The Ethyl Controversy

How the news media set the agenda for
a public health controversy over leaded gasoline, 1924-1926

William J. (Bill) Kovarik
Ph.D. Dissertation, University of Maryland
DAI 1994 55(4): 781-782-A. DA9425070

A brief note about Polyhymnia

The cover illustration on the preceding page is from the *Congress des Applications de L'Alcool Denature*, Dec. 16 – 23, 1902, published by the Automobile Club de France, found at the National Agricultural Library archives in Beltsville, MD. (Congress of Applications of Denatured Alcohol).

This muse of biofuels is probably an adaptation of the image of Polyhymnia, the muse of agriculture and lyric poetry, one of the nine muses of Greek mythology. Of course, the hair style and the cog-wheel brooch are modern for the year 1902, but the diadem and the robe would be typical of depictions of a Greek muse through the ages.
She is holding an overflowing bouquet of roses, looking down over a steering wheel with a rather serious expression, which is typical of Polyhymnia. She is a portrait of wisdom and beauty, firmly in control of a gentle machine located in some lush flower garden.

The printed program of the Congress where the muse appears has no explanation, but we may interpret the image as a depiction of the potential for harmony between agriculture and industry, and of the prospect for humanizing industrial machinery by bringing together the two major theaters of civilization (agriculture and industry) in a new synthesis. The idea of balance between these theaters of civilization has held a fascination for generations, and the potential for ethanol and biofuels has been seen as one part of that larger theme.

The Congress of 1902 was opened by the French minister of agriculture and was one of a series that had been held in France since 1899 often accompanied by auto races and exhibits. In 1901 the congress also had an exhibit of alcohol motors, stoves, coffee roasters, irons, water heaters and other household appliances. It was probably first assembled in Germany in the 1895 – 1900 period. The exhibit was in Paris in 1901, in Germany in Feb. 1902, back in Paris in Dec. 1902, stayed there for a few more months and then traveled to Italy, Spain and other European nations. In 1907 it was shipped to the US and was part of the 300th anniversary of Jamestown, and then went to several Grange meetings, including one in Baltimore in 1908. We don't know what happened to it afterward. We don't even have photos of the exhibit.

Many cars ran on alcohol at the time but these were primarily racing and demonstration cars. Racing cars used alcohol because it had less knock in higher compression engines, a quality that was later called "octane." Alcohol was more expensive than gasoline and far less abundant, since of course there was an existing kerosene distribution system for lamp fuel all over the US and Europe, and gasoline was just a refinery byproduct of the kerosene industry. However, official German and French policy was to provide an alternative to petroleum so that the countries would not be subject to the whims of the oil industry, and this was done through research support, support for these exhibits, and (in Germany at the time) through tariffs on imported oil.

Given all this, how was it possible for an American industry spokesman to claim, in 1925, that no alternatives to octane-boosting leaded gasoline existed?

That is part of the mystery this dissertation addressed.

Introduction and historiographic notes

December 2013

Twenty years after I defended The Ethyl Controversy dissertation at the University of Maryland's College of Journalism, it's time to make the dissertation available as an easy-to-distribute file for other historians. Although the dissertation is already public, the delay in wider distribution has involved hoped-for releases of additional industry documents which have not yet taken place.

Even so, a few historiographic notes are in order.

To begin with, an important origin of this dissertation was my desire to follow up on 15 years of active journalism in environmental controversy, from about 1977 to 1992, particularly with respect to the oil industry and its products and alternatives.

Before the dissertation, I had been privileged to write two books about biofuels and ethanol: one for the London-based International Institute for Environment and Development in 1983 and another with two friends, Hal Bernton and Scott Sklar, in 1982. I'd been especially interested in the role of the press in reporting the controversy and in providing information that helped (or sometimes did not help) to unravel the mysterious technical and political fog that surrounded the arcane but environmentally significant topic of "octane" boosting additives for gasoline.

Ethanol was well known as one of these additives, but was also considered to be the stepchild of the oil industry, at best an "alternative" to leaded gasoline's tetra-ethyl-lead (TEL) additive, which was always depicted as the standard, economical and most logical choice.

Yet there were a host of anomalies and omissions in this hegemonic depiction of the "standard" fuel additive TEL throughout its 90 years of life. One of the most interesting was an apparent Soviet-style erasure of photographic history in a paper by an Ethyl company chemist. The paper depicted the benefit of tetra-ethyl lead in volumetric terms compared to other substances. The photograph and its caption claimed TEL was technologically the best option because it took the least amount of the substance to obtain the same octane-boosting results. A very small vial of TEL had been placed on the left side of a lineup composed of increasingly large bottles of substances like iodine, aniline, benzene and other possible octane boosting additives. There were 11 depicted, but the photo left room for 12. It occurred to me that a non-political chemist wouldn't line up 11 of anything and leave the twelfth place free. Could someone have cut something out of the picture? Given the volumetric progression, this twelfth additive would very likely have been ethyl alcohol, an octane booster that had to be added at higher volumes to achieve the effect in gasoline.

Alcohol as a fuel had been so well known to engineers from the earliest days of the automobile that European engineers created their own special "muse of biofuels," the adaptation of Polyhymnia, on this dissertation's cover. Yet, apparently, the American oil and chemical industry considered ethanol so politically dangerous that it could not even be acknowledged in a scientific paper. How was that possible?

The contrasting images, and many similar misrepresentations from the American oil industry, stayed with me through years of research. At the time, I was one of a handful of researchers who understood that dozens of refinery workers had died writhing in straight jackets, and hundreds more severely damaged for life, and that millions of consumers had been adversely affected by TEL and leaded gasoline.[1] So what this missing twelfth image represented, it seemed to me, was in its own way as Orwellian, as sinister and as deadly as those old Soviet era photos in which a missing person had been assassinated or shipped off to Siberia.

My own research was taking place in the 1980s against the backdrop of the prevailing wisdom that environmentalism was an anti-scientific pseudo-religion, and that it had sprung up out of the fertile imaginations of the 1960s boomers. The view was widely discussed by people as diverse as radio personality Rush Limbaugh, novelist Michael Crichton and policy analyst Robert H. Nelson. It was an idea that many conservatives deeply wanted to believe for reasons that are rather far beyond this discussion. And yet, despite their claim to the scientific high ground, those who championed this 'environmentalism-as-religion sprung-up out-of-nowhere' idea never made much of an effort to prove it.

My own not-so-astonishing historical research had shown just the opposite: that there had been plenty of public environmental controversy in the news media long before the 1960s, starting at least as far back as Benjamin Franklin and the Dock Creek water pollution controversy in 1739, and including virtually all of the other great names in American and European journalism. My research also showed that what we call environmental controversy — public health, air pollution, water pollution, toxic chemicals, conservation of farm, forest and wilderness land— was widespread through humanity's historical record. Today this is more or less taken for granted, but at the time environmental history was brand new and hotly controversial.

Also, in 1991, I was concerned about how I might narrow my research framework for this dissertation, and kept thinking about the picture of the missing twelfth octane booster as opposed to Polyhymnia. Great historians like Gerald Markowitz and David Rosner had missed this one particular piece of the puzzle in Dying for Work, but I wasn't sure I could find it either.

The breakthrough came in 1992, when I checked with what was then the General Motors Institute (now Kettering University) in Flynt, Michigan. I learned that 80 linear feet of "unimportant" archives from the office of leaded gasoline inventor Thomas A. Midgley Jr had been released only a few months beforehand. No one had taken the time to look through the mass of disorganized unclassified material. A former Marine colonel and US Energy Department official, William Holmberg, thought it might be important and insisted that I spend a week in Flynt going through the archives. Holmberg was absolutely right. Most of what we historians now know about the context of the development of leaded gasoline has come from those archives — despite a rather large collection of historical information still (as of December, 2013) being withheld by industry. (Specifically, the successors to the Ethyl Corp., such as Afton

Chemical and New Market Inc.)

After this dissertation was completed in December, 1993, the conclusions ran so counter to what was then understood about leaded gasoline that I decided to present papers to a variety of historical and engineering groups and benefit from their reactions. Although confident about my own work, I was worried that I had overlooked something or, possibly, that the political interests around Ethyl Corp., a Virginia company, would find ways to attack me, since I was a Virginia-based academic without tenure at the time. I was aware, for instance, that Ethyl critics had been attacked in past decades, notably Clair Patterson of Cal Tech and Herbert Needleman of the University of Pittsburgh.

The first papers from the dissertation went to the Society of Automotive Engineers, the Society of Automotive Historians, and the Association for Education in Journalism and Mass Communications. The best that can be said of the SAE was that it was technically equipped to understand the problem, but psychologically constrained to avoid its implications. The paper was presented at a conference, and for some engineers, it was a bombshell. I vividly remember one Japanese engineer quickly scanning through it and gasping "this changes everything." Yet the SAE refused to publish the paper in its series for reasons it would not discuss. 1995, at the SAH, on the 50th anniversary of Farm Chemurgy conference, I was privileged to discuss "Henry Ford, Charles Kettering and the Fuel of the Future," which was subsequently published by the SAH in 1998. That paper has been widely cited, for example, by musician and car enthusiast Neil Young, former CIA director James Woolsey, and former White House counsel C. Boyden Gray, and many other historians. Branching out, I presented a papers on the topic to the American Society for Environmental History in 2003 and was invited to submit an article to the International Journal of Occupational and Environmental Health in 2005. Both of these were well received without a word of criticism.

The one criticism of the dissertation's thesis took place at the Society for the History of Technology conference in 2007. I presented a paper on the motives of three famous engineers — Henry Ford, Charles Kettering and Harry Ricardo — with respect to fuel development. The SHOT panel's formal discussant criticized the paper because ethanol "takes more energy than it produces," so why would I want to promote it? It was also criticized because this was "like investigative journalism." Leaving aside the question of whether history is, in itself, a promotional endeavor, or whether historians should or should not "investigate," or even whether ethanol is or isn't net energy positive (here, reasonable people differ), the criticism was the strongest of any that directly came my way.

I can understand and accept a pejorative use of the term "journalism" as a reference to shallow approaches to topics. However, in their most responsible moments, journalists craft their work to be the first rough draft of history, with the idea that second and third drafts may be in the offing. After all, it was a trail of breadcrumbs, left by an unknown New York World reporter in May of 1925, that helped me connect the missing twelfth octane booster and the portrait of

Polyhymnia with the leaded gasoline disaster. Despite its all-too-frequent disappointments, there are reasons to take a charitable view of journalism.

In 2000, automotive writer Jamie Kitman published an award-winning investigative article in the Nation magazine called "The Secret History of Lead." Much of its historical information was based on, and attributed to, this dissertation. Kitman checked my conclusions and took the time to travel to Flynt, Mich. And he also followed up with additional information about leaded gasoline in the 2000s. Kitman's article was the first time the issue emerged beyond scholarly circles. In response, the Ethyl corporation claimed that Kitman's article was "a distorted interpretation of known historic events and documents that have long been in the public record." But of course, those documents have not been in the public record. And after withholding a million pages of evidentiary documents in the Reginald Smith Jr., et al, v. Lead Industries Association case of 1999 in Baltimore Maryland, it certainly seemed as if Ethyl wanted to have it both ways. As noted above, those documents are still being withheld by Ethyl / New Market Corp. (For more about these missing documents, see Appendix 5, Research Notes).

There are two reasons why we need to remember this disaster: One is environmental and the other is historical.

On the environmental side, the Ethyl corporation (now Afton and New Market) is (in 2013) widely marketing another metallic additive that is also suspected of causing neurological damage. The additive is Methylcyclopentadienyl manganese tricarbonyl or MMT, and its use in octane boosting operations has been seen as questionable by public health advocates and the international auto industry.

Also, historians like Devra Davis, Naomi Oreskes and Deborah Blum have seen the Ethyl controversy as the first instance of the "merchants of doubt" approach to public relations. They have made comparisons to the tobacco controversy of the 1960s and the climate controversy of the 21st century, in which the intent of industry propaganda has simply been to create enough doubt to encourage more research, offset the precautionary principle, and forestall government regulation.

But the Ethyl controversy is also unique. It is one of the few environmental controversies that have come full circle, through a variety of stages: from invention and development, through near-universal adoption, to monopolistic marketing and hegemonic science, through changes in the paradigm of perceived progress, and then to an outright global ban.

On the historical side, this had been a difficult subject for some historians since, all through the 20th century, leaded gasoline was a "success story." For example, the University of Virginia's Joseph C. Robert, chair of the history department there for many years, published a book funded by the Ethyl Corporation in 1983 that did not even accurately account for the lives lost in the development of leaded gasoline in the 1920s, much less attempt to understand the story from an environmental or critical perspective. Many other historians have advanced the idea that

Ethyl was a great success of modern empirical engineering.

It's hard to escape a general conclusion that there are serious difficulties for historians in approaching relatively closed areas of technical expertise, and that the very process of acquiring knowledge may involve commitments to world views that may later come into ideological conflict. I'm aware that previous historians may have positivistic views of science, an understandable loyalty to a business, or even an historical sense of *stare decisis* with a resistance to "revisionism."

I take a different view. Historians have a responsibility, I would argue, to set the record straight and to test and re-test conclusions when the foundation of factual evidence changes. As Von Ranke said, it takes courage to be an historian.

It's unfortunate that, even 20 years later, the only books in print on the Ethyl controversy are by Joseph C. Roberts and the others who have nothing but praise for GM, Standard Oil (Exxon/Mobil), DuPont and Ethyl.

The Ethyl controversy is not just about an interesting episode without precedent — although it certainly is that. The controversy also foreshadowed a deep structural weakness in handling dozens of similar controversies that would rage across the front pages, and in political debates, over the coming decades. As environmental toxicologist Ellen Silbergeld has said, the Ethyl controversy reminds us of the power of industry to manipulate imperfectly designed institutions. To her list of governmental, scientific and educational institutions, we need to also add the news media, which is responsible for public understanding of science.

Just how weak was the news media, and what were its strengths? How can we, as the great historian Thucydides once asked, use our knowledge of the past as a guide to an interpretation of the possibilities of the future? That is of course the focus and context of this dissertation and the subsequent publications and research in the field over the past 20 years.

