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The University of Pennsylvania's Department of Mines, Arts, and Manufactures in Context

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Abstract

This paper argues that even though it was short-lived compared to its contemporary engineering schools, the University of Pennsylvania's Department of Mines was an integral part of the changing energy landscape of 19th-century Pennsylvania. In addition to walking the reader through the history of Penn's Department of Mines, the paper explains how the value of science lies not in the lone pursuit of knowledge for knowledge's sake, but in its application to problems of economic importance, ultimately advocating the importance of the dissemination of knowledge.

The University of Pennsylvania's Department of Mines, Arts, and Manufactures in Context

Will Kearney

The University of Pennsylvania, as part of a restructuring of its undergraduate education,[1] established the Department of Mines, Arts, and Manufactures in 1852, but courses were not offered until the 1855-56 school year. While the Department ceased to operate during the Civil War and never resumed classes, Penn's Scientific School, later the Towne Scientific School and eventually the School of Engineering and Applied Science, rose from the remnants of the Department of Mines. Behind these institutional changes lies a broader change in what Christopher Jones, in his University of Pennsylvania Ph.D dissertation, calls the "energy landscape" of eastern Pennsylvania. This energy landscape, according to Jones, consists of the energy source and everything that it comes in contact with on its journey to the consumer, including mining, transportation, and consumption technologies and the people who use those technologies.[2] But an energy landscape, or any landscape defined by technologies for that matter, also includes the knowledge economy that grows up to support technological progress. Penn's Department of Mines, while short-lived compared to other contemporary engineering schools, was an integral part of the changing energy landscape of 19th century Pennsylvania.

The Energy Landscape of Eastern Pennsylvania

An energy landscape starts with an energy source – anthracite coal in the case of northeastern Pennsylvania – and adds in the people and technology that take the energy source to its consumers whether they are iron manufacturers or homeowners.[3] This landscape is distinct from its place because, in a mineral-based economy like the Coal Region, the energy source is

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[1] A scientific course, emphasizing natural philosophy and leading to a Bachelor of Science degree, was also established alongside the classical Bachelor of Arts education in the College.

[2] Jones, Christopher, "Energy Landscapes: Coal Canals, Oil Pipelines, Electricity Transmission Wires in the Mid-Atlantic, 1820-1930" (Ph.D diss., University of Pennsylvania, 2009), 8.

[3] Ibid.

tied to geological processes that occur in specific locations. Anthracite coal exists in the Coal Region because of mountain-building processes that compressed former swampland into coal;[4] the infrastructure and consumption patterns of that coal conform to the geology, so the energy landscape of northeastern Pennsylvania is unique to and rooted in this specific place.[5] Changes in energy landscapes, therefore, involve changing patterns of infrastructure and consumption.

Development of these anthracite coalfields forced the creation of new networks for energy. Fuel for heating and for iron smelting had come from charcoal made from the prevalent forests of the eastern United States. However, while trees are a renewable resource, a sustainable and perpetual yield for an iron furnace required several thousand acres to be dedicated solely to forests.[6] Any other use of that land, including agriculture or even other forest industries like timber, was limited by the amount of charcoal needed, and without at least that much forest set aside for charcoal production, the forest would be unable to regenerate itself quickly enough to maintain a furnace for longer than a few years. Bituminous coal had been used in Britain for almost a century, starting with Abraham Darby's method of producing coke from bituminous coal. The little coal that was used for heating and iron production in America was either imported from England or from the James River area of Virginia. During the War of 1812, the supply of bituminous coal from Virginia and England was cut off from the iron furnaces of Pennsylvania.[7] Fortunately, northeastern Pennsylvania sits on top of a number of anthracite coal veins created during the formation of the Appalachian Mountains. Anthracite has the advantages of burning hotter and cleaner than bituminous coal or charcoal, meaning iron made with

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[4] Dublin, Thomas and Walter Licht, *The Face of Decline: The Pennsylvania Anthracite Region in the Twentieth Century* (Ithaca, NY: Cornell University Press, 2005), 9.
[5] Ibid., 9.
[6] Bartholomew, Craig L. and Lance E. Metz, *The Anthracite Iron Industry of the Lehigh Valley* (Easton, PA: Center for Canal History and Technology, 1988), 6.
[7] Ibid., 8.

