rescue courses.[28]

Despite such efforts, progress was glacial. Because manhours and employment were no longer so closely associated after WorldWar I, changes in mine safety are best indicated by the fatality rate per million manhours. As can be seen (figures 1 and 7), mine safety stagnated throughout most of the 1920s and 1930s.

Figure 7
Anthracite Coal Fatality Rates Per Million Manhours, Inside and Outside Employees, 1920-1945



Source: Various Bureau of Mines *Bulletins* and calculations by the author.

In part the failure of safety to improve resulted because most safety programs were, like that of Hudson, not very thorough. None of the programs systematically addressed the major causes of haulage accidents, roof falls, or gas explosions. Thus, a state inspector of Pennsylvania Coal Company electrical installations described them as "very good engineering practice except that the item of safety has not received proper attention." And Joseph Davies of the U.S. Bureau of Mines blamed poor management for the gas explosion that killed a miner in Blue Ridge Anthracite Coal Co. in 1933. The man had been setting timbers after hours when the fan was off. "This occurrence indicates a gross lack of supervision verging onto criminal negligence on the part of the management," Davies reported.[29]

In 1939, when U. S. Bureau of Mines engineer Simon Ash was trans-

ferred from Washington State to the anthracite fields, he toured one of Hudson's collieries. "The things that impressed me most," Ash wrote, "are practices which were in effect years ago and it is quite evident that progress in safety has not advanced to the degree it has in other mining regions." Ash cited the use of black powder for blasting, the absence of shot firers, the use of open or mixed lights, and smoking in gassy mines. "It is going to be a long time and a hard pull to do very much under such circumstances," he concluded.[30]

In addition, the underground environment was becoming increasingly hazardous during these years. Mechanization continued apace while areas were mined a second or third time and pillar extraction (removal of the coal that supported the roof) increased. Dan Harrington, a U. S. Bureau of Mines expert, stressed that such procedures were "much more hazardous than the original mining." They increased the risk of roof falls and led to squeezes and "bumps" (the explosive fracturing of a pillar or roof). Harrington also thought that greater depth and size of abandoned workings (where gas might accumulate) also made the mines more dangerous.[31]

Improving Safety in a Declining Industry 1940-1960

Real progress began only with the Second World War. This time the combination of changing mining technology and regulations finally began to work in concert to improve anthracite mine safety. As noted, productivity change in the 1920s and 1930s occurred without upsetting the distribution of employment between above and below-ground workers. This balance ended during World War II. As wages rose and output expanded, companies increasingly turned to strip mining, where labor productivity was higher and work much less risky than in underground mining. The share of production from stripping increased sharply from 12 percent in 1939 to 17 percent in 1943 and 22 percent in 1945. As a result, the share of underground manhours which had fluctuated around 73 percent of the total plunged to 65 percent in 1945, thereby diminishing the overall fatality rate.[32]

A new era of safety regulation also began in 1941. The first federal mine inspection law was passed in that year, and the U.S.Bureau of Mines began its inspection work in early 1942. By January, 1943 it published its first inspection standards for anthracite mines. While the bureau had no power of enforcement, whenever it inspected mines, it issued a report that was then posted at the mine and sent to both the company and the United Mine Workers. The reports were also regularly excerpted and reported on the front page of the *Anthracite Tri-District News,* often right next to stories of fatalities.

The bureau followed a standard format. Each report began with modest praise of some aspect of a company's operation. But the investigations revealed a truly astonishing number of unsafe practices: almost invariably bureau engineers urged improvements in ventilation, the banning of smoking

and open lights in gassy mines, guarding of trolley wires, improvements in haulage, guarding of sparking electrical machinery, the use of safety explosives, and more widespread use of hard hats.[33]

The Bureau of Mines had been founded upon the premise that investigation and publicity would be the cure for mine accidents and sometimes the inspections produced immediate results. As Dan Harrington dryly observed, "the publicity given to inspection reports usually has considerable influence in obtaining compliance with recommendations." A bureau inspection of the Saint Clair Coal Company in March 1942 led the company to begin systematic timbering, guard trolley wires, ground electrical equipment, and remove power lines from the (gassy) return air courses. Later that year, the Locust Coal Company responded to the bureau's prodding by improving ventilation and installing guard rails on the tipple. Many other companies also agreed to switch to electric cap lamps and various other safety improvements.[34]