To the extent that I have been able to approach these questions, albeit imperfectly, I can only express gratitude to dissertation committee members James Grunig, Maurine Beasley, and Robert Friedel; and to my family: Linda, Ben and Nick Kovarik.

Bill Kovarik
Floyd, Virginia
2013

1. We now know there were close to 1.1 million deaths and economic losses of $2.4 trillion per year to the world economy, according to a United Nations Environmental Program assessment of 2010,

CHAPTER ONE

THE ETHYL CONTROVERSY

The responsibility and capability of the news media to inform public opinion has long been a point of concern and controversy in democratic nations.[1] In recent decades, the role of the news media in complex scientific and technological issues has raised questions about similar controversies in history.[2] Very little research has been performed about the role of the news media in reporting such controversies, and in the vacuum of history, such ideas have sprung up as, for instance, the claim that radical journalists were more or less responsible for the environmental controversies of the latter decades of the 20th century.[3]

This dissertation explores the role of the news media in a 1924 to 1926 public health controversy over the introduction of "Ethyl" leaded gasoline, a type of fuel that was commonly on the market until 1986 in the United States and is still used in most Third World countries.[4] In addition, the dissertation examines new evidence concerning the technical issues that were involved in the controversy and that were partially addressed by the contemporary news media.

Until recently, historians dismissed the role of the news media in the Ethyl controversy as sensationalistic and irresponsible. For example, historian Rosamond Young said "sensational stories" about the Ethyl controversy gave the impression "that gasoline containing Ethyl ... [could cause] unconsciousness and death before the victim could wash his hands."[5] Industry historian Joseph C. Robert said newspapers "pictured in lurid detail the agonies of the ill and dying."[6] Mainstream historians have passed along these caricatures of negative publicity. Even highly critical writers have accepted the industry's views of the press in the Ethyl controversy.[7] In sum, virtually all existing histories have been strongly influenced by the perspective of the automotive, chemical and petroleum industries, especially industry's views on the role of the news media.

This dissertation is the first historical study of the newspaper coverage of the Ethyl controversy and the first time that newspapers, magazines and technical journals have been used to establish a more comprehensive history of this vituperative public health controversy. The dissertation is based in part on articles printed by the New York City news media between 1924 and 1926 and in part on a set of primary documents recently made public. The dissertation argues that a broad reconsideration of the industry perspective is needed in light of facts recently made available.

The dissertation concludes that although the contemporary news media could only hint at depths beyond the surface of the controversy, it can hardly be said to have undertaken an irresponsible or sensational attack on industry. On the contrary: the news media were easily misled and manipulated by industry scientists who publicly claimed that there was no alternative to leaded gasoline and yet privately tested and patented a variety of alternatives. By wrapping the mantle of scientific authority around a dangerous commercial product, industry scientists attempted to demean the news media and the public health scientists who dared to publicly criticize the technology they selected.

<u>Overview of the Ethyl controversy</u>

The historical facts of the Ethyl controversy are simple, although some of the related technical issues are complex. The leaded gasoline additive dubbed "ethyl" by famed inventor Charles F. Kettering in 1921 is the same leaded gasoline that was phased down by the Environmental Protection Agency starting in 1975 and banned in 1986 out of concern for public health. Cars built in 1975 and later were built to run on unleaded fuel, which does not contain this additive.

The reason for the lead additive was simply to raise "octane," which is the anti-knock property of gasoline (as measured by iso-octane reference fuel). A gasoline that does not "knock" (or pre-detonate in the cylinder) burns more efficiently and allows an engine to produce more power.[8] The value of lead in reducing knock was discovered by Kettering's General Motors research team in 1921, and leaded gasoline was first marketed by G.M. in 1923. By 1924, G.M. had developed partnerships with several oil companies, especially Standard Oil of New Jersey (now Exxon).

Technically, the additive was called "tetraethyl" lead. It was simply the metal lead suspended in ethyl alcohol. However, it was produced through an extraordinarily hazardous reaction with the explosive element sodium and poisonous liquid ethyl chloride under severe temperature and pressure conditions.

The public controversy began in October 1924 with the severe poisoning of 50 workers in a Standard Oil refinery in New Jersey just across the bay from New York City. When five of the workers died one day at a time from absorbing the liquid lead, exhibiting symptoms described as "violently insanity," the news was carried on the front pages of newspapers around the country. Kettering and other scientists with G.M. and Standard insisted that the progress of civilization depended on their new product and that there were no alternatives. Public health scientists from Harvard and Yale universities vehemently disagreed.

The facts of the case and the intense disputes between scientific authorities were described in about 124 articles in seven New York City daily newspapers between October of 1924 and January of 1926. Politically liberal editors were apparently inclined to believe the public health scientists like Alice Hamilton of Harvard University, who feared the introduction of lead into an everyday product like gasoline. Hamilton was familiar with lead poisoning among American factory workers and the historical example of lead's devastation of ancient Roman civilization. She also insisted that alternatives were available. Politically conservative editors were more inclined to take G.M. scientists at their word when they said that Ethyl leaded gasoline had been discovered through a careful scientific process and no alternatives were available. When these scientists, especially Kettering and his associate Thomas A. Midgley, evoked the belief in progress as a justification for a minor risk in 1925, they were calling on a widely accepted world view that cut across political and cultural lines in academia, industry and the news media.

Despite the news media's deep commitment to this world view and to the ideal of objectivity in the approach to facts, individual newspapers differed greatly in their emphasis of facts and their investment of credibility in authorities. Two editors in particular set the agenda that others followed. One was Walter Lippmann, who was then editorial page editor of the liberal New York World; the other was Carr Van Anda, who was then editor of the conservative New York Times and who had a particular reputation for understanding science. Van Anda was an old-school science booster for whom the authority of science was a given and the classic embodiment of science was invention. Hence, the scientific view of the Ethyl controversy, according to the Times, was that sentimentality about workers and remote public health dangers should not stand in the way of progress. Lippmann guided the World's overrated "crusade" against Ethyl partly because of its progressive anti-business, pro-labor philosophy. Yet paradoxically, Lippmann himself viewed regulation of technology as an obstacle to progress and “unsuited to the highly dynamic character of the industrial revolution.”[9]

Events came to a head when public health and industry scientists were invited to testify at a special hearing of the U.S. Surgeon General on May 20, 1925. The immediate question hinged on how much harm small amounts of lead could do to people. Would the diluted lead in ordinary gasoline be as hazardous to motorists as the concentrated substance was to refinery workers? Since blood testing had not yet arrived at the accuracy of micrograms per milliliter, the question was difficult to decide conclusively. Therefore, in the absence of certainty, the broader question was which side had the burden of proof and which got the benefit of the doubt. Underlying these questions was the practical issue of whether Ethyl was absolutely necessary. Industry insisted that it was, but the attempt of public health scientists to introduce testimony about alternatives appears to have been sidetracked.

Despite the known dangers of lead as a poison, the status quo was on the side of industry. In the 1920s, calls for regulation went against the grain of the anti-labor political climate and the idea that progress should be unfettered by political authority. The Public Health Service found "no good reason" for prohibiting leaded gasoline in 1926 following a tightly controlled and controversial investigation by a committee of experts. From that point until about 60 years later, Ethyl leaded gasoline could be found in nine out of every ten gallons of gasoline on the American market. Billions of pounds of powdered lead were flung into the air, settling mainly in the soil of urban areas.

The knot of problems surrounding government regulation and scientific freedom remains at the heart of the modern public health and environmental regulatory dilemma -- a dilemma that has been characterized by late 20th century industry leaders as a frustrating cycle of publicity, legislation, regulation, litigation, and more publicity.[10] This pattern is created in part by the uncertain balance of political power and scientific knowledge. The role of the news media in the pattern is frequently that of spotlighting the problem and reporting public debate, yet rarely does it help to accredit facts and provide independent perspective. Public health advocates in the Ethyl controversy in 1924 to 1926 hoped the news media would provide the public with the tools to make an evaluation. Yet even the sympathetic liberal press, unsure of its technical competence, deliberately avoided this role. Ironically, contextualizing facts were readily at hand.

In historical hindsight, the Ethyl case is especially interesting because no uncertainty about the effects of leaded gasoline lingers today. When it was banned in the United States in 1986, the Environmental Protection Agency said it had documented “overwhelming evidence” of its severe health impacts, particularly on brain and nerve development in children. Inner city children were particularly victimized. As it turned out, the public health scientists like Alice Hamilton were posthumously vindicated, but by 1986 they had been forgotten by the public and neglected by historians.

By the time widespread public concern about public health and the environment emerged in the 1960s and 1970s, the Ethyl controversy was totally obscured in the fog of time. When the Chicago City Council voted in 1984 to ban the sale of leaded gasoline in the city, the

New York Times said the ordinance was the first of its kind in the nation.[11] In fact, New York City itself had such an ordinance between 1924 and 1928 and the controversy had been heavily covered in the Times. As it happened, the Ethyl leaded gasoline controversy of the 1970s and 1980s was resolved in a complete historical vacuum.

Had the Ethyl controversy occurred in a different era, it might have been remembered as a landmark of American political confrontation and adjustment to the industrial revolution. However, the controversy was coincident with the collapse of the progressive movement, and meanwhile, two world wars and a subsequent cold war had necessitated the fusion of science, government and industry.

Although federal anti-trust suits made documents and testimony about the Ethyl controversy public in the 1930s and again in the 1950s, it was not until a group of memoirs, oral history notes and secondary documents become available in the 1970s that scholarly histories began to be written. It is important to emphasize that these were not primary documents, but rather were processed memoirs based on primary documents retained by the companies. A second major group of documents emerged in the early 1990s when the General Motors Institute (G.M.I.) Alumni Foundation's Collection of Industrial History began unpacking about 80 boxes of unprocessed primary General Motors memos and reports from the Dayton, Ohio research laboratories. These new documents, on which part of this dissertation is based, illuminated long-hidden technical and strategic issues behind the public aspect of the Ethyl controversy. A third group of documents remains to be released, however, and tens of thousands of pages of primary material remain unavailable.[12]

The Ethyl controversy is interesting not only as an important episode in American industrial history but also because it demonstrated the extraordinary reach of the protective mantle of scientific authority, which could be used for commercial reasons when important issues were at stake. The question of whether such use eroded the credibility of scientific authority in the 20th century is beyond the scope of this dissertation but may deserve attention..

The Ethyl controversy also demonstrated the struggle of journalists and editors who were lost in technical issues but attempted to understand and promote science and technology in general. And it revealed the difficulty of engaging in a democratic dialogue in the terra incognita of scientific specialties where expertise and advocacy were almost impossible to distinguish. Like a spotlight striking an unfamiliar scene, the sudden emergence and disappearance of public controversy over Ethyl leaded gasoline in the mid-1920s illuminated a moment when scientific authority seemed to be fragmented, tenuous and coldly partisan rather than confident and full of its familiar promise for humanity.

The 1920s Ethyl controversy was no teapot tempest -- it was a full-blown front page dispute that has been called "the Three Mile Island" of the 1920s.[13] Officials with the companies involved in making and marketing Ethyl gasoline -- G.M., Standard, E.I. du Pont de Nemours and their creation, the Ethyl Gasoline Corp. -- were not unaccustomed to controversy. Yet in later years they insisted that they had been under attack by the press and that their business had been publicly thrown into the breach. The memoirs and court statements from industry officials reflect a bitterness that is difficult to understand given the fact that industry won the battle.[14] They apparently believed, as one industry physician claimed at the time, that "nothing should be said about this in the public interest."[15] This attitude may be interpreted as an example of outright arrogance or it may be seen as an objection to the arrival of the news media as a new and unpredictable force in scientific and technological controversies.It may also acknowledge that although the battle was won in the case of the Ethyl controversy, industry lost the broader war over whether dangerous chemicals were to be regulated.

The Ethyl controversy is important not only because it was an early public health and environmental controversy involving the news media but also because it demonstrates some of the problems inherent in the democratic influence of public opinion over applied science and technology. Enormously complex stereotypes emerged in the controversy that seem to have been very difficult to escape. These include the stereotype of yellow journalism (which influenced industry and industry historians), of the "Edisonian" scientific inventor (which influenced nearly everyone), and of greedy industries sacrificing workers for profits (which influenced the progressive forces).

Defining "Science and Technology"

The phrase "science and technology" is used in a popular and generic sense in this dissertation. However, it should be clearly recognized from the outset that historians of technology and historians of science have seen the two domains as emerging from entirely distinct traditions. According to historian Stephen Mason, the technical tradition and the spiritual or philosophical tradition remained separate until the early 19th century, when they combined to form a rudimentary science with both practical and theoretical elements.[16] Louis Mumford also noted that technology arose from the crafts tradition while the philosophical study of the natural world gave rise to what we today call science. The technological achievements of early modern Europe -- wind and water mills, clocks, printing, gunpowder, and so on -- came from the crafts tradition. Although practical applications were on the minds of many "natural philosophers," pure science had little direct impact on most people until the late 19th century.[17]

Despite the important differences between theoretical science and crafts technology, the two are closely linked in public policy writing and in popular culture. John Dewey, for example, noted that "the great mass of people come in contact with science only in its application" and therefore "science doesn't mean technique in the abstract; it means technique as it operates under existing political, economic and cultural conditions."[18] According to Vannevar Bush, science advisor to President Franklin Roosevelt in World War II, the discussions about politics and crops at the corner store may not explicitly involve democracy and science and technology, but these elements are constantly in the background. "They determine our destiny, and well we know it."[19]

The questions that arise in the Ethyl controversy, although frequently relating only to mechanics, engineering or technology, were often so closely linked to popular conceptions of science in the minds of the principal figures as to make contemporary use of the terms "science and technology" inseparable. Ethyl, as we will see, was frequently said to be a "scientific" invention as opposed to an "empirical discovery," and Charles F. Kettering and Thomas Midgley of G.M. were usually seen as "scientists" or "inventors" rather than automotive engineers. Midgley often framed his work in terms such as: "So far as science knows..."[20]

Risking oversimplification, then, it appears that the Ethyl controversy is best understood as involving applied science and technology in the cultural context rather than simply as a technological controversy. This approach also seems useful in considering the role of the news media and the public resonance of controversial ideas. "Science and technology," then, will be treated in this dissertation not as two separate historical domains but as the interactive process of empirical testing and theoretical advance that has had such profound social, cultural and political ramifications in the 20th century.