anthracite has fewer impurities. On the other hand, anthracite is almost pure carbon, the volatile compounds present in bituminous coal having been squeezed out by the immense pressure of the Appalachians over the veins. The lack of volatiles makes anthracite difficult to ignite. It was not until Josiah White and Erskine Hazard, wire makers on the Schuylkill Falls, accidentally stumbled upon ignited anthracite fuel after leaving their furnace alone for half an hour[8] that the anthracite revolution in eastern Pennsylvania took off. As iron manufacturers realized the value of clean- and hot-burning anthracite coal for their blast furnaces, the demand for anthracite coal skyrocketed. This led to massive changes in the energy landscape of the region, necessitating major improvements not only in the mining operation itself but also in the transportation networks that took coal and iron from the Lehigh and Schuylkill valleys and delivered products to markets in Philadelphia and New York. Railroads, for instance, are cost-effective at bringing coal to market, and they require iron (made in an anthracite furnace) for their rails and coal to power their steam engines. The technical changes in the energy landscape built upon themselves, fueling more technical and economic development.

Yet an energy landscape is not solely a technical system. It is rooted in its social context which, in northeastern Pennsylvania includes not only the miners, mine operators and landowners of the coal valleys but also the people down the Schuylkill and Lehigh in Philadelphia, in particular the elite of that city. Committed to a “Whiggish culture” and its “emphasis on planning and control,” the Philadelphia elites recognized the inseparability of the twin projects of economic development and scientific progress.[9] They accordingly were major figures in both industry and the scientific institutions of their city such as the American

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[8] Ibid., 9.

[9] Slotten, Hugh R., *Patronage, Practice, and the Culture of American Science: Alexander Dallas Bache and the U.S. Coast Survey* (Cambridge, UK: Cambridge University Press, 1994), 16.

Philosophical Society, the Franklin Institute, and the University of Pennsylvania. Furthermore, they recognized that the value of science lay not in the lone pursuit of knowledge for knowledge's sake but in its application to problems of economic importance – technology.

The program of technological advancement among Philadelphians can be broadly categorized into three projects: actual technological and scientific work that produced useful knowledge for industrialists, mechanics and other interested parties such as the federal and state governments; the dissemination of that useful knowledge among those already involved in industry; and the education and training of men who could apply the latest technical advances to the broader transformation of the eastern Pennsylvania energy landscape. The Franklin Institute took the lead on the first two. Their exhibitions and associated awards encouraged the solution of real problems such as a gold medal offered at the 1825 exhibition for the production of iron in a blast furnace using only anthracite coal.[10] Under the leadership of Alexander Dallas Bache, the Franklin Institute took on scientific projects, using the experimental knowledge of its members to solve problems of the utmost importance to the economic livelihood of Pennsylvania and the country. The most famous of their investigations examined the causes and prevention of steamboat explosions begun, and in 1830.[11]

Supporting these efforts was the Franklin Institute's journal, according to influential Institute manager Peter A. Browne, was the "grand lever with which we will raise everything."[12] The knowledge which was created by the Franklin and those associated with the Institute was useless without subsequent dissemination, and the *Journal* did just that by publishing both

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[10] Sinclair, Bruce, *Philadelphia's Philosopher Mechanics: A History of the Franklin Institute, 1824-18*65 (Baltimore: Johns Hopkins University Press, 1974), 87.

[11] Ibid, 176.

[12] Peter A. Browne to Thomas P. Jones, August 22, 1825, Letterbook, Corresponding Secretary, 1824-1826, Franklin Institute Archives, quoted in Sinclair, *Philadelphia's Philosopher Mechanics*, 57.

scientific and technical articles and descriptions of recently patented inventions, "one of the *Journal*'s most popular features."[13] In addition, the Committee on Instruction, particularly when led by Alexander Dallas Bache, provided a lecture course for mechanics on various topics in the mechanic arts and sciences often taught by young scientists such as James Espy, a meteorologist, Henry Darwin Rogers, who would go on to lead the Pennsylvania geological survey, and James C. Booth, a future Penn professor and founder of an industrial chemistry laboratory which would educate many young chemists on the model of German laboratories like that of Justus von Liebig.