With both regulation and technology finally pulling in tandem, anthracite safety sharply improved (figures 1 and 7). The shift of men to the surface reduced the share of dangerous jobs. The safety of all forms of surface work also improved steadily, while the death rate for underground work, which had ranged between 1.8 and 2.0 per million manhours from 1920 to 1943, now declined gradually to between 1.1 and 1.3 in the early 1950s. By this time the industry was collapsing rapidly, and while fatality rates rose again toward the end of the decade, by 1960 there were fewer than 10,000 men at work underground. The anthracite era was over.

Summary and Conclusion

This analysis provides a complex and somewhat paradoxical picture of the causes of changing anthracite mine safety. The impact of technological change was different than has sometimes been suggested. The overall data on fatalities reveal that dangers first declined after 1870 and then increased steadily from the 1880s to World War I. The early decline reflected the beginnings of state regulation, while the apparent worsening of safety after 1880 was the result of changes in mining methods, although these were not the sort of changes that are usually stressed. Increasing mechanization raised the risks of above ground work after 1880, although such dangers still remained far below those experienced by underground workers. Despite increasing mine depth and perhaps deteriorating skills of the miners, underground work actually grew a bit safer down to the mid 1890s, and underground risks in 1911-1920 still averaged less than they had three decades earlier.

But the main reason that technological progress worsened mine risks during these years was because it increased the share of employment in the relatively dangerous underground jobs. A majority of the overall rise in risk from the 1880s to the decade after 1911 resulted from this shift in employment.

Thus a paradox: even as the overall fatality rate rose after 1880, around the time of World War I most anthracite workers labored below ground at slightly less dangerous jobs than they had a generation earlier.

These complex effects of technological changes on job risks are by no means limited to anthracite mining. New technologies elsewhere can affect risks directly, sometimes aiding, sometimes swamping regulatory efforts. Thus mechanization probably worsened factory workers' hazards after the Civil War even as states were beginning to pass safety codes, while the shift to jet aircraft after 1960 powerfully reinforced federal efforts to improve air transport safety. Similarly, the impact on job safety of technologically-driven changes in employment is not confined to anthracite mining. In this century the shift to stripping has made iron and copper mining vastly safer, while the relative growth of white-collar work has reduced risks throughout the economy.

After 1920 anthracite safety stabilized for about two decades despite the introduction of workmen's compensation and widespread company safety work. Commitment of the large operators to safety-first programs was haphazard, and at best their safety work offset the worsening dangers that resulted as mines grew steadily deeper and more mechanized, and as pillar removal became more common. In addition, technological change during these years was balanced, raising the productivity of underground and above-ground workers in about the same proportion, and so changes in employment shares had little impact on overall mine safety. Beginning in the early 1940s, however, the growth of stripping, dredging, and washing increased the share of employment in relatively safe surface jobs at the same time that federal inspection began to reduce all mine risks. Finally, in the twilight of the anthracite era, as technological change reinforced regulatory efforts, the safety of hard coal mining began to improve.

Notes

1. For the importance of anthracite in early industrialization see Alfred Chandler, "Anthracite Coal and the Beginnings of the Industrial Revolution in the United States" *Business History Review* 46 (Summer 1972): 131-181. For employment in Pennsylvania industries see United States Tenth Census, *Report on the Manufactures of the United States* (Washington, 1883), 167-169 and *Report on the Mining Industries of the United States* (Washington,1886), 621-623.

2. Early gas explosions are noted in Howard Eavenson, *The First Century and a Quarter of American Coal Industry* (Pittsburgh: privately printed, 1942). The roof fall is from Hudson Coal Company, *The Story of Anthracite* (New York, 1932). See also Charles M. Keenan, "Historical Documentation of Major Coal Mine Disasters in the United States Not Classified as Explosions of Gas or Dust: 1846-1962," U.S. Bureau of Mines *Bulletin* 616 (Washington, 1963). For mining fatality rates I have relied on Albert Fay, "Coal Mine Fatalities in the United States, 1870-1914," U.S. Bureau of Mines *Bulletin* 115 (Washington, 1916).