Historical Methodology and Research Goals

At the simplest level, the historical methodology employed in this dissertation was to search a dozen important archives for documents and papers relating to Ethyl gasoline. In some cases this meant using catalogues and other finding aids and looking through folders or microfilm relating to the subject; in other cases it meant going through cabinet after cabinet of raw unprocessed documents and reading everything with a view toward its relevance to the central themes of the Ethyl controversy. The role of the news media was a major concern, as were the issues raised in the public controversy, especially the industry experts' knowledge about the dangers of lead and the availability of alternatives to leaded gasoline.

It has been noted that historical research is not necessarily a straightforward and objective process since so many value-laden questions are so often involved.[21] It is sometimes recommended, therefore, that initial hypotheses be disclosed early in the work. Like many historical projects, this one began with questions and assumptions that I developed in part from past work on the history of journalism and the history of technology and also in part from my own news writing interests in the energy technology area.[22] The hypotheses that I developed were completely subject to challenge, revision or falsification in light of new data that might emerge. This is in keeping with the traditions of journalism and historical research. However, the premises underlying the hypotheses themselves were relatively new, the product of new historiographic directions and of modern concerns about technology and the environment that would not have occurred in quite the same way to researchers two or three decades ago.

When I first heard about the Ethyl controversy I was struck by the disdainful attitude industry historians took toward the press that appeared to be unaccompanied by any serious research. The problem was not merely a churlish view of the news media. Instead, it appeared as though some industry historians were falling back on a convenient stereotype to trivialize not just the news media but, more importantly, the issues that the news media explored at the time. As a result, these historians relied heavily on archival materials. Ordinarily this is not a problem; however, in this particular case, several serious flaws are found in the archives. For example, in some cases, especially that of General Motors, secondary documents have taken the place of primary documents.[23] In other cases, especially the National Archives, documents which should have been present were missing.[24]

If contemporary news sources are considered in the Ethyl controversy, then the scientific criticism of the oil, chemical and automotive industries reflected in the press must be examined, and a very different perspective emerges. It is impossible to take at face value the industry claims that Ethyl was produced through the scientific method, that no alternatives were known to science, and that Ethyl was proven to be safe to manufacture and to use. Public health scientists quoted by the news media presented their own competing claims, including critiques of safety research and general statements to the effect that alternatives could be found.

It would seem as if the news media played a much more constructive role than had been described in the histories of the Ethyl controversy. The broader question remained, however, as to whether the news media provided the public with enough information for informed decision-making. Reading the news articles more closely, I was often struck by how journalists of the 1920s (much like their counterparts today) seemed to lack even the most basic understanding of the technical dimensions of the controversy. If the journalists had spent any time examining trade and scientific publications in the topic area, the knowledge was not displayed in print. In only one case in 124 news articles was there any reference to a scientific paper. Hundreds of contemporary chemical abstracts, magazine articles listed in the Readers Guide to Periodical Literature and articles in professional journals would have been available.

My mental image of this "information gap" was that of a frozen lake in winter, with a layer of wind-driven snow on top, a thick layer of ice in the center and an unknown amount of water underneath. My original hypothesis was that the news media provided a slight glimpse of what lay beneath the surface of the controversy and performed some minimal research to broaden the agenda. However, I found that this was probably overstating the case. Most of the news reports remained at the superficially objective level, quoting both sides and yet never attempting a deeper analysis of the problem. Using the analogy, we might say that the news media never even brushed away the snow, much less plumbed the depths of the lake. This finding does not provide a great deal of support for the ideal, expressed by presidential science advisor Vannevar Bush, that public opinion in a democracy points out the technological path it wishes to have pursued.[25] It supports Walter Lippmann's idea, expressed in 1922: "The press is not so universally wicked [but] ... it is very much more frail than the democratic theory has yet admitted."[26]

Another hypothesis was that while Ethyl scientists claimed that science knew no alternative to leaded gasoline, a few alternatives were generally known at the time. Because general statements to that effect were reflected in the contemporary news media, this seemed a promising avenue of research. I was also encouraged to pursue these areas by historian John Staudenmier's advice to explore the “roads not taken” in history of technology and to avoid the “whiggish” focus on “success stories.”[27] Most historians have depicted Ethyl as a success story, and the product's 90 percent market dominance for 50 years would seem to argue for a "success" approach -- the critics be hanged. However, in 1986, leaded gasoline was banned from the American market because it was proven to be a direct threat to public health. This modern development added weight from the present perspective to the need to reassess the history of the Ethyl controversy. More importantly, histories that emphasized market success and excluded or trivialized contemporary controversy are inadequate because they do not help explain the ultimate failure of the technology. The omissions represent an oversight of major proportions.

The central question that has been much overlooked involves the need for leaded gasoline and the possibility of alternatives. Industry scientists vehemently denied any such alternatives were possible, while public health scientists insisted in general terms that alternatives to leaded gasoline were available. I expected to find that alternatives would have been generally known to the scientific community at the time and were somewhat familiar to General Motors researchers. Many documents showed, however, that not only were alternatives to leaded gasoline very well known, but they had been universally assumed to represent the fuels of the future in the face of expected oil shortages. Documents in the G.M.I. archive showed that these assumptions played a key part in G.M.'s long term strategy to outlast any oil shortage, although in the public debate the company vehemently denied that alternatives existed or could be used. On this point, G.M., Standard and Ethyl researchers engaged in a deliberately crafted and surprisingly bold distortion of facts well known to them.

Another hypothesis was that despite its knowledge of the dangers of lead manufacturing, industry pushed ahead recklessly to make a profit and needlessly cost workers lives. This hypothesis was not confirmed so much as it was deepened to take into account a bitter internal industry controversy over production technology that broke out between engineers with E.I. du Pont de Nemours Corp. on the one hand and Standard Oil and G.M. on the other over dangerous production methods. The controversy raged privately in the spring and summer of 1924, a few months before the Bayway, N.J. refinery disaster of October, 1924 when five workers were killed. It was only after the Bayway disaster that the public learned anything at all about leaded gasoline. However, the hazards of leaded gasoline manufacture were privately appreciated long before. This fact stands in sharp contrast to industry histories, which have rushed to absolve the industry. For example, Joseph C. Robert claimed in a 1983 corporate history of Ethyl that *following* the Bayway disaster the manufacturing process "was discovered to be hazardous ..." and "lethal far beyond original estimates."[28]

The general attitude toward health hazards is another dimension to the problem that may be difficult to appreciate today. Industrialists and many other people of the 1920s era tended to scoff at concerns of public health advocates even when confronted with irrefutable evidence of a problem. For instance, in February, 1923, Kettering's assistant, Thomas Midgley, wrote that he hoped that "fanatical health cranks" would not block plans to market leaded gasoline even while he was in Florida recuperating from lead poisoning and experiencing symptoms of severe trembling and shortness of breath. A year later two of his employees died, and soon afterwards 17 were dead and hundreds more poisoned. Although Midgley is said to have been greatly distressed, and may well have been, he did not use his position as managing vice president of Ethyl Gasoline Corp. to slow down production or marketing in any way that could be discerned from the archives. This scoffing attitude toward health fanatics was also a factor in Irenee du Pont's insistence in 1925 that his company's prestige was on the line and that industry could not back down. Profits were a motive, to be sure, but not the only motivating factor; attitudes such as scepticism of overly cautious critics and willful stubbornness must also be considered.

Thus, in approaching what the industry knew about alternatives to leaded gasoline and about what was known about the hazards of tetraethyl lead, the hypotheses that industry possessed some knowledge was expanded to take into account the recently released memos and reports that provided important new historical information.

<u>Chapter Overviews</u>

This dissertation is primarily concerned with the role of the news media in the Ethyl controversy. In the literature review in Chapter Two, the dissertation reviews literature about the history of the Ethyl controversy in general and the performance of the news media in particular. Chapter Two also reviews literature about the hazards of lead poisoning known in the 1920s and considers the traditions of public health advocacy and social reform.

Chapter Three begins a chronological account of the controversy with with the discovery of Ethyl gasoline in the 1919 - 1924 period before the controversy became public. The context of the discovery is partly to be found in G.M.'s strategy to survive any oil shortage by accommodating new fuels in its engines. A concerted effort to identify antiknock fuels did not arrive at one single solution (Ethyl leaded gasoline) but rather at many possible solutions, from which lead was chosen. It is important to recognize that others were tested and patented as fall-back possibilities.

Chapter Four follows the public controversy as it emerged in the New York City press in October, 1924. Although they tended to present facts objectively, the news media followed only superficial developments and never fathomed the technological depth of the controversy. Significant information easily available in public libraries was overlooked in the hurry to get out the news.

Chapter Five examines the internal controversy among officials of Ethyl, Standard, G.M. and du Pont in the November 1924 to April 1925 time period, showing that du Pont engineers warned of gross negligence at the Standard refinery at Bayway. However, G.M. pushed both Standard and du Pont to meet market demand. Chapter Five also describes Charles Kettering's trip to Europe to consider alternatives to leaded gasoline and meet with the famous German chemist Carl Bosch.

Chapter Six discusses the May 1925 P.H.S. conference on Ethyl gasoline and the Surgeon General's committee of experts report. In addition, the chapter notes that Ethyl brand leaded gasoline probably contributed to the crash of the Navy dirigible Shenandoah in September, 1925. Chapter Six also discusses leaded gasoline marketing in the 1930s through the 1980s, noting two anti-trust suits involving Ethyl Gasoline Corp.

Chapter Seven departs from the chronological history and reviews the historical literature that deals specifically with the news media in the Ethyl controversy, noting that the supposed sensationalism of the media has been greatly exaggerated along stereotypical lines. It also provides a content analysis of the news coverage and addresses the canard that the press invented the term "loony gas" when in fact refinery workers labelled it as such because of their hallucinations.

Chapter Eight is a discussion of science news writing in the 1920s with a particular focus on the differences between the Times and World as illustrated by the Ethyl controversy. The chapter shows that science and technology were important components of the public affairs agenda for both the conservatives and liberals in the news media of the era.

Chapter Nine concludes the dissertation with a discussion of the crisis of authority and the role of the news media in assisting public understanding of the relationship between democracy and science and technology.

Because many of the details, events and technical terms are unfamiliar, the Appendices include a bibliography, a chronology, a glossary and other associated explanatory materials about the technical details of the controversy.

Additional Introductory Note

It is often the case that histories that might shed light on technological controversy and the roles of authority are hampered by a dense fog of technical details. The Ethyl controversy is a case in which the fog is thin enough that technical issues are possible to understand. It represents only one of many scientific and technological debates that have emerged throughout the 20th century, many of which we may never be able to understand from the outside and yet may also find to be inextricably involved in public policy issues. It also demonstrates that the direction of technology is often a matter of policy choices and not a matter of pre-determined or inevitable conditions that arise from some intrinsic property of a technology.

In surveying such controversies, it is useful to bear in mind historian Arnold Pacey's admonition not to adopt a "drooping despondency which offers no remedy for the abuses it bewails." The direction of civilization is a matter of choice, and to the extent that issues can be understood, a matter of democratic choice. "The problem, therefore, is to define new directions of progress in which there is a promise for the future."[29] How these new directions are defined is a responsibility that was not accepted by the news media at the time, and, some argue, is still problematic for the news media today.

The Ethyl controversy demonstrates what happened when the press mistakenly believed that the responsibility was too complex for its resources and too easily surrendered its independent perspective to the presumed safety of "interpretive" reporting and the false balance between battling experts.

---

1. Walter Lippmann, Public Opinion (1922; reprint ed., New York: Macmillan, 1949), p. 361-362.

2. John Burnham, "Of Science and Superstition: the Media and Biopolitics," Craig LaMay and Everette Dennis, eds., Media and the Environment (Washington: Island Press, 1991), p. 31.

3. Edith Efron, The Apocalyptics (New York: Simon & Schuster, 1984), p. 30; Stanley Rothman and Robert Lichter, "The Media, Elite Conflict and Risk Perception in Nuclear Energy Policy," paper to the American Political Science Association (Washington, D.C., Aug. 1986), p. 1.

4. The gasoline was first sold by the Ethyl Gasoline Corp., a 50-50 partnership of General Motors Corp. and Standard Oil of New Jersey, in 1923. It was manufactured at GM, Standard and E.I. du Pont de Nemours. Ethyl was the only brand of leaded gasoline to have been marketed in the U.S.

5. Rosamond Young, Boss Ket: A Life of Charles Kettering, (New York: Longmans Green & Co., 1961), p. 162.

6. Joseph C. Robert, Ethyl, A History of the Corporation and the People Who Made It (Charlottesville, Va.: University Press of Virginia, 1983) p. 122.

7. Nicholas Regush, "MMT," Mother Jones, May/June 1992, p. 24.

8. The system for using iso-octane as a reference fuel had not been developed in the mid-1920s, so the term “anti-knock” was used. Straight octane itself, an eight carbon liquid distilled from petroleum, does not have a high “octane” rating; branched isomers tend to have the high anti-knock properties. See the Glossary in this dissertation.

9. Walter Lippmann, The Good Society (Boston: Little, Brown & Co., 1937), p. 12.

10. Frank Popoff, “Life After Rio: Merging Economics and Environmentalism,” Speech for Chemical Week Conference, Oct. 15, 1992, Houston, Texas, personal communication with Dow Chemical Co.

11. New York Times Sept. 7, 1984, p. 12.

12. These include the “Lead Diary,” day-to-day test diaries of the 1919-1921 period, the 1924 reports of the “Medical Committee,” and the minutes of the Ethyl Gasoline Corp. Board of Directors and the GM Technical Committee. A detailed list of documents known to have existed but currently missing from archives is included at the end of the Bibliography.