The work of the Franklin Institute was first targeted at mechanics – those who built and operated machinery –skilled workers who learned their trade on the job. Miners, for instance, used a rule of thumb to remember that every thirty-yard-wide tunnel required a ten-yard-wide pillar to support it.[14] This craft knowledge was passed down through the generations, and technical information in the pages of the *Journal of the Franklin Institute* and the many mining publications such as Benjamin Bannan's *Miners' Journal* supplemented that traditional knowledge. Under Bache, the Franklin Institute became more expressly abstract and theoretical, publishing, for instance, Espy's meteorological work. This transition skipped over a growing class of engineers who applied more scientific knowledge to industrial and commercial problems largely through surveying and planning. These new engineers occupied a place between technicians and scientists and so needed a unique educational program.

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[13] Sinclair, *Philadelphia's Philosopher Mechanics*, 201.

[14] Wallace, Anthony C., *St. Clair: A Nineteenth-Century Coal Town's Experience with a Disaster-Prone Industry* (New York: Alfred A. Knopf), 50.

Educating Engineers

In the early 19th century, three major types of engineering education arose. The United States Military Academy provided engineering training to its cadets, including Alexander Dallas Bache. Though many of its alumni went on to distinguished military careers, some entered civilian life as engineers. Many other engineers were trained as apprentices on internal improvement projects such as the New York Canal System, which produced nearly 75% of chief engineers on projects in 1837.[15] Geological and geodesic surveys also provided informal educational experiences in technical fields: Fairman Rogers (future Department of Mines faculty member) worked with Alexander Dallas Bache on the Coast Survey (of which Bache was the commissioner) and John Fries Frazer and J. Peter Lesley were assistants on Henry Darwin Rogers's geological survey of the Commonwealth of Pennsylvania.

Maintaining a supply of engineers was always a problem. The Military Academy could not simply become an engineering school without losing its public mandate to train army officers, and the engineering projects, which gave apprenticeships to budding engineers, were not numerous enough to quickly provide skilled workers for the boom in demand for engineers. So began the dedicated engineering school. This school took many forms, from Rennselaer Polytechnic Institute, which only provided engineering education, to the special courses of established universities such as Penn's Department of Mines, Arts and Manufactures. Rennselaer was founded under Stephen van Rennselaer's vague direction to provide instruction in the "application of science to the common purposes of life."[16] To that end, van Rennselaer appointed the polymath geologist and surveyor Amos Eaton, often called "the father of American

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[15] Calhoun, David Hovey, *The American Civil Engineer: Origins and Conflict* (Cambridge, MA: The Technology Press,1960), 52.

[16] Stephen van Rennselaer to Rev. Samuel Blatchford, November 5, 1824. quoted in Palmer C. Ricketts, *History of Rennselaer Polytechnic Institute, 1824-1934* (New York: John Wiley and Sons, 1934), 9.

geology," to the senior professorship at his school.[17] It was Eaton's ability as a teacher and scientist that made Rensselaer a "Mecca for teachers of applied science".[18] Like Eaton's far-ranging knowledge, and in line with van Rensselaer's instruction, the education provided by Eaton was "aimed at a general diffusion of the natural sciences."[19] This highly democratic view of engineering education fundamentally differentiated Rensselaer from programs such as Yale's Sheffield Scientific School and Penn's Department of Mines.

Yale's applied science education began in 1847 in the School of Applied Chemistry under the direction of Benjamin Silliman, Jr. and John Pitkin Norton. They modeled their school on the great chemistry laboratory of Justus von Liebig in Giessen, Germany. Liebig's laboratory method demanded practical experience in chemical experimentation which Liebig himself had not received in his own classical education. Eventually the School of Applied Chemistry expanded into other engineering disciplines and became the Sheffield Scientific School. Like Penn, Yale formed its engineering department as a separate college integrated within a university, but unlike Penn, The Sheffield School offered graduate degrees with Josiah Willard Gibbs taking the first Ph.D in 1861.[20] Yale managed to find support for its engineering school outside the proprietary model that Penn settled on. The donations from its namesake and funding the Sheffield School received under the Morrill Act of 1863 ensured the School's continued existence until 1956 when the School's operations were consolidated within Yale's other schools.