3. For studies of hard coal mines and miners that discuss safety see Anthony Wallace, *St. Clair. A Nineteenth-Century Coal Town's Experience with a Disaster Prone Industry* (New York: A. A. Knopf, 1987); Robert Gordon, "Custom and Consequence: Early Nineteenth Century Origins of the Environmental and Social Costs of Mining Anthracite," in *Early American Technology,* ed. Judith McGaw, (Chapel Hill: University of North Carolina, 1994), pp. 240-277, and Harold Aurand, "Mine Safety and Social Control," *Pennsylvania History,* 52 (October 1985): 227-241. Discussions of the industry that say little about safety include Perry Blatz, *Democratic Miners: Work and Labor Relations in the Anthracite Coal Industry, 1875-1925* (Albany: SUNY Press, 1994), and his "Local Leadership and Local Militancy: The Nanticoke Strike of 1899," *Pennsylvania History,* 58 (October 1991): 278-297; Craig Phelan, *Divided Loyalties: The Public and Private Life of Labor Leader John Mitchell* (Albany: SUNY Press, 1994), and his "The Making of a Labor Leader: John Mitchell and the Anthracite Strike of 1900," *Pennsylvania History* 63 (Winter, 1996): 53-77, and Harold Aurand, "Early Mine Workers' Organizations in the Anthracite Region," *Pennsylvania History* 58 (October 1991): 291-310.

4. The Pennsylvania Inspectors of Mines, *Annual Report, Anthracite, 1870-* (Harrisburg, 1870-) are the best sources on the dangers of mining anthracite. (Hereafter, *Annual Report, Anthracite*).

5. On the coming of mine legislation see Alexander Trachtenberg, *The History of Legislation for the Protection of Coal Miners in Pennsylvania, 1824-1915* (New York: International Publishers, 1942) and Harold Aurand, *From the Molly Maguires to the United Mine Workers* (Philadelphia: Temple University Press, 1971), ch.12. Andrew Roy, *A History of Coal Miners of the United States* 3d ed. (Columbus: Trauger Printing Co., 1907) also discusses early safety legislation. Wallace, *St. Clair,* provides a scathing assessment of the early laws.

6. The inspectors' observations are in Pennsylvania Inspectors of Mines *Annual Report, Anthracite, 1872,* 67 and 100; *Annual Report, Anthracite, 1874,* 104; *Annual Report, Anthracite, 1882,* 105.

7. Gay's remarks are in *Annual Report, Anthracite, 1877,* 18-20. "Editorial," *Colliery Engineer* 8 (January 1888): 5; "The Benefits of Mine Legislation and Inspection," *Colliery Engineer 10 (July 1890): 276-277.* While the legislation itself was beneficial, there was no apparent connection between the number of inspectors and the level of mine safety. In his *Annual Report, Anthracite, 1902,* 9, Chief Inspector James Roderick commented that he was "not sanguine" that the increase would have beneficial results, and the next year *(Annual Report, Anthracite, 1903,* xvii) he claimed that there had been "no better results." The statistics support his contention. In 1881 there were 7,600 underground employees per anthracite inspector. By 1891, the number had risen to 9,571, even as safety was improving, and by 1901 it stood at 12,304. Modifications in the mine laws then increased the inspection force in several steps from eight to twenty-five men, and the ratio of employees to inspectors declined sharply to 4,120 in 1920, while under-

ground fatality rates rose slightly.

8. *Annual Report, Anthracite, 1879,* 82; *Annual Report, Anthracite, 1888,* 95-96; *Annual Report, Anthracite, 1894,* 87-88. Roderick's remarks are from *Annual Report, Anthracite, 1910,* 13.