13. Joseph A. Pratt, “Letting the Grandchildren do it: Environmental Planning During the Ascent of Oil as the Major Energy Source,” The Public Historian, 2 No. 4., (Summer 1980), p. 28.

14. Ralph C. Champlin, "Historical Summary of the Ethyl Corp., 1923 - 1948," unpublished manuscript by the Ethyl Corp. Dept. of Public Relations, 1951, third draft, GMI, also known as the "Green Book." Also see Testimony of W.F. Harrington, p. 6487, Earl Webb, p. 3646, Charles F. Kettering, p. 3565, and Alfred Sloan, p. 2941, Transcript of U.S. v. E.I. Du Pont de Nemours and Co., et. al., 126 F. Supp. 235. (cited as U.S. v du Pont), 1952.

15. "Odd Gas Kills One," New York Times, Oct. 27, 1924, p. 1.

16. Stephen Mason, A History of the Sciences (New York: MacMillan, 1962), p.11.

17. Louis Mumford, Technics and Civilization (New York: Harcourt: 1932), p. 58.

18. John Dewey, "The Revolt Against Science," The Humanist, Autumn 1945, reprinted in ed. Jo Ann Bydston, John Dewey, The Later Works, Vol. 15, (Carbondale, Ill: Southern Illinois University Press), p. 188.
19. Vannevar Bush, Modern Arms and Free Men: A Discussion of the Role of Science in Preserving Democracy (New York: Simon and Schuster, 1949), p. 5.
20. "Radium Derivative $5,000,000 an ounce / Ethyl Gasoline Defended," New York Times, April 7, 1925, p. 23; Also see Thomas Midgley, Jr., "Tetraethyl Lead Poison Hazards," Industrial and Engineering Chemistry, 17, No. 8, (August, 1925), p. 827.
21. Peter Novick, That Noble Dream: The "Objectivity Question" and the American Historical Profession (Cambridge: Cambridge University Press, 1988), p. 5.
22. Hal Bernton, Bill Kovarik, Scott Sklar, The Forbidden Fuel: Power Alcohol in the Twentieth Century (New York: Griffin, 1982); Bill Kovarik Fuel Alcohol: Energy and Environment in a Hungry World, (London: Earthscan, 1982). Also see Energy Resources and Technology, Solar Energy Intelligence Report, Coal Daily and Latin American Energy Report (Silver Spring, Md.: Business Publishers Inc., 1978 - 1979); Also see Appropriate Technology Times, (Butte, Mont.: National Center for Appropriate Technology, 1979 - 1981).
23. For instance, T.A. Boyd's Early History of Ethyl Gasoline repeatedly refers to "The Lead Diary," a collection of thousands of pages of primary materials that has not been released to the GMI archive by General Motors.
24. There were serious problems with the management of some historical archives which is beyond the scope of this history to address. However, files at the National Archives were in gross disarray with many documents missing. Files at the GMI collection in Flint Michigan were incomplete and, in the words of one observer, "sanitized" prior to their release from General Motors Corporation.
25. "In a free country, in a democracy, this [path taken] is the path that public opinion wishes to have pursued, whether it leads to new cures for man's ills, or new sources of a raised standard of living, or new ways of waging war. In a dictatorship the path is the one that is dictated, whether

the dictator be an individual or part of a self-perpetuating group." Bush, Modern Arms and Free Men, p. 6.

26. Lippmann, Public Opinion, p. 362.

27. John Staudenmier, Technology's Storytellers (Oxford: Oxford University Press, 1988), p. 175.

28. Robert, Ethyl, pp. 119 - 120.

29. Arnold Pacey, The Maze of Ingenuity (Cambridge, Mass.: MIT Press, 1986), p. 309.

Text

CHAPTER TWO

THE HISTORICAL CONTEXT OF PUBLIC HEALTH CONTROVERSY

Public health and environmental controversy seem to have emerged in the late 20th century in what has been called an "historical void."[1] Many observers believe that the development of science and technology was "largely unquestioned" until the late 20th century,[2] and that Rachel Carson's 1962 book, Silent Spring, marked the beginning of environmental and public health controversies.[3] Historians are starting to find, however, that the problems of conservation, oil spills, air pollution, endangered species and dangerous chemicals have all engaged public attention in previous decades and centuries.[4]

Spanish writer Miguel de Cervantes once said that experience is the mother of knowledge. Recent trends in historical writing would seem to bear him out. Knowledge of African-American history was animated by the experience of the civil rights movement of the 1960s; women's history came alive with the feminist movement of the 1970s; and the history of Native Americans took on a more serious cast with the 500th anniversary of Columbus' arrival in the New World in 1992.[5] Similarly, modern concerns about public health and the environment have begun to generate scholarly inquiry about history of technology, science and the environment. This is not to say that the agenda for historical research is driven solely by modern concerns, but that they can be an appropriate factor.

Another factor has been a recognition that histories of wars, politics, great men and great institutions have been overemphasized to the detriment of other interesting and valid perspectives. The recognition has given rise to various schools of social, cultural and intellectual history since the 1960s. History of science and history of technology have been among these schools. Among concerns in socio-historical approaches to science, according to historian Peter Stearns, is the resonance of scientific ideas among the public and the causal role that popular assumptions and demands play in the development of scientific thinking and scientific institutions.[6]

In a similar vein, historians of journalism have examined the way the news media has explained science and technology. Scholarship in the history of science writing in the 1960s and early 1970s[7] has been complemented by some recent work,[8] but a great deal remains unexplored. There are no anthologies of science journalism, only a handful of biographies about science writers, and only one or two historical studies concerning the performance of the press in scientific controversies.

About a dozen important scholarly histories dealing with the Ethyl controversy have been published in the past two decades, each from a somewhat different historical perspective. Although many directly comment on the performance of the news media, none take a scholarly approach to the news media. Labor historians David Rosner and Gerald Markowitz devoted two chapters of their 1989 book, Dying for Work, to the Ethyl leaded gasoline controversy and focus in part on the power of industry over the government's public health bureaucracy and the use of scientific authority as an exercise in hegemony. They wrote that the poisonings were "due to what the newspapers called 'loony gas.'"[9] Stuart Leslie chronicled the discovery of Ethyl gasoline in one chapter of his 1983 biography, Boss Kettering, as a story of heroic invention more or less in the stereotype of Thomas Edison. The role of the news media was characterized by "shocking cartoons depicted Ethyl as a greedy giant squeezing blood from an innocent public."[10] Joseph C. Robert devoted a chapter of his 1983 company history of the Ethyl corporation to the discovery of Ethyl gasoline and a defense of Kettering and his research team. Robert claimed that newspapers "gave sensational publicity to the Bayway story, picturing in lurid detail the agonies of the ill and dying."[11] Hounshell and Smith discussed the development of Ethyl as one of many projects exemplary of du Pont's research and development strategy and they mentioned newspapers "detailing the horrible effects" of tetraethyl lead.[12] In a dissertation on health reformer Alice Hamilton by Angela Nugent Young, the role of the press was seen as assisting in creating the “conference system,” a transitional phase in public health regulation in the conservative 1920s.[13] Also, Joseph A. Pratt said in article on early environmental problems that publicity helped create national concern about tetraethyl lead.[14]

Several important histories that touch on Ethyl did not mention the press or the controversy. Thomas Hughes wrote about the discovery of Ethyl leaded gasoline in an article on historiographic understanding of invention.[15] Also, S.D. Heron wrote of the development of anti-knock fuels for aviation.[16]

Along with these scholarly histories, the literature about the Ethyl controversy includes Thomas A. Boyd's 1957 memoir and biography of Charles Kettering, Professional Amateur, and Rosamond Young's 1961 popular biography, Boss Ket.[17] Also, a scattering of public relations articles and a few references in scientific papers may be found about the Ethyl controversy.[18] These works, contemporary articles and a few scientific papers represent the relatively small amount of material that has been written about Ethyl gasoline and the Ethyl controversy of the 1924 - 1926 period.

Histories of the discovery of Ethyl leaded gasoline and the subsequent uproar over its use have been deeply influenced by the perspective of the oil, chemical and automotive industries and have not taken the public controversy very seriously. For example, most of the histories that mention the news media do so from an extremely negative perspective, claiming that wildly partisan stories inflamed public opinion and caused panic and hysteria. The most even-handed historians use the idea of sensationalistic coverage as something of an indicator of the bitterness of the controversy. However, the contemporary news accounts do not seem to have been consulted in the process of arriving at this impression, as this dissertation argues in Chapter Seven.

In addition, no history to date has challenged two of the key contemporary assertions of the oil, chemical and automotive industries: that no alternatives existed (and thus the public policy choice was between fear and progress) and that the hazards of tetraethyl lead manufacturing were only appreciated after the Bayway incident (and thus the lack of tests for a public health hazard prior to marketing was no oversight). In their haste to exonerate themselves, industry historians left gaping holes in the story of the Ethyl controversy that other historians have not apparently noticed, in part because the record of the controversy is found primarily in newspaper reports

Lead Poisoning in History

At the time Ethyl leaded gasoline was introduced, people were just becoming aware of new perils from science and technology, such as radiation, carbon monoxide gas and automobile accidents. However, at least one peril had been well appreciated from antiquity: that of lead poisoning. Not only was lead debilitating, but during the Middle Ages, sceptics who did not believe in "spirits" were frequently referred to the lead mines to see for themselves the way the miners behaved. Early works on tradesmen's diseases usually note, as did Bernardo Ramazzini in 1700, that: "The skin [of lead workers] is apt to bear the same color of the metal ... Demons and ghosts are often found to disturb the miners."[19] For over two millennia, overexposure to lead was known to cause hallucinations and severe mental problems.

Lead is not just the scourge of miners and a few luckless refinery workers; it has also been called the "assassin of empires." In a granulated compound similar to tetraethyl lead, the gradual and undetectable poison was called "succession powder" due to its use in regicides since the dawn of recorded history. Egyptian hieroglyphics record such assassinations, while the Bible refers to poisons that may have been made of lead.[20] In addition, the fall of the Roman Empire has been linked to lead poisoning since at least 1909,[21] but it was commonly suspected since at least the mid-19th century. In 1857, Scientific American noted:

> It is remarkable that this metal (lead), when dissolved in an acid, has the property of imparting a saccharine taste to the fluid. Thus the common acetate of lead is always called 'sugar of lead.' It was perhaps on this account that the Greeks and Romans used sheet lead to neutralize the acidity of bad wine -- a practice which now is happily not in use since it has been found that all combinations of lead are decidedly poisonous.[22]

Along with wine, other sources of lead poisoning in ancient Rome included piping, cookware, cups and plates. But the use of grape sweeteners made in lead vessels probably caused the most damage. Since the Romans did not have sugar, they frequently boiled down grape pulp (or "must") and used large amounts as a condiment to sweeten their food. They called the pulp "sapa" or "difrutum." According to lead historian and toxicologist Jerome Niragu: "One teaspoonful of sapa per day could cause chronic lead poisoning, and countless Romans would have consumed more than this dosage from their foods and drinks. ... The Roman fondness for sweet and sour flavors is well known, and the cooks made common use of the cheap ... sapa in their sauces and seasonings to assuage the appetites of their patrons."[23] Thus, the Romans deliberately consumed large quantities of lead. Piping also contributed, although not as much, to lead poisoning. Roman engineer Vitruvius was aware of its problematic nature: "We can take example by the workers in lead who have complexions affected by pallor. For when, in casting, the lead receives the current of air, the fumes from it occupy the members of the body, and burning them thereon, rob the limbs of the virtues of the blood. Therefore it seems that water should not be brought in lead pipes if we desire to have it wholesome."[24]

The sterility and high infant mortality rates experienced by the ruling class during the Empire period, as well as reports of rapid increase of cases of gout where the symptoms directly mirror chronic lead poisoning, were probably results of eating foods sweetened with "sugar" of lead.[25]

It should be noted that the history of lead poisoning in antiquity has been a matter of some dispute by industry. In 1971, when the Environmental Protection Agency began discussing a phase-out of leaded gasoline, Ethyl Corp. officials claimed their opponents were embarked on a "witch hunt" and using "scare tactics" by blaming lead for the fall of the Roman Empire. "The clincher by all prophets of doom is that someone started the rumor that lead was the cause of the fall of the Roman Empire," said Ethyl vice president Lawrence E. Blanchard, Jr. "The legend always gets fuzzy -- sometimes it is caused by lead-lined aqueducts, other times it is from their wine being drunk from lead-lined flasks."[26] [Ethyl's self-serving revision of the historical record shows the corporation's awareness of the historical problem and the extent to which officials were willing to stretch their point.]

Perhaps the first early modern concern about lead poisoning as a public health problem is documented in the 18th century, when a British physician named George Baker became curious about the "Devonshire colic." Each autumn, it seemed, there was an infestation of colic that tended to be more severe with the age of the patient. In 1767, Baker examined conditions in Devonshire and traced the colic back to apple cider made by presses lined with lead. He also noted that no similar colic attended the apple harvest in the cider drinking counties of Hereford, Gloucester and Worcester. The presses there had wooden sides without the lead linings. Baker's paper to the Royal College of Physicians also showed that Devonshire cider itself contained lead. Rather than the praise that might have been expected, Baker was condemned by the clergy, by mill owners and even by fellow doctors.[27]

Benjamin Franklin was also concerned about lead poisoning. In 1724, when Franklin worked as printer's apprentice, he observed that the practice of heating lead type while cleaning off ink seemed connected to what was called "the dangles," an extremely debilitating paralysis of the hands that "dangled" from the wrists for the rest of the worker's life. In 1745, Franklin also published a paper on the "dry gripes," or stomach cramps -- an epidemic that plagued America that he traced to drinking rum distilled in vessels with lead coils and other parts.