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[17] Ricketts, *History of Rensselaer Polytechnic Institute,* 25-6.

[18] Mann, Charles Riborg, "A Study of Engineering Education" *Bulletin of the Carnegie Foundation for the Advancement of Teaching* 11 (1918), quoted in Ricketts, *History of Rensselaer Polytechnic Institute*, 29.

[19] Durfee, Calvin, *A History of Williams College* (Boston: A. Williams and Company, 1860), 371.

[20] Warren, Charles H., "The Sheffield Scientific School from 1847 to 1947," in *The Centennial of the Sheffield Scientific School*, ed. George Alfred Baitsell (New Haven, CT: Yale University Press, 1950), 59.

Unlike Rensselaer, situated in the rural industrial hamlet of Troy, New York, the Department of Mines, Arts, and Manufactures at Penn was founded right in the heart of the city of Philadelphia. With good reason, too, as Charles Eastwick Smith, an engineer associated with the iron industry and future president of the Philadelphia and Reading railroad, wrote to John Frazer shortly after the Board of Trustees approved a resolution establishing the Department:

> More than one half of all the iron made, and three fourths of all the coal mined, in the United States are produced within the Borders of Pennsylvania. The chief part of the financial arrangements incident to the production and sale of these great staples, accounting annually to more than *thirty-five millions of dollars*, are made in Philadelphia. Hence most persons who are connected with these arrangements, either as producers, or as large consumers, have acquaintances and correspondents here, and are obliged to visit the city several times during each year. Thus the place is the most convenient for the aggregate of the classes who are to be benefitted by the proposed school.[21]

Furthermore, Smith had just returned from a tour of Europe's famous schools of mines in Paris, (Freiberg, Germany, and Schemnitz, Hungary) and Smith suggested to Frazer a curriculum based on those schools. While Rennselaer's organization was reminiscent of Count Rumford's Royal Institution in London (and which ultimately was similar to the Franklin Institute's original purpose), [22] Penn's own school of mines was modeled after those mining institutions which served the public not through direct education of skilled workers but through the advancement of industry by the training of engineers. Smith, as secretary of the American Iron Association would later lend his organization's support to such a school, as was "eminently needed to the

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[21] Charles Eastwick Smith to John Fries Frazer, March 8, 1852, "1852-School of Mines", Archives General Collection (UPA 3), University of Pennsylvania Archives and Records Center, Philadelphia, Pennsylvania.

[22] Ricketts, *History of Rennselaer Polytechnic Institute*, 12.

economical conduct of the iron manufacture."[23] Like coal mines, canals and railroads, the Department of Mines was built into and rooted in the changing energy landscape of eastern Pennsylvania just as the coal mines and the Lehigh Canal

The Department was founded by a resolution of the Trustees on June 1, 1852, with John Henry Alexander as the Professor of Civil Engineering. John Fries Frazer, Professor of Chemistry and Natural Philosophy in the College, expanded his duties to teach those same subjects in the Department of Mines as did E. Otis Kendall, professor of Pure and Applied Mathematics. Charles Trego was appointed Professor of Geology and Mineralogy. Problems with financial and organizational support for the Department precluded the beginning of instruction in that year. By 1855, Alexander had resigned, and Fairman Rogers was appointed in his place. Rogers, the son of an iron merchant, had graduated from Penn in 1853 and had spent the intervening years on a tour of Europe and surveying the marshes of Florida under the command of Alexander Dallas Bache. With the young civil engineer (he was in his mid- to late twenties during his tenure) occupying the deanship, the Department of Mines took off. The success of Rogers's first course in 1855 led to the beginning of courses in the other subjects the following year, and a Professor of Mining, J. Peter Lesley, librarian of the American Philosophical Society and a former apprentice on Henry Darwin Rogers's survey, was finally appointed for the 1859-60 school year.