9. U. S. Immigration Commission, *Report on Immigrants in Industries, Part 19, Anthracite Coal Mining* (Washington, 1911), ch. 3. For changes in mine depth and size during these years see the following articles by Dever C. Ashmead, "How Greater Depth and Reduced Thickness of Coal have Intensified Lackawanna Mine Problems," *Coal Age* 23 (February 22, 1923): 323-329; "In Half Century Depth of Coal at Wilkes-Barre More than Doubles and Thickness Falls 30 Percent," *Coal Age* 23 (March 22, 1923): 475-480; "Nanticoke Coal is Thickest Though Deepest of All Measures in Northern Anthracite Field," *Coal Age* 23 (April 5, 1923): 551-558; "Steep Pitches in Thick Coal Seams Greatly Affect Eastern Middle Anthracite Field Operations," *Coal Age* 23 (May 12, 1923): 749-754; "Panther Creek District Mines Thickest Coal Found in Pennsylvania Anthracite Region," *Coal Age* 23 (May 31, 1923): 885-890; "Anthracite Workings in Western Middle Field Are 148 PerCent Deeper Than in 1872," *Coal Age* 23 (June 21, 1923): 999-1004; "Southern Field Has Deepest Workings in Entire Pennsylvania Anthracite Region," *Coal Age* 24 (November 6, 1923): 347-350.

10. The overall fatality rate for anthracite miners rose from 3.22 per thousand employees in 1881-1890 to 3.60 in 1911-1920 or by .38 points. If the share of underground workers had remained at 62 percent of total employment as it was in 1881 to 1890, the overall fatality rate would have risen only to 3.35 or by .13 points. Thus the remainder of the increase (.25 points) resulted from the shift in employment to below-ground work and that is about two-thirds of the total.

11. A discussion of the origins of mine mechanization is beyond the scope of this paper. The mechanization of surface work in anthracite mines is discussed in R. V. Norris, "Labor Saving Devices in Coal Mining," *Engineering Magazine* 28 (January 1905): 553-569, and in Dever C. Ashmead, "Advances in the Preparation of Anthracite," American Institute of Mining Engineers *Transactions* 66 (1920), 422-508. Horsepower per worker is from U. S. Fifteenth Census, *Mines and Quarries: 1929 General Report and Reports for States and Industries* (Washington, 1933), 275.

12. See the sources cited in n. 9.

13. For above-ground fatalities by cause see Albert Fay, "Coal Mine Fatalities in the United States, 1870-1914," U. S. Bureau of Mines *Bulletin* 115 (Washington, 1916), table 125.

14. On the certification of miners see Trachtenberg, *The History of Legislation.* On the trading in mine certificates see *Annual Report, Anthracite, 1907,* xiii-xiv.

15. *Annual Report, Anthracite, 1903,* xx-xxii; *Annual Report,* Anthracite, 1914, 25.

16. On the role of unions in health and safety see Alan Derickson, *Workers' Health, Workers' Democracy: the Western Miners' Struggle, 1891-1925* (Ithaca: Cornell University Press, 1988), which discusses the union role in health and safety at western metal mines, and his "Participative Regulation of Hazardous Working Conditions: Safety Committees of the United Mine Workers of America, 1941-1969," *Labor Studies Journal* 18 (April 1993): 25-38. Priscilla Long, *Where the Sun Never Shines: A History of America's Bloody Coal Industry* (New York: Paragon House, 1989) is particularly good on safety issues in the Colorado mine labor disputes on the eve of World War I. See also David Rosner and Gerald Markowitz, eds, *Dying for Work: Workers' Safety and Health in Twentieth Century America* (Bloomington: University of Indiana Press, 1987). On the anthracite unions see Blatz, *Democratic Miners,* and Phelan, *Divided Loyalties.* For the role of safety in labor negotiations see U.S. Anthracite Coal Commission, *Report to the President on the Anthracite Coal Strike of May-October 1902* (Washington, 1903), and W. Jett Lauck, "Occupational Hazard of Anthracite Miners," Employes Exhibit Before the United States Anthracite Coal Commission (Washington, 1920). United Mine Workers of America, Tri District Convention of Districts Nos. 1—7—9 *Proceedings* (various years). Walter Glasgow to L. C. Isley, April 3, 1930, box 11, general correspondence, Department of Mines, Record Group 45, Pennsylvania State

Archives (hereafter DM, RG 45, PSA).