Franklin and Baker corresponded on scientific matters, and in 1768, Baker said his suspicions that lead might be cause of Devonshire colic "had been greatly confirmed by the authority of Dr. Franklin of Philadelphia." Also around that time, Franklin obtained a list of patients in La Charite Hospital in Paris who had been hospitalized for symptoms that would today be diagnosed as lead poisoning and showed that the patients were involved in occupations that exposed them to lead.[28] In 1786, he wrote a long letter to a friend following a conversation on the effects of lead. He concluded: “The Opinion of the mischievous Effect from Lead is at least above Sixty Years old, and you will observe with Concern how long a useful Truth may be known and exist before it is generally receiv’d and practic’d on.”[29]

Lead poisoning is often found in literature. One moving account was given by Charles Dickens:

> I saw a horrible brown heap on the floor in the corner, which, but for previous experience in this dismal wise, I might not have suspected to be ‘the bed.’ There was something thrown upon it and I asked what it was.
>
> 'Tis the poor craythur that stays here, sur; and ‘tis very bad she is, ‘tis very bad shes been this long time, and ‘tis better she’ll never be ... and ‘tis the lead, sur.'
>
> 'The what?'
>
> 'The lead, sur. Sure, ‘tis the lead-mills, where women gets took on at 18 pence a day, sur, when they makes application early enough, and is lucky and wanted; and ‘tis lead pisoned she is, sur, and some of them gets lead pisoned soon, and some of them gets lead pisoned later, and some but not many, niver; and ‘tis all according to the constitooshun, sur, and some constitooshuns is strong, and some is weak, and her constitooshun is lead pisoned, bad as can be, sur[30] ... '

In the United States at the turn of the 20th century, concerns about worker health seemed to carry a flavor of “sentimentality if not socialism.” Problems like paralysis of the hands among workers in the lead trade were usually attributed to drinking or to a wife's cooking.[31] It was difficult even to understand the scope of the problem -- no law forced industries to admit researchers to conduct their studies. Many did so only after a considerable amount of persuasion and assurances that the results of a study would not be reported individually, but rather about an industry in general.

One of the most important researchers and advocates for safe working conditions in the hazardous trades was Alice Hamilton, an M.D. who had done post-doctoral work at the Universities of Munich and Leipzig in Germany, at the Pasteur Institute in Paris, and at John Hopkins University in the U.S. Her interest in what was called "occupational disease" was sparked by her years working with social activist Jane Addams at Chicago's Hull House, a settlement house in the middle of Chicago's working class slums where social activists lived and worked for progressive causes. Hamilton was to become the acknowledged national expert on lead toxicology, the first woman on the Harvard University faculty and a key figure in the Ethyl controversy.

In 1910, the labor department of the state of Illinois hired her to look into the question of workers' compensation claims from the lead industry trades. Hamilton found appalling conditions and 578 cases of outright lead poisoning, some of which were quite severe, or as Hamilton put it, "equal to those described by French authorities of the early 19th century."[32] Shocked that Illinois was a century behind Europe, the legislature quickly passed a law requiring ventilation and other safety standards for workers. The Illinois study brought Hamilton to the attention of the U.S. Department of Labor, where she worked from 1910 to 1919 as a special investigator of industrial poisons. She was then invited to join the faculty at Harvard University, and was the first woman to do so. This was not out of egalitarian academic impulse but simply because she was by far the best occupational toxicologist in America, according to biographer Barbara Sicherman.[33]

Hamilton worked with notable tact to popularize the views of social reformers among labor leaders, fellow physicians and industrialists.[34] In a speech to the superintendents of the National Lead Company, she praised their efforts to safeguard worker health while at the same time noting that their factories were "so dangerous ... that they would be closed by law in any European country."[35]

In 1920, she managed to obtain funding from the American Institute of Lead Manufacturers to study lead metabolism in the human body at Harvard. The study found that lead did accumulate in the bones and tissues of people who were exposed to it, and was not quickly or fully metabolized and excreted. As a practical result, lead manufacturers were disappointed in their attempts to evade workers compensation claims and civil damage suits.[36] A few years later, when General Motors began to put lead into gasoline, Hamilton and others -- including Surgeon General Hugh Cumming -- felt that this study laid the key scientific issue to rest. With the cumulative nature of the poison, no one could reasonably advocate the sure, slow public poison from the use of lead in gasoline.[37]

Contradictory studies about lead poisoning, however, eventually formed a makeshift scientific foundation for the Ethyl leaded gasoline industry. Robert A. Kehoe, a University of Cincinnati physician who also played a role in the Ethyl controversy, performed studies in the 1920s through the 40s that supposedly showed lead in bones and blood of indigenous peoples never exposed to industrial sources, and that the human body had a "natural" threshold of tolerance for lead. These studies would later be seen as grossly inaccurate and biased.[38]

World Views in Collision

In its broadest context, the Ethyl controversy reflects the continued development of a progressive, humanistic orientation of scientific research and advocacy that had roots not only in the American progressive movement of the 1890-1910 period, but also in the European sanitary reform movements stretching back two centuries. It also reflects a growing rift with the ideology of industry and industry-oriented scientific positivism. The clash between the two world views shows an inability to define common ground and accept criticism and peer review across scientific disciplines.

The Ethyl controversy takes place amid a welter of novelty and contradiction reflected in the description of the era, the “Roaring Twenties.” Most environmental histories, such as A Fierce Green Fire by Phillip Shabecoff, see the 1920s as the lull in the storm over public health and the environment. Shabecoff dismisses the era as a time when the country’s “most tainted stewardship of public resources” occurred under the administration of President Warren Harding, which was “slavishly subservient to business.”[39] Although, as we shall see, this description aptly fits Harding's Treasury Secretary, Andrew Mellon, there is a great deal more to say about the 1920s and concern over public health and the natural environment. For example, organizations such as the Workers Health Bureau, the Izaak Walton League and the Consumers League reflect a path of continuity from the progressive era to the New Deal. New federal and academic institutions and agendas were also emerging. The Corps of Engineers and the Bureau of Mines both directed studies of pollution of the natural environment, while the Department of Labor and the Public Health Service took new initiatives in worker health and occupational disease. State and municipal organizations such as the National Coast Anti-Pollution League helped create federal and international laws about oil pollution in coastal waters. Harvard University established its School of Public Health.

These and other developments show a continuity of the progressive agenda into the post World War I years. Yet the need to establish new institutions also reflects to a certain extent a disillusioned retrenchment of the approach to science and technology and its impact on humanity. Before World War I, the idea that science could solve virtually all problems had been an unambiguous article of faith, shared by artists and chemists, poets and physicists. All human problems, even labor disputes and political debates, would soon be soluble using scientific techniques. The enthusiasm for science and technology was as dear to the progressive liberal reformer as it was to the industrialist tycoon. The progressive movement embraced the new science of bacteriology, for example, that allowed scientists to identify epidemic diseases and paths of contagion in everything from ice to oysters to milk. This lowered infant mortality rates and may have done more actual social good than all the settlement houses and social work combined.

That new faith in science had been motivated by a belief in the disinterested scientific method of inquiry. The method involved the ability of individual scientists to conduct systematic research, cover all possible elements of the problem and deliver objective answers without being influenced by personal considerations or desires. Newspaper editor Walter Lippmann wrote that the inner principle of modern science was not reflected in technologies such as automobiles and refrigerators themselves but in the behavior of those who invented them with a power of insight that was much like “high religion.”[40]

These views on the sanctity of science were a late reflection of scientific positivism, the 19th century philosophy that stressed positive facts to the exclusion of faith and speculation.

Positivism was rarely articulated in detailed terms. It was often simply labelled "Progress," and proof of its efficacy was everywhere -- the telephone, the electric light, the wireless and the automobile. Enthusiasts who elevated science and technology to the status of a religion also made it the focal point of political and social activity. No question was too grand, too complex, too human or too small that it could not be solved by science. Not all progressives shared these views, and as the decades of the 20th century unfolded, many developed profound disagreements with the ideology of progress and industry. The flaws in the naive view of an all-powerful science, the collapse of the positivist / Newtonian consensus among physicists in Europe, and the general cultural malaise of the post-World War I era led many scientists and social critics to utterly reject the doctrine of positivism. Dissenters from the positivist creed, including Henry Adams in America and Georges Sorel in France, rebelled at the eclipse of innocent, humanistic philosophies and the ascendance of an industrial culture they considered mechanical, sterile and profane. Significantly, their work, although written before World War I, only became popular afterwards. As historian Henry F. May has argued, the war marked the "end of American innocence" that "had been the common characteristic of the older culture and its custodians, of most of the progressives, of most of the relativists and social scientists, and of the young leaders of the pre-war Rebellion..."[41]

The old world withered in the wake of the "catastrophe in heaven and on earth," as psychologist Carl Jung called World War I. The horror of mechanized warfare withered the simple faith in both religion and science, and it destroyed the moral bridge between the two foundations of Western thought. Mankind was no longer "perfectible," and scientists who had passionately embraced the moral purpose of their work suddenly found themselves in a deep moral quagmire. "Science has made slaughter possible on a scale never dreamed of before," wrote Alice Hamilton in a popular magazine in 1916, questioning whether science was "for or against" humanity.[42] Other scientists objected to military technology on humanitarian grounds; one German scientist who dared to speak out against poison gas was accused of "conduct unbecoming to a German."[43] Facing similar pressures in the U.S., and not wishing to be seen as unpatriotic or disloyal, Hamilton and others did their best to keep war industries clean even though the "bewildering complexity" of a host of chemicals led to workers "sickening and dying in the effort to produce something to kill other men." In this light, it was no accident that Hamilton and Yandell Henderson of Yale University, who worked with poison gas production during the war, would become the most vocal opponents of Ethyl gasoline.[44]

Scientific positivism was so strongly rooted, however, that even poison gas was not an unmitigated evil to some people. Charles Baskerville of the American Chemical Society noted in a conference on industrial hygiene and occupational disease in 1919: "The universal publicity given to poison gas" had drawn great attention to chemistry, with its "mysterious possibilities ... and opportunities for production of wealth and possible control of trade..." The optimism extended to conditions in factories, which, although replete with "evils," were being solved in the spirit of American cooperation because "It is good business to have healthy labor."[45] Baskerville assumed, as did most Americans, that their working conditions tended to be better and their standard of living higher than that in European countries. This idea, which had become a patent falsehood by the dawn of the 20th century, originated in the myth of the "machine in the garden." According to historian Leo Marx, the capacity of the American environment to "purify" the European factory system, with its unfortunate feudal residues, was the "central theme in the ideology of American industrialism" of the 19th and early 20th centuries. The factory system, transferred to the New World, "is redeemed by contact with nature and the rural way of life..."[46] Despite the pervasiveness of the this view, actual standards for occupational health lagged far behind those of England, Germany or France. The lead trades, as already noted, had cases of lead poisoning of a severity not seen in Europe for a century.[47] Working conditions in coal mining, railroad work and other heavy industry also tended to be more dangerous in the United States than in Europe.

The myth of the machine in the garden helped support the headlong rush into industrialization in the United States. It was a small rationalization in a larger ideology of industry, noted as "a loosely composed scheme of meaning and value so widely accepted that it seldom required precise formulation," according to Leo Marx. In the written record "it appears chiefly as rhetoric in homage to 'progress.'"[48] According to historian Thomas Hughes, the ideology of industrialism was the technological and uniquely American expression of scientific positivism, noted as "Fordismus," and "Americanismus" by German observers.[49]

This ideology of industry is often contrasted with Thomas Jefferson's agrarian vision of America, discussed in 1785 in his Notes on Virginia, which extolled the concept of the yeoman farmer as the backbone of democracy and which disparaged European factories. "The work shops of Europe are the most proper to furnish the supplies of manufactures in the United States," he wrote. By the early 19th century, the emerging myth of the machine in the garden was sometimes seen as supporting the ongoing movement for America's economic independence. Yet by 1816, even Jefferson supported industrialization.

> We must now place the manufacturer beside the agriculturalist... The grand inquiry now is, shall we manufacture our own comforts, or go without them at the will of a foreign nation. He, therefore, who is now against domestic manufacturers must be for reducing us to dependence on that nation, or to be clothed in skins and live like wild beasts in dens and caverns. I am proud to say I am not one of these....[50]

Although important, economic independence was not the true mainspring of the ideology of industry. According to Leo Marx, the machine itself became "a signal for the salvation of mankind." Americans didn't merely welcome new technology: "They grasped and panted and cried for it. Again and again, foreign travellers in this period testify to the nation's obsessive interest in power machinery. The typical American, says Michael Chevalier, has a perfect passion for railroads: he loves them ... as a lover loves his mistress." Recognizing the obsession, Jules Verne wrote in 1865 that Yankees "are engineers ... by right of birth" just as Italians are musicians and Germans are metaphysicians.[51]

While the pastoral ideal of an agrarian America was sometimes evoked against railroads, mills, steam power and industrialization, the dissent, "aside from apologists for Southern slavery" came from small social or literary groups on the fringes of influence and power. Even Jacksonian democrats were ambivalent, and ".... not inclined to insist on a root contradiction between industrial progress and the older, chaste image of a green Republic."[52]

Eli Whitney, Robert Fulton and Samuel Morse were widely applauded (if not always financially rewarded) for their inventions in the first half of the 19th century. However, the explosion of industrial technology in the second half of the 19th century so radically transformed the American landscape that mere applause seemed irrelevant. Thomas Edison, Alexander Graham Bell, the Wright Brothers and Henry Ford had become the American equivalent of a pantheon of deities. Although only Bell was in fact a trained scientist, the prestige of their accomplishments spilled over onto nearly all the scientific and technological enterprises of the age. By the turn of the century, the adoration of science and technology had become nearly universal. "We may speak without exaggeration of a 'cult of science,' a cult at whose shrines many thinking men worshipped with ... fanatic intolerance of other gods," said historian Warren Wagar.[53]

Charles F. Kettering, the first president of the Ethyl Gasoline Corp., might be called a high priest in the cult of science in the 1920s; he was certainly among the most visible and articulate authorities, as the president of the Society of Automotive Engineers and the head of General Motor's research division. He was also the inventor of numerous improvements to the automobile and internal combustion engines and the director of the laboratory where Ethyl gasoline was discovered. Kettering consciously emulated Thomas Edison's "scientific foxhunt" methods and organized a "factory" for inventions that was purchased by General Motors in 1919. Historians have seen Kettering's "corporate" inventive style as representative of the transitional phase between the heroic individualistic approach (such as that of Edison) and the more anonymous scientific group efforts that followed.[54]

The ideology of industry that embraced Ethyl gasoline was, to its proponents, a more complex proposition than "mere" public health concerns. "The responsibility of ... the Public Health Service is rather simple: Is this a public health hazard?" said Frank A. Howard of Standard Oil Co., in partnership with G.M. to sell Ethyl leaded gasoline. "Unfortunately, our problem is not that simple... [On automobiles and oil] our civilization is supposed to depend...