The Department's collapse after just six years of operation, despite being due primarily to the external circumstances of the Civil War, shows that the Department as an institution was not capable of drawing in enough students after normalcy was restored at the close of the war to

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[23] Resolution of the American Iron Association communicated to the Trustees of the University of Pennsylvania, March 20, 1855, Minutes of the Board of Trustees of the University of Pennsylvania, Vol. 10, 1852-1869, University of Pennsylvania Archives and Records Center, Philadelphia, Pennsylvania.

justify its continued existence as a proprietary school of the University. Rogers and the Trustees counted on the state's recognition of the course as integral to its continued economic development and therefore on the state's financial support as was provided to the European schools of mines. Justin Smith Morrill, a U.S Senator from Vermont, had pushed a bill through the wartime congress establishing a federal land-grant program which provided money from the sale of federal lands to universities provided that those universities maintained instruction in "such branches of learning as are related to agriculture and the mechanic arts."[24] Penn threw its name into the running for Pennsylvania's Morrill money with Rogers arguing that "While such inexhaustible beds of coal and iron lay yet undeveloped beneath her surface there is great need of a body of able men to turn her resources to the best advantage and to conduct the factories which are ever increasing within her limits."[25] Penn, Rogers believed, was uniquely positioned through its Department of Mines to provide that "body of able men" to the state of Pennsylvania and therefore it deserved the state's Morrill money. However, the Agricultural College of Pennsylvania – later Pennsylvania State University – eventually won the grant,[26] and "The Trustees of the University have found it impracticable to make the School of Mines what it should be without some endowment which will tend to put it on a permanent footing."[27] Without state support, the University simply could not sustain the Department of Mines after the Civil War.[28]

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[24] Morrill Act of 1863, 7 U.S.C. § 301 (1863).

[25] Rogers, Fairman, "Historical Sketch of the School of Mines, University of Pennsylvania," "1857-School of Mines," Archives General Collection (UPA 3), University of Pennsylvania Archives and Records Center, Philadelphia, Pennsylvania.

[26] "An Act To accept the grant of Public Lands, by the United States, to the several states, for the Endowment of Agricultural Colleges," no. 227, General Assembly of the Commonwealth of Pennsylvania (April 1863).

[27] Rogers, "Historical Sketch," 13.

[28] For more discussion on the push for state recognition of the Department of Mines, see Edward Potts Cheyney, *History of the University of Pennsylvania 1740-1940* (Philadelphia: University of Pennsylvania Press, 1940), 253-256.

But all was not lost for engineering education at Penn. The Scientific School of the University was organized as Penn moved to West Philadelphia in 1871. The Scientific School combined the engineering tradition of the Department of Mines with the pure scientific course that had been established in the College simultaneous to the School of Mines. While the Department of Mines did contribute the basis of technical education and many professors to the Scientific School, including J. Peter Lesley, who would serve as the Dean of the latter institution, the Scientific School was not a revitalized version of the Department of Mines but a completely new institution devoted to applied science. It was more general than the Department of Mines, with an added emphasis on mechanics (previously taught as part of Frazer's natural philosophy course). The new institution graduated engineers with the degree of Bachelor of Science,[29] reflecting a greater standardization of engineering training, and it offered the beginnings of majors, allowing students to concentrate in Applied Chemistry, Geology and Mining, Civil Engineering, or Mechanical Engineering. These concentrations were a major break from the generalist engineering education of the Department of Mines. Ultimately, the Department was responding to an economic situation that needed engineers capable of broadly participating in Pennsylvania's energy transformation. However, by the time the Scientific School was established, the industry of Pennsylvania and the country didn't need general civil and mining engineers, but specialists who could focus on one part of the complex industrial system.

The success of the Department of Mines should be measured not by its lack of longevity, which was the result of financial and political contingencies, but by the success of those students who did pass through in its six years of operation. Two of these, Eckley Brinton Coxe and

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[29] Students pursuing the scientific course in the College also graduated with a B.S., but their education was primarily in pure science; what engineering education they received while at Penn came through the special course in the Department of Mines.