17. For examples of the union's role in policing compliance with the mine laws, see William Cox, Secretary of UMW Local, 1617 to Mr. Button, June 19, 1918, Fifth Anthracite District and David T. Williams to P. H. Tucker, Secretary of UMW Local 1672, April 27, 1928, Sixth Anthracite District. Union participation in accident investigations is revealed in "Diamond Trip Shaft Disaster" (n.d, ca. 1914), Third Anthracite District. All in box 1, general correspondence of anthracite inspectors, DM, RG 45, PSA.

18. The course of production and employment may be followed in U.S. Department of the Interior, *Minerals Yearbook* (Washington, various years).

19. For Susquehanna Collieries see "Susquehanna Colliery Co.'s Improvements Near Shamokin, Pennsylvania," *Coal Age* 17 (April 15,1920): 756-757 and Dever C. Ashmead, "New Entry System Aids Anthracite Mining," *Coal Age* 27 (June 18, 1925): 903-905; J. T. Jennings, "Anthracite Turns to Automatic Control," *Coal Age* 32 (September 1927): 129-130. For Hudson see Alphonse Brodsky, "Machines Extend Limits of Thin-Coal Mining," *Coal Age* 35(October 1929): 591-594, which also notes the use of automatic doors. Price-Pancost is discussed in Dever C. Ashmead, "Reopening Thick, Flat Anthracite Beds," *Coal Age* 27 (April 16, 1925): 579-580, and Ivan Given, "Conveyer Mining Overcomes Adverse Conditions at Price-Pancost Colliery," *Coal Age* 38 (January 1933): 3-6. For labor productivity data see Vivian Spencer, *Production Productivity and Employment in the Mineral Extractive Industries, 1880-1938,* Works Progress Administration, National Research Project, Report S-2 (Philadelphia, 1940).

20. For the costs of injuries under workmen's compensation see "Annual Report of Workmen's Compensation Bureau and Board," *Pennsylvania Labor and Industry* 18 (February 1931): 8-13.

21. M. J. Shields, "First Aid to the Injured in Coal Mines," *Engineering and Mining Journal* 85 (1909, Coal Mining Supplement): 42-43. See also *Annual Report, Anthracite, 1906* and *Annual Report, Anthracite, 1912* on first aid, rescue hospitals and electric cap lamps. J. H. Dague and S. J. Phillips, *Mine Accidents and Their Prevention* (New York: Delaware, Lackawanna and Western, 1912). E. A. Holbrook, "Safety in Anthracite Mining," in U.S. Coal Commission *Report,* part 2 (Washington,1925), 627-648, and Aurand, "Mine Safety and Social Control," (n. 3 above), 22. Origins of "work at the face" from Thomas Coates, Improved Methods of Work at the Face, May 24, 1923, microfilm reel 46, Hudson Coal Company, office files Record Group 2, Historical Collections and Labor Archives, Pennsylvania State University (RG 2, HCLA, PSU). Aurand, "Mine Safety and Social Control," (n. 3 above) stressed the connection between increasing productivity and safety. That the company's approach was not always best is revealed in Carl Peterson to Cadwallader Evans, "Report," August 31, 1925, January 31, 1926, May 2, 1926, and June 4, 1926, box 1, file 1, Peterson Papers, HCLA, PSU. "Minutes of Work at the Face Dinner Given the Miners of Jermyn Colliery on Saturday Evening, September 10, 1923," microfilm reel 58, Hudson Coal Company, office files, RG 2, HCLA, PSU.

23. The exchange is from "Testimony Relative to Fatal Accident of Stephen Visit" (N.d., ca. 1927), Second Anthracite District; L. M. Evans to Walter Glasgow, October 17, 1927, and A. M. Fine [Vice President, Hudson Coal] to L. M. Evans, December 30, 1927, Third Anthracite District. All in box 1, general correspondence of anthracite inspectors, DM, RG 45, PSA.

24. Cadwallader Evans, "Safety Problems Faced in Anthracite Coal Mining," National Safety Council (NSC) *Proceedings* 28 (1939), 455-457; Minutes of Staff Meeting, May 4, 1929, and May 29, 1930, microfilm reel 57, Hudson Coal Company, office files, RG 2, HCLA, PSU.