Now as a result of 10 years research ... we have this apparent gift of God of three cubic centimeters of tetraethyl lead." The "gift" would allow cars to travel 50 to 100 percent further on a gallon of gasoline, he claimed. "If would be an unheard-of blunder if we should abandon a thing of this kind merely because of our fears."[55] Responding to Howard was Grace Burnham, director of the Workers Health Bureau, who pointed out that tetraethyl lead "was not a gift of God when those ... men were killed or 149 men were poisoned."[56] She followed up with this idea: "The thing we are interested in, in the long run, is not mechanics or machinery, but men, [and this] is a thing we must bear very carefully in mind in this age of speed and rush and efficiency and machines."[57] Thus, Burnham neatly summed up the difference between a humanistic and progressive scientific world view and the increasingly distant ideology of industry.

Three Traditions of Public Health and Environmentalism

Although the ideology of industry had a great deal of momentum in the 1920s, those who spoke out against Ethyl gasoline had links to scientific and political traditions that were far richer than may be appreciated today. They were only the latest in the long line of conservation and public health advocates who were often in the scientific mainstream and frequently vocal about their concerns. Three distinct traditions of humanistic or progressive science that evolved into what is now called "environmentalism" are found in the 1920s, and each approached public controversy in its own way.

First, conservationists have been active in political questions dealing with land and other resources from the time of the Louisiana Purchase in 1803. The doctrine of efficient land use, as defined by forestry scientists and other specialists, was an ideal that was not often applied in practice. Secondly, advocates of technology regulation had emerged to question the 19th century laissez faire attitude; the establishment of a weak federal bureaucracy guided by scientists at the turn of the century was one result of the regulatory approach. Finally, public health reformers were part of a "sanitary reform" movement that began centuries beforehand in Europe had taken hold in the US in the mid-19th century. The movement began with concerns about water and sewer systems but was eventually taken up by the progressive movement as part of a broad "housecleaning" that addressed food, milk, drugs, child protection and workers health.

The fact that so little is known about these movements and their mode of public advocacy reflects a narrow definition of history in various disciplines. Older studies of public health, labor and social history have covered some of the ground, and new approaches to environmental history are beginning to explore it as well.[58] However, in the history of public relations, where an understanding of advocacy in the context of public controversy is needed, such movements are only rarely included in history. The exclusion of social advocacy in the agenda of public relations history and the focus only on paid self-defined practitioners reflects a tendency toward "whig" history in an important component of the history of communication.[59]

Conservation: a high-profile reform movement

Most histories of American environmental issues focus on the conservation movement and the disagreements over wilderness preservation or utilization at the turn of the century.[60] Historian Joseph Petulla and others have noted three major themes of conservation movements: 1) the "biocentric" approach, epitomized by transcendentalists like Henry David Thoreau and Ralph Waldo Emerson and wilderness preservationists like James Audubon, John Muir and Aldo Leopold;

2) the ecological and scientific tradition of thought, which included geographer George Marsh and Forest Service chief Gifford Pinchot; and 3) The economic / utilitarian approach that allowed nearly unlimited forestry and mining, curbed theoretically only to the extent that future generations also be left with resources.[61]

Concerns over the wanton destruction of forests, fisheries, wildlife and ranges in the late 19th century led to some of the earliest scientific studies. The beginning of the conservation era has been traced to 1873, when the American Association for the Advancement of Science advocated laws for forest protection. The American Forestry Association and the American Fisheries Society were both established around this time, and within a decade the Forestry

Service was established in the U.S. Dept. of Agriculture and a Commissioner of Fish and Fisheries was designated in the Dept. of the Interior. Yet government was not the motivating force in conservation, according to historian Henry Clepper. "In truth, the government did little until public-spirited citizens began to criticize it and to challenge its failure to protect forest and other resources from despoliation... The rise of the conservation movement following the Civil War was an American phenomenon in that it was started by the crusading zeal of a small group [who]... demanded government protection of the nation's woodlands."[62] Supporting and sometimes surpassing the efforts of scientific groups such as the forestry and fisheries societies were the sportsmens' associations, the Sierra Club (founded in 1892) and women's groups.[63]

"The rationale for women's involvement lay in the effect of waterways on every American home," said historian Carolyn Merchant. "Pure water meant health; impure meant disease and death."[64] The General Federation of Women's Clubs, founded in 1890, was "steeped in conservation ideals," Merchant said, while the Daughters of the American Revolution focused attention on conservation of soil and water resources for future generations.

Conservationists at the turn of the 20th century fought to preserve the redwood forests in California, save the ancient Pueblo cliff dwellings in Colorado from vandals, and rescue the scenic Pallisades on the Hudson River from quarrying. Issues such as beautification, saving waste paper, cleaning up towns and cities and planting trees were taken up in the spirit of the progressive movement. The most bitter environmental controversies of the era involved dams. In 1905, for example, an electric company wanted to put up a generating dam at Niagara Falls. A public outcry against the ruin of the scenery promptly ensued, and the dam was never built. In 1906, however, when the city of San Francisco wanted Forest Service land for the Hetch-Hetchy dam to provide drinking water, conservationists bitterly fought the city and the federal government -- but the dam was built.[65] In 1912, the Audubon Society led women to help save the endangered bird species favored by hat makers by boycotting certain kinds of hats, and a letter campaign led to laws against importation of wild bird feathers in 1913.[66]

A similar campaign in 1923 involved the Izaak Walton League's lobbying efforts in

Washington to block a huge project to dredge parts of the Mississippi river. The league's president and founder, Will H. Dilg, "organized and directed what may have been the first modern environmental lobbying campaign in Washington, employing a full-time staff of assistants and enlisting the support of a wide range of groups, including the General Federation of Women's Clubs," according to Shabecoff.[67]

The conservation movement attempted to replace natural resource politics with science, according to historian Samuel Hays. A scientific system guided by the ideal of efficiency and dominated by technicians or engineers would be preferable to a political system geared towards pressure groups and partisan debate. Although the ideal was never realized, it tended to guide the arguments by conservation advocates and, on a broad scale, the general trend of public policy. Moreover, the spirit of efficiency permeated professional societies and many realms of life. It played a role in "the transformation of a decentralized, nontechnical, loosely organized society, where waste and inefficiency ran rampant, into a highly organized, technical and centrally planned and directed social organization that could meet a complex world with efficiency and purpose."[68] Across the spectrum of the conservation movement , the "gospel of efficiency" was not that far removed from the ideology of industry while the "biocentric" traditions of Muir and Thoreau remained far from the mainstream of politics.

Hays also argued that conservation was not always coincident with the progressive movement. Certainly, many disputes erupted between private industry advocates of exploitation and others advocating conservation through public ownership. Yet, Hays points out, there were also controversies where private interest and the ideal of conservation coincided. Federal range control and mineral policies are examples of private interests that promoted conservation, he said. The fact that Ethyl officials occasionally invoked the ideal of conservation of petroleum in promoting tetraethyl lead indicates not only the ubiquitousness of the ideal of conservation but also reinforces the point that conservation was not always the central issue for progressives.

Regulating America's Technological Explosion

One of the most troubling aspects of the Ethyl controversy facing the federal government, and the Public Health Service (P.H.S.) in particular, was the lack of authority to regulate the safety of industrial chemicals in the 1920s. The P.H.S. was reluctant to ask for regulatory authority, and the Congress would have been reluctant to grant it, since the political climate of the Roaring Twenties was conservative, pro-business and contrary to new federal initiatives. Conservatives saw regulation as expensive and frequently motivated by unreasonable fears of technology.

The reaction to "groundless" fear of technology comes up frequently in discussions of environmental history. Examples often employed include the battle over smallpox inoculation in Boston in the early 18th century; exploding steam boilers and collapsing bridges in the 19th century; and safety issues surrounding the introduction of electricity and automobiles in the 20th century.[69] Even the hum of telegraph wires evoked a fearful response in the 1840s.[70] In Britain, a law required that horseless carriages have a flagman precede on foot to warn those in the way in the 1890s, while the first horseless carriage in the U.S. was ordered off the road in 1885 by fearful residents of Berks County, Pennsylvania.[71] Similarly, historian Thomas Hughes noted in Networks of Power the dampening effect that regulation had on the development of electrical systems in Britain.[72]

However, regulation has also had positive impacts on technologies. For example, steam engines had already been operating on boats in U.S. rivers for many decades when the Steamboat Inspection Service was established around 1850 following a series of devastating steam boiler explosions. Federal regulations helped open the Mississippi River basin to settlement by making river travel far safer. Similarly, in the 1860s more than 25 bridges collapsed every year, and in 1873 the American Society of Civil Engineers set up a commission to regulate and certify bridge builders and techniques. By the turn of the century, bridge failures had become rare.[73]

Aside from steamboats and railroads, efforts to regulate industry were weak throughout the 19th century. However, federal regulation increased dramatically after the turn of the 20th century, mainly as a result of popular demands for progressive reform linked with "muckraking" journalism. Example of expose journalism include Ida Tarbell's History of Standard Oil and Upton Sinclair's semi-fictional book about the Chicago meat packing industry, The Jungle. The latter inspired the establishment of the Food and Drug Administration and the Animal and Plant Health Inspection Service under USDA in 1906 and 1907.[74] "Big business" had become a public anathema, and in 1911, the U.S. Supreme Court upheld the Sherman Anti-Trust Act in a case involving the Standard Oil Company and ordered it dissolved into various components.[75]

Big business was also the target of the first water pollution law, the Refuse Act of 1899, which empowered the Secretary of War, through the Corps of Engineers, to prohibit any industrial discharge into a waterway that had not been granted a permit.[76] Dirty coastal waters also inspired a movement for environmental regulation of oil pollution in the early 1920s. A well publicized campaign by the National Coast Anti-Pollution League drew attention to the problem in 1921 and 1922. The league was formed by beachfront resort city governments and marine insurance agents worried about harbor fires.[77] Around the same time, the P.H.S. asked its representatives to report on the quality of river waters[78] and the Corps of Engineers performed a study of coastal waters and rivers downstream from oil refineries, paper mills and other industrial plants.[79] The resulting reports invariably mentioned enormous impacts of pollution on fish and wildlife as well as scenery. By 1924, despite qualms about a lack of constitutional authority, Congress passed a law regulating oil pollution in tidal waters.[80] Inter-departmental and international conferences on the subject of oil pollution led to international treaties prohibiting the dumping of water-damaged oil from oceangoing tankers.[81]

These laws would have been more in tune with the political climate under Democratic president Woodrow Wilson a decade beforehand, when the FDA was strengthened and the Federal Trade Commission and the Department of Labor were established. However, following the virtual collapse of the progressive consensus in the postwar era, a less active role for government was a theme of Republican presidents Warren Harding, Calvin Coolidge and

Herbert Hoover. Government authority was seen as best limited and most useful when used informally to convene teams of experts who could persuade industry to reform. To Hoover especially, systematic and cooperative planning were much more effective than laws and regulations to guide the emergence of key industries such as aviation, radio, electric power and highway construction.[82] This approach also guided the P.H.S. as it attempted to deal with the Ethyl controversy -- a problem clearly in its jurisdiction for which it had no concrete regulatory authority. Most other worker health issues remained dormant, according to historians Rosner and Markowitz who saw the 1920 as “one of the most repressive eras in American labor history.”[83] Not until the 1930s, when the Great Depression ushered in a pro-labor presidency, would the federal government once again expand its regulatory role.

Public Health Reform Movements

The reforms of the progressive era at the turn of the century that influenced the thinking of many progressives at the time of the Ethyl controversy had been inspired by several previous generations of sanitary reform campaigns in the U.S. and Western Europe. Most of these campaigns and movements are understood only in outline, and additional research is needed.

Historian George Rosen traced the origins of the progressive public health movement to the Enlightenment period following 1750, when infant mortality (up to 80 percent in the worst slum areas) was first recognized as a serious social problem. English reformers directed their first efforts against liquor, especially gin. The campaign combined newspaper editorials, Hogarth’s book Gin Lane, letters by physicians and magistrates, and petitions to the government. It was “a prototype of public health agitation which was to assume crucial significance in the 19th century,” said Rosen, culminating in the 1751 Gin Acts that gave magistrates control over the licensing of pubs. The Foundling Hospital of London, established in 1741, and other children's hospitals in Germany and France, are also examples of the mounting concern over infant mortality. By the turn of the 19th century, infant mortality had decreased in one London hospital from 66 per thousand to 13 per thousand.[84]

Along with infant mortality, concern about prisoners, soldiers and sailors led to reforms and laid the groundwork for the sanitary movements of the 19th century. One well known benchmark in public health was the adoption of lemon juice in the British Navy to prevent scurvy. Less well known were the efforts of reformers like John Howard, sheriff of Bedfordshire, whose 1777 book State of the Prisons aroused public opinion. Howard showed that "people are galvanized into action when the facts about social disease are forced upon them and that an aroused public opinion could be employed as a lever to compel reform."[85] Concerns about the health of the general population also increased, and by the early 19th century, hundreds of hospitals had been established throughout France, Germany, England and the United States.