Alfred Pancoast Boller, became prominent engineers in the coal and railroad industries respectively. Coxe was the son of prominent Pennsylvania judge Charles Sidney Coxe who was himself the son of politician and economist Tench Coxe. After graduating from Penn, Eckley Coxe went to Europe where he studied at Paris's Ecole des Mines and under Julius Weisbach at the Freiberg Bergakademie, the schools after which Penn's Department of Mines had been modeled. When he returned, he and his brothers founded Coxe Brothers & Company to mine anthracite coal on the lands in the Lehigh Valley that Tench Coxe had first purchased several decades earlier. Coxe Brothers would, by the time of Eckley Coxe's death in 1895, be second only to Jay Gould's coal empire in size and when Coxe Brothers was bought out in 1905 in was the largest independent – not owned by a major railroad – coal company in the Coal Region, owning 5,000 acres of land and mining 1.3 million tons of coal in that year.[30] Among his many achievements, he invented the Coxe stoker (which automatically passed anthracite coal through a furnace,) he was a member of the American Philosophical Society, President of the American Society of Civil Engineers and he served as a state senator from 1881-1884. Alfred Pancoast Boller also went on to further his engineering education, taking a Civil Engineer degree from Rennselaer in 1861, after having graduated from Penn with Eckley Coxe in 1858. His career exemplifies the diverse range of tasks that budding civil engineers learned at Penn. He started out, as many engineers did, as a rodman, one who carries the surveyor's rod which is sighted through the surveyor's theodolite to measure levels, on the Nesquehoning Railroad. He was then employed to survey the coalfields of the Lehigh Valley for the Lehigh Coal and Navigation Company. From that early surveying work, he would move into what was to become the focus of his later career: bridge building. Throughout the 1860s, he built bridges for a number of

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[30] Dublin and Licht, *The Face of Decline*, 19.

different railroads. He was eventually an agent of the Phoenix Iron Works and Vice President of Engineering at the Phillipsburg Manufacturing Company, both of which produced bridge materials. Like Coxe, Boller was a driving force in his field's professional organization, the American Society of Civil Engineers, which he helped bring back to national prominence. Educated in both the engineering tradition of Rennselaer and Penn's Department of Mines and the literary tradition of Penn's College, Boller was, throughout his career, concerned with the aesthetic properties of bridges as well as their structural purposes, and "his most important contribution to the advancement of engineering,", according to *The Engineering Record*, was "an unceasing advocacy of the architectural treatment of engineering works."[31]

Penn in its Energy Landscape

An analysis of an energy landscape starts with an energy source and adds in the networks of producers, transporters, and consumers surrounding that source as well as the technology that they use to produce, transport, or consume it. But when an energy landscape, or any kind of landscape defined by a technical system for that matter, changes as drastically as the one in eastern Pennsylvania did upon the implementation of the anthracite-based mineral economy, the process of change requires an extraordinary amount of knowledge. The means of producing and disseminating that knowledge become an integral part of the energy landscape and tie the energy landscape into the larger scientific and cultural community. Journals like *The Journal of the Franklin Institute* and *The Miners' Journal* disseminated new knowledge among the mechanic classes while institutions like the various engineering schools developing at this time produced a new kind of mechanic, the engineer, whose job was planning technical landscapes at the macro

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[31] "Alfred Pancoast Boller." *The Engineering Record*. Dec. 5, 1903, 706.

level as opposed to the mechanic who developed and operated technical landscapes at the micro level. And each individual engineering school was part of a unique technical landscape. The similarity of Rennselaer to the Royal Institution, the Sheffield School to a Liebig laboratory, and the Department of Mines, Arts and Manufactures to the Bergakademie at Freiberg is largely superficial, as each of these schools dealt with a set of circumstances unique to its place. The Department of Mines, for instance, was not the only school of engineering in the country nor was its engineering program particularly unique. However, it was the only engineering institution (short of Lehigh University, founded in 1865 after the Department of Mines has functionally ceased to exist) founded specifically to produce engineers for an anthracite-based economy. Anthracite did not exist in sizable and usable quantities outside the Coal Region, and no other group of the elites who controlled higher education had more of a stake in the success of the Coal Region than those in Philadelphia and in charge of the University of Pennsylvania.

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