25. Cadwallader Evans to All Colliery Superintendents, November 23, 1927, and Evans to Walter Glasgow, January 5, 1928, box 9, general correspondence, DM, RG 45, PSA; Minutes of Staff Meeting, May 4, 1929, microfilm reel 57, Hudson Coal Company, office files, RG 2, HCLA, PSU. The explosion at the Baltimore mine is reported in *Annual*

Report, Anthracite, 1928, 6-10. On explosives use generally see S. P. Howell, "Explosives Accidents in the Anthracite Mines of Pennsylvania, 1922-1927," U. S. Bureau of Mines *Bulletin* 326 (Washington, 1931).

26. Minutes of Staff Meeting, February 14, 1930, April 8, 1930, May 29, 1930, microfilm reel 57, Hudson Coal Company, office files, RG 2, HCLA, PSU.

27. Minutes of Staff Meeting, May 29, 1930, microfilm reel 57, Hudson Coal Company, office files, RG 2, HCLA, PSU. Carl Peterson, "Safety Key Men," NSC *Proceedings* 28 (1939), 457-459.

28. J. W. Wetter, "How Madeira, Hill Company Has Reduced Accidents 40 Percent Since 1924," *Coal Age* 29 (June 17, 1926): 871-873; "Safety Work a Paying Proposition at Madeira, Hill and Co., Collieries" *Coal Age* 38 (June 1933): 177-179; "Safety at Lehigh Navigation Coal Co.," *Coal Age* 40 (December 1935): 518-521. C. G. Brehm, "Organized Safety in the Anthracite Mines of the Susquehanna Collieries Company," American Institute of Mining Engineers *Transactions* 139 (1940), 130-137. J. J. Forbes et al., "Work of the Bureau of Mines Safety Cars in the Pennsylvania Anthracite Region From 1934 to 1939," U. S. Bureau of Mines *Information Circular* 7132 (Washington, 1940), 23.

29. The electrical inspection is from C. M. Means to James Roderick, September 8, 1913, Third Anthracite District, box 1, general correspondence of anthracite inspectors, DM, RG 45, PSA. Joseph E. Davis, "Confidential Letter Report of Explosion, Blue Ridge Anthracite Coal Co.," September 11, 1933, box 1783, general classified files, Bureau of Mines, Record Group 70, National Archives.

30. Simon Ash to J. J. Forbes, August 29, 1929, box 3082, general classified files, Bureau of Mines, Record Group 70, National Archives.

31. Daniel Harrington, et al., "Safety in the Mining Industry,"Bureau of Mines *Bulletin* 481 (Washington, 1950), 48. Dever C. Ashmead, "Bumps and Shocks Disturb Johnson Colliery," *Coal Age* 26 (November 6, 1924): 641-643.

32. For fatality rates and man-hour shares see W. W. Adams et al., "Coal-mine Accidents in the United States, 1942," U.S. Bureau of Mines *Bulletin* 462 (Washington, 1944), and Seth Reese et al., "Injury Experience in Coal Mining, 1949," U.S. Bureau of Mines *Bulletin* 525 (Washington, 1943).

33. "Tentative Inspection Standards for Anthracite Mines," U. S. Bureau of Mines *Information Circular* 7231 (Washington, 1943); Daniel Harrington, "Activities of the Health and Safety Division, Bureau of Mines United States Department of the Interior During the War Years, 1941-45," U.S. Bureau of Mines *Information Circular* 7487 (Washington, 1949).

34. Harrington, "Activities of the Health and Safety Division," pp. 19-20. "Saint Clair Coal Company Commended by Safety Bureau for Employed Safety Methods," *Anthracite Tri-District News* 25 (August 14, 1942): 1-2; "Recommendations for Improvement of Conditions at Locust Coal Co. Operations Made by Mine Inspector," *Anthracite Tri-District News* 25 (December 25, 1942): 1-2. See also for example "Federal Men Make Inspection of Three Luzerne County Collieries," *Anthracite Tri-District News* 27 (January 7, 1944): 1-2, and "Federal Men Inspect Three Anthracite Operators,"*Anthracite Tri-District News* 27 (March 31, 1944): 1-2

35. Fatality rates and employment from various issues of "Injury Experience in Coal Mining," U.S. Bureau of Mines *Bulletin* (Washington, 1943-).