Around the early 19th century, reformers and their allies in the news media generated increasing concern about the poor quality of drinking water and the handling of sewage. In 1827, for example, Londoners learned that a water company's main inlet was only three yards away from the outlet of a large sewer. The construction of city water systems in the U.S. began with the 1797 Watering Committee of Philadelphia and the 1799 Manhattan Company. Water supplies usually preceded the development of sewage systems by anywhere from five to 50 years.[86] Water systems in the U.S. were primarily set up by private companies to turn a profit and only in the 20th century were they incorporated into publicly owned municipal systems. The private model did not work as well in Britain. In 1830 the city of London could boast seven sewer boards, 100 paving, lighting and cleaning companies and 172 vestries of one sort or another. The chaos was a stimulus to the sanitary reform movement.[87]

Social reform leader Jeremy Bentham addressed the chaos in his Constitutional Code of 1820, proposing that the prime minister's cabinet include a minister of health, whose department would be in charge of environmental sanitation, the treatment of epidemics, and the general administration of medical care. Bentham had been influenced by French physicians who participated in the revolutionary government's centralization of public assistance, and he in turn influenced leaders of the British sanitary reform movement such as Edwin Chadwick and Southwood Smith. Another influence was German health pioneer Peter Frank (1748-1821), who advocated clean water, sewage systems, garbage disposal, food inspection and other health measures, including supervision of worker safety and occupational disease by authorities.

By the first third of the 19th century, the human cost of the industrial revolution presented a significant challenge to the structure of governments themselves. In Britain, the Royal Commission inquiries of 1843-45 that exposed dreadful conditions in factories and mines also led to the the Public Health Act of 1848 and the appointment of municipal health boards with authority to regulate water and sewer service. Meanwhile, a movement of volunteer groups began attempting to address problems of housing, sanitation and other reforms. One objective of these groups was to organize public opinion in support of further legislative action. Such support was not always forthcoming. When the Public Health Act expired in 1854, and members of the National Board of Health were fired, the Times of London approvingly said: “We prefer to take our chance of cholera and the rest than be bullied into health.” Thus, progress toward improved living and working conditions proceeded by fits and starts, with variations from one place and one nation to another. “Nevertheless, the thread of continuity is not an illusion, an artifact of the historian,” said Rosen. “Throughout most of the 19th century health workers confronted substantially the same problems... The fundamental doctrines remained virtually unaltered because the conditions to which they applied remained fundamentally the same.”[88]

Public health concerns in New York city in 1804 led to the appointment of a health inspector whose duties included quarantine and environmental sanitation. Also that year the Manhattan Corp. was formed to create a clean water supply. The company evolved into the Chase Manhattan Bank. The wave of immigration from Europe in the 1830s and '40s compounded existing public health problems in American cities, and cities began filling up with overcrowded tenement slums. The population of New York alone grew from 123,000 in 1820 to 515,000 in 1850, and in 1837 Benjamin McCready wrote his pioneering essay on occupational medicine and the conditions of the slums. Voluntary associations, such as those in Britain, soon sprang up to mobilize the community with a high moral purpose. The Massachusetts Sanitary Commission was one of the first of these, and its 1845 census of Boston slums showed shockingly high infant and maternal mortality rates as well as a witch's brew of communicable diseases. A second report in 1850 confirmed the findings, but not until 1869 was a state board of health established.

The American Medical Association, formed in 1847, also surveyed city conditions through a public health committee, but proposals for improving city slums were not adopted. The establishment of the American Public Health Association in 1872 came along with a wave of state health departments and the organization of the Marine Hospital Service under the Treasury Department. In 1879, the U.S. established the National Board of Health to collect information, to advise the federal and state governments, and to report to Congress with a plan for a national health organization. The board was terminated four years later, with partial success behind it but the problem of state versus federal regulation of public health unresolved.

It was around this time that Louis Pasteur's theories about the transmission of disease began to be accepted and amplified with further research by Joseph Lister, Walter Reed and others. The consequences of the “bacteriological era” of science in the decades before and after the turn of the 20th century were profound, with dramatic decreases in mortality and major improvements in general public health. In the U.S. and Western Europe, adult death rates began falling in the mid- to late-19th century due to improvements in water supply and sanitation, while infant mortality rates fell around the turn of the 20th century due to better nutrition and medical care.[89] Epidemics of diphtheria, malaria, yellow fever and bubonic plague were halted, and the pathways for contagious spread of tuberculosis, typhoid and cholera were identified in food, milk and water supplies. One index of public health improvement, the infant mortality rate of New York City, dropped from 273 to 94 per thousand from 1885 to 1915. Child welfare movements continued through the turn of the century well into the 1930s. Voluntary associations and settlement houses (such as Hull House in Chicago) set up clean milk stations, then well-child clinics that also educated mothers on health issues. Health pioneer Josephine Baker showed how, in New York City in 1908, a visit from a public health nurse following the birth of a child could save thousands of children from death. Reform was stimulated by an aggressive campaign by "that dedicated, militant group of men and women ... who undertook to curb some of the worst abuses of industrialization and prepared the way for social legislation we take for granted today," Rosen wrote.[90] In 1912, the federal government set up a Children's Bureau to survey and report on the health of children.

The problem of improving the generally dismal working conditions was also seen as related to public health in the 1870 - 1930 period. Most of the responsibility for regulation in the United States in the late 19th century rested with the states, and in 1877 Massachusetts passed the first factory inspection law, with 22 states following over the next 20 years.[91] Coal mining safety laws were first passed in Pennsylvania in 1870 following a tragic fire that suffocated 179 men. "The public press of the nation throughout the whole length and breadth of the land united in demanding that provisions be made by law for ... safeguards," said a book written at the time.[92] A patchwork quilt of state laws protecting workers in various trades and providing compensation for workers injured under certain job descriptions developed in the pre-World War I years. For purposes of worker compensation, the U.S. government listed nine hazards in employment, only one of which was an "occupational disease," even though "there are 709 occupations in which poisons are a hazard," according to a 1926 National Consumers League report. At least 53 industrial poisons were recognized at the time, but only two states gave blanket compensation to all industrial diseases. Others listed a few well known diseases: New York listed 19; Ohio, 15; and New Jersey, 10.[93]

The federal government began to actively study occupational safety in 1885, with the establishment of the Bureau of Labor Statistics in the Department of Labor. The bureau reviewed occupational diseases, factory sanitation rules, European laws and workmen's compensation bills, among other topics. With a change in leadership in 1905, the bureau focused more on health problems of workers, including coal miners, workers in phosphorous and dust-ridden trades, and workers exposed to dangerous machinery. Around 1915, a bureaucratic turf fight for workers health research broke out between the P.H.S. and the Department of Labor, and the Public Health Service began to actively research an area that until then it had completely neglected.[94] Many objected to the P.H.S. growing responsibilities in the area on the ground that workers were not the agency's primary constituency. Nevertheless, its role grew until, in the 1920s, it was the logical agency to deal with the Ethyl controversy. By taking the reins and calling the conference on leaded gasoline in May, 1925, the P.H.S. would take a bold and somewhat progressive move, but at the same time would secure an important and high profile piece of bureaucratic turf.

---

1. Joseph A. Pratt, "Letting the Grandchildren Do It: Environmental Planning During the Ascent of Oil as the Major Energy Source," The Public Historian 2, No. 4 (Fall, 1980), p. 28.

2. Dorothy Nelkin, ed., Controversy: Politics of Technical Decisions (London: Sage Publications, 1979), p. 9.

3. Nelson Smith and Leonard J. Theberge, Energy Coverage Media Panic (New York: Longman, 1983), p. 142. Also, see ; Edith Efron, The Apocalyptics (New York: Simon & Schuster, 1984), p. 30; Rothman, S., and Lichter, R., "The Media, Elite Conflict and Risk Perception in Nuclear Energy Policy," American Political Science Association (Washington, D.C., Aug. 1986), p. 1.

4. Rachel Carson, Silent Spring, (Boston: Houghton, Mifflin & Co., 1962). Some historians have noted that public health, conservation and environmental controversy have long been part of American politics. Samuel Hays, The Response to Industrialism (Chicago: University of Chicago Press, 1957); Idem., Conservation and the Gospel of Efficiency, (Cambridge, Mass: Harvard Press, 1959). Recent years have seen the formation of the American Society for Environmental History and publication of several hundred papers concerning various environmental controversies. See Carroll Pursell, "Conservation, Environmentalism and the

Engineers: The Progressive Era and the Recent Past, in Kendall E. Bailes, ed., Environmental History: Critical Issues in Comparative Perspective, (New York: University Press, 1985) p. 176; Lester J. Bilsky, ed., Historical Ecology (Port Washington, N.Y.: Kennikat Press, 1980), p.7.; Joseph M. Petulla, American Environmentalism: Values, Tactics, Priorities (College Station, Tx: Texas A & M University Press, 1980), p. 25.

5. Personal communication with Howard Zinn, author of A People's History of the United States (New York: Harper & Row, 1980), October 9, 1992.

6. Peter N. Stearns, "Trends in Social History," ed. Michael Kammen, The Past Before Us: Contemporary Historical Writing in the United States (Ithaca, N.Y.: Cornell University Press, 1980), p. 211.

7. Calder M. Pickett, "Six New York Newspapers and their Response to Technology in the 19th Century," Ph.D. Dissertation, University of Minnesota. 1959; Idem, "Technology and the New York Press in the 19th Century," Journalism Quarterly 37 (Summer 1960), p. 398-407; Carolyn D. Hay, "A History of Science Writing in the United States and of the National Association of Science Writers, Inc.," Master's Thesis, Northwestern University, 1970; Frank Carey, "A Quarter Century of Science Reporting," Nieman Reports, June 1966.

8. Sally A. Harris-Wheeler, "The Ladies Home Journal Between 1890 and 1906: The Influence of its Crusade to Regulate Food and Drug Products;" Virginia Sliman, "Alcoholism: The Virtuous Woman's Secret Vice, Turn of the Century Patent Medicine Abuse;" Bill Kovarik, "Dr. North and the Kansas City Milk War;" Papers presented to AEJMC conference, Washington, D.C., August 1989; Marcel LaFollette, "Authority, Promise and Expectation: The Images of Science and Scientists in American Popular Magazines, 1910-1955," Ph.D. Dissertation, Indiana University, 1979; Harry H. Stein, "American Muckraking of Technology Since 1900," Journalism Quarterly 67, Vol. 2 (Summer 1990), p. 401.

9. David Rosner and Gerald Markowitz, "A Gift of God?" in Dying For Work: Workers Safety and Health in 20th Century America, (Bloomington, Indiana: Indiana University Press, 1989), p. 125.

10. Stuart Leslie, Boss Kettering (New York: Columbia University Press, 1983), p. 166.

11. Joseph C. Robert, Ethyl: A History of the Corporation and the People Who Made It (Charlottesville, Va.: University Press of Virginia, 1983), pp. 122- 123.

12. David Hounshell and John Smith, Science and Corporate Strategy: Du Pont R&D, 1902-1980 (New York: Cambridge University Press, 1988), p. 154.

13. Angela Nugent Young, "Interpreting the Dangerous Trades: Workers' Health in America and the Career of Alice Hamilton, 1910 - 1935," Ph.D. Dissertation, Brown University, June, 1982, p. 160.

14. Pratt, "Letting the Grandchildren Do It," p. 28.

15. Thomas P. Hughes, "Inventors: The Problems they Chose, The Ideas They Have, and the Inventions they Make," in Patrick Kelly and Melvin Kransberg, Eds., Technological Innovation: A Critical Review of Current Knowledge (San Francisco: San Francisco Press, Inc., 1978), p. 177.

16. S.D. Heron, Development of Aviation Fuels, (Cambridge, Mass.: Harvard University Graduate School of Business Administration, 1950) p. 560.

17. T.A. Boyd, Professional Amateur (New York: E.P. Dutton, 1957); also Rosamond Young, Boss Ket (New York: Longmans, Green & Co., 1961), p. 162.

18. Graham Edgar, "Tetraethyl Lead," paper to the American Chemical Society, New York, Sept. 3-7, 1951, reproduced by the Ethyl Corp.; T.A. Boyd, "Pathfinding in Fuels and Engines," Society of Automotive Engineers Transactions, (April 1950), pp. 182-183; Stanton P. Nickerson, "Tetraethyl Lead: A Product of American Research," Journal of Chemical Education 31, (November 1954), p. 567.

19. Bernardo Ramazzini, "A Treatise on the Diseases of Tradesmen," circa 1700, cited in an unpublished paper by Lewis R. Thompson, "Knowledge of Industrial Hygiene in the Early Days of History," National Institutes of Health, RG 443 Box 195, National Archives, Washington, D.C.

20. Jerome Nriagu, Lead and Lead Poisoning in Antiquity (New York: Wiley Interscience, 1983),

p. 12.

21. R. Kobert, In Beitrage aus der Geschichte der Chemie, ed., P. Diergart, pp. 103-119; 1909.; also see S. Gilfillan, "Roman Culture and Dysgenic Lead Poisoning," Mankind Quarterly, 5, 3-20, Jan-Mar, 1965. // J. Occup. Med., 7:53-60. Both citations from Nriagu, Lead and Lead Poisoning, p. 323.

22. "Sugar of Lead," Scientific American, Aug. 29, 1857, p. 403.

23. Nriagu, Lead and Lead Poisoning, p. 332.

24. J. Hughs, Ecology in Ancient Civilizations (Albequerque, N.M.: University of New Mexico Press, 1975), p. 5.

25. Niragu also notes that studies of Roman bones show from two to five parts per million of lead, with increasing amounts in bones of people who died at an older age. Pre-technical cultures which did not use lead, such as the Inca of Peru, show a small fraction of this amount of lead exposure at all ages. Moreover, the bimodal distribution of high lead content in unclassified Roman bones --which has been used to argue against the theory of lead as a factor in the fall of the Roman empire -- may acurately reflect Roman social structure, with the aristocratic group (high lead) able to afford plenty of lead sweetened wine and “sapa” and the lower class unable to afford it.

26. Lawrence E. Blanchard, Jr., “Washington Press Briefing,” National Press Club briefing, Jan 18, 1971, (Richmond, Va.: The Ethyl Corp., 1971).

27. Marjorie Smith, “Lead in History,” eds. Richard Lansdown and William Yule, Lead Toxicity: History and Environmental Impact, (Baltimore, Md.: Johns Hopkins University Press, 1986) p. 20.

28. Ibid.

29. Ibid. p. 21. Also see C.P McCord, “Lead and Lead Poisoning in Early America: Benjamin Franklin and Lead Poisoning,” Ind. Med. Surg. 22, 393-9, cited in Smith, "Lead in History," p. 21.

30. Charles Dickens, The Uncommercial Traveler, cited in Niragu, Lead and Lead Poisoning, p.

319.

31. Alice Hamilton, "Nineteen Years in the Dangerous Trades," Harpers, Oct 1929, pp. 580-591. This is not quite so far fetched as it might seem -- lead poisoning can come from improperly distilled spirits or from kitchen pots and pans made of lead. However, the problems of workers in the lead trade were often casually dismissed with these remote possibilities.

32. Ibid., p. 581.

33. Barbara Sicherman, Alice Hamilton: A Life in Letters (Cambridge, Mass., Harvard University Press, 1984),

34. Ibid., p. 33.

35. Ibid., p. 35.

36. Ibid, p. 238.

37. Alice Hamilton, Paul Reznikoff and Grace Burnham, "Tetra Ethyl Lead," Journal of the American Medical Association, May 16, 1925, pp. 1481-1486.

38. William Graebner, "Hegemony through Science: Information Engineering and Lead Toxicology, 1925 - 1965," in David Rosner and Gerald Markowitz, eds., Dying For Work: Workers Safety and Health in 20th Century America, (Bloomington, Indiana: Indiana University Press, 1989), p.140.

39. Phillip Shabecoff, A Fierce Green Fire (New York: Hill and Wang, 1993), p. 80.

40. Walter Lippmann, A Preface to Morals (New York: MacMillan, 1929). Lippmann's perspective on the sanctity of science was widely shared and applied to most professional fields (including the news media) in the form of "objectivity." See Peter Novick, That Noble Dream: The Objectivity Question and the American Historical Profession (London: Cambridge University Press, 1988).

41. Henry F. May, The End of American Innocence (New York: Knopf, 1959), p. 393.

42. Alice Hamilton, "Is Science For or Against Human Welfare?" The Survey Mid-Monthly, Feb. 5, 1916, p. 560.

43. L. F. Haber, The Poisonous Cloud: Chemical Warfare in the FIrst World War (Oxford:

Clarendon Press,1986), p. 292.

44. John E. Mitchell, "Will Ethyl Gasoline Poison All of Us? Scientists Disagree," The World, May 3, 1925, Editorials, p. 1.

45. Charles Baskerville, Remarks to the Conference on Industrial Hygiene, Yale Club, New York, Nov. 14, 1919, Public Health Service RG 90 File 0875-76, National Archives. Baskerville also noted an "urgent need for publication of an immense amount of valuable research by the Chemical Warfare Service which now appears to have little chance to reach the light of day." Use of gas masks in civilian chemical industries was one "important problem."

46. Leo Marx, The Machine in the Garden (London: Oxford University Press, 1964), p. 158.

47. Madeleine P. Grant, Alice Hamilton: Pioneer Doctor in Industrial Medicine, (London: Abelard-Schfuman, 1967), p. 84.

48. Marx, Machine in Garden, p. 181.

49. Thomas P. Hughes, "Machines, Megamachines and Systems," eds. Stephen H. Cutcliffe and Robert C. Post, In Context: History and the History of Technology (Bethlehem, Pa.: Lehigh University Press, 1984), p. 244.

50. Niles Weekly Register, Feb. 24, 1816, p. 451.

51. Jules Verne, From the Earth to the Moon -- and a Trip Around It, (New York: Fawcett, 1958), p. 1; first published 1865.

52. Marx, Machine in the Garden, p. 397. It is interesting that in Niles Weekly Register we find discussion of how machinery will not only lighten the load but also make slavery moot. A topic for further research might be the extent to which 19th century enthusiasm or disdain for technology was consciously a clash of free and slave societies.

53. W. Warren Wagar, Good Tidings: The belief in Progress from Darwin to Marcuse (Indianapolis, Ind.: Indiana University Press 1972).

54. Thomas P. Hughes, "Inventors: The Problems they Chose, The Ideas They Have, and the Inventions they Make," in Patrick Kelly and Melvin Kransberg, Eds., Technological Innovation: A Critical Review of Current Knowledge (San Francisco: San Francisco Press, Inc., 1978), p. 166

- 182.

55. U.S. Public Health Service, Proceedings of a Conference to Determine Whether or Not There is a Public Health Question in the Manufacture, Distribution or use of Tetraethyl Lead Gasoline, PHS Bulletin No. 158, (Washington, D.C.: U.S. Treasury Dept., August 1925), p. 105. (Hereafter cited as PHS Conference).

56. Burnham mentioned "those 11 men" who had died. The full number of actual deaths was not public in May, 1925. The final count of refinery workers in the 1936 du Pont report by N.P. Wescott was 16 deaths plus one related suicide.

57. PHS Conference, p. 108.

58. Shabecoff, Fierce Green Fire , p. 3.; also Kirkpatrick Sale, The Green Revolution (New York: Hill and Wang, 1993), p. xi.

59. The arguments about this point are significant enough to be noted here but beyond the scope of this dissertation. According to historian Herbert Butterfield's Whig Interpretation of History, (London: Oxford Press, 1931), the use of history as a tool for defining professional status is by definition a whig approach. The primary approach to history in most public relations textbooks before 1990 is the definition of professional status. See Carolyn Byerly, "Redefining the History of Public Relations" paper to the Association for Education in Journalism and Mass Communications, August, 1993.

60. Carl H. Moneyhon, "Environmental Crisis and American Politics, 1860-1920" in Lester J. Bilsky, ed., Historical Ecology: Essays on Environment and Social Change, (Port Washington, N.Y.: Kennikat Press, 1980), p. 3; Michael P. Cohen, History of the Sierra Club, 1892-1970 (San Francisco, Sierra Club Books, 1988), p. 25.

61. Joseph M. Petulla, American Environmentalism: Values, Tactics Priorities (College Station, Texas: Texas A&M University Press,1980) p. 24; L.M. Wolfe, Son of the Wilderness, the Life of John Muir (NY: Knopf, 1945); Aldo Leopold, Sand County Almanac, (Oxford University Press, 1949); William Tucker, Progress and Privilege (New York: Doubleday, 1983), p. 42.

62. Henry Clepper, The Origins of American Conservation (New York: The Ronald Press Co.,

1966), p. 11.

63. Michael P. Cohen, History of the Sierra Club, (San Francisco: Sierra Club Books, 1988), p. 51.

64. Carolyn Merchant, "The Women of the Progressive Conservation Crusade: 1900-1915," ed., Kendall E. Bailes, Environmental History, (New York: University Press, 1985), pp. 153 - 175.

65. Cohen, History of the Sierra Club, p. 29; Anon., "Battle for Wilderness," The American Experience series, Public Broadcasting Service documentary, 1989.

66. Merchant, "Progressive Conservation Crusade," p. 154.

67. Shabecoff, A Fierce Green Fire, p. 86. The idea that this was a "first" is clearly mistaken, but it illustrates the general lack of historical work in these areas.

68. Samuel P. Hays, Conservation and the Gospel of Efficiency: The Progressive Conservation Movement, 1890 - 1920, (Cambridge, Mass.: Harvard University Press, 1959).

69. Samuel C. Florman, "Technology and the Tragic View," ed. Albert H. Teich, Technology and the Future, (New York: St. Martin's Press, 1986), p. 124.

70. Daniel J. Czitrom, Media and the American Mind: From Morse to McLuhan (Chapel Hill, N.C.: UNC Press, 1982), p. 7.

71. Herbert Hosking, "The Automobile of James F. Hill Was Ordered Off the Street in 1885," Automotive Industries, May 2, 1931.

72. Thomas Hughes, Networks of Power: Electrification in Western Society, 1880-1930 (Baltimore, Md.: Johns Hopkins University Press, 1983).

73. We can interpret these accidents and the subsequent regulation by government and professional societies in a variety of ways. According to Florman, unwanted side effects attend "practically every technological advance ... Along with each triumph of mechanical genius came an inevitable portion of death and destruction. Instead of becoming discouraged, however, our forebears seemed to be resolute in confronting the adverse consequences of their own inventiveness." Of course, it is one thing to regulate and fix bridges and steam engines; it is another to "fix" an industrial poison. See Florman, "Technology and the Tragic View," p. 122.

74. Stein "American Muckraking of Technology," p. 401.

75. Leonard W. Weiss, "Introduction: The Regulatory Reform Movement," eds. Leonard W. Weiss & Michael W. Klass, Case Studies in Regulation (NY: Little, Brown & Co., 1981), p. 4.

76. Larry E. Ruff, "Federal Environmental Regulation," in Weiss, Case Studies in Regulation, p. 235. The act was not enforced until 1970 when it became a legal foundation for the Clean Water Act.

77. "Proceedings of the Conference on Oil Pollution," National Coast Anti-Pollution League and the League of Atlantic Seaboard Municipalities, Atlantic City, August 10 & 11, 1922; Corps of Engineers Record Group 130506-181, National Archives, Washington, D.C.

78. Public Health Service Record Group 90, Boxes 3450 "Stream Pollution," 3832, "Mine Sanitation," 5489 "Sewage Hygiene Lab," and 0875-96, "Hygiene & Sanitation / Industrial," National Archives, Washington, D.C.

79. "Acid Pollution of Streams," U.S. Engineers Office, Pittsburgh, Pa. August 20, 1922, Corps of Engineers Record Group 130506-181, National Archives, Washington, D.C.

80. Pratt, "Letting the Grandchildren Do it," p. 28.

81. "Fourth Meeting of the Inter Departmental Committee on Pollution of Navigable waters," Sept. 21, 1922, Corps of Engineers, Record Group 130506 -170, National Archives, Washington, D.C.

82. Alan I. Marcus and Howard P. Segal, Technology in America: A Brief History (New York: Harcourt, Brace, Jovanovich, 1989), p. 262.

83. David Rosner and Gerald Markowitz, eds., Dying For Work: Workers Safety and Health in 20th Century America, (Bloomington, Indiana: Indiana University Press, 1989), p. 53.

84. George Rosen, A History of Public Health, (New York: MD Publications, 1958), p. 140.

85. Ibid., p. 143.

86. W.G. Smillie, Public Health: Its Promise for the Future, A Chronicle of the Development of Public Health in the United States 1607 - 1914 (New York: McMillan, 1955), p. 75.

87. Rosen, A History of Public Health, p. 160.

88. Ibid., p. 228.

89. Arnold Pacey, Technology in World Civilization (Cambridge, Mass.: MIT Press, 1990), p. 187.

90. Rosen, A History of Public Health, p. 360-361.

91. Rosner and Markowitz, Dying for Work, p. 65.

92. Andrew Roy, The Coal Mines (Cleveland: Robison Savage Co., 1876), cited in Jacqueline Corn, "Protective Legislation for Coal Miners, 1870-1900," in Rosner and Markowitz, Dying for Work, p. 72.; Also William Graebner, Coal Mining and Safety in the Progressive Period, (Lexington, Ky.: University Press, 1976).

93. National Consumers League, Nov 20, 1926 meeting, NCL file No.18, microfilm reel No. 4, Library of Congress Manuscript Division, Washington, D.C.

94. Young, "Interpreting the Dangerous Trades," p. 45.

Text

CHAPTER THREE

THE DISCOVERY FROM DAYTON

The discovery of tetraethyl lead as an antiknock additive to make "leaded" gasoline has long been seen as an example of scientifically driven research at its finest. According to a leading historian of technology, Thomas Hughes, the discovery was "a beautiful [piece] of pure, or at least deliberately planned, research" and a systematic approach to the "reverse salient," -- a key problem in the broad front of technological progress. Engine knock was a key problem because it occurred at the upper limit of efficiency , power and cylinder compression in the internal combustion engines of the early 1920s. General Motors (G.M.) researchers Charles Kettering and Thomas A. Midgley "tried out all elements possible in a so-called Edisonian style," Hughes said. By overcoming knock, they opened the door to engines with almost twice the power and fuel efficiency. Hughes saw the discovery of Ethyl as closer to the heart of generic questions about invention than most other stories about other discoveries, that have often been "simplistic and adulatory."[1]

The fact that Kettering and Midgley combined both the Edisonian "cut and try" method and a scientific approach has been well appreciated in books about the discovery and marketing of Ethyl leaded gasoline. Historians Joseph C. Robert, Stuart Leslie, Joseph Pratt and David Rosner and Gerald Markowitz, along with biographers T.A. Boyd and Rosamond Young, tended to focus on leaded gasoline as the final successful step in a progression of discovery.[2] They focused on Ethyl brand leaded gasoline as a "success story" and rarely mentioned the alternative possibilities in their historical context or the controversy surrounding leaded gasoline.

In recent years, the need for a revised interpretation of the discovery has become evident. The focus on the financially successful aspect of fuel technology has had, as in other instances of preoccupation with technological success, a "whiggish" tendency. Whig history is a term for an approach to history which tends to distort the past through the optic of the present. According to historian John Staudenmier, one way to avoid "whiggishness" is to study some of the "roads not taken."[3] Avoiding "whiggishness" may point to useful ideas for the future, as Pursel suggested,[4] or , more importantly, it may simply help keep ideas in contemporary perspective. Another reason for revising the interpretation of the discovery of Ethyl leaded gasoline is that it is no longer a "success" in any event. Leaded gasoline was banned from the American market in 1986 due to its impact on public health. Thus, there are many reasons why we need to return to the moment in history and try to understand what may have been on the minds of General Motors researchers Charles Kettering and Thomas A. Midgley when they discovered the effect of tetraethyl lead as an anti-knock agent.

Setting the Stage: the Oil Crisis of the Early 20th century

The antiknock effect of lead in gasoline was discovered at an historical moment that was a complex crossroads of possibilities for the oil and automotive industries. One major impetus for change was the growing demand for new cars after World War I. Consumers also favored higher speeds and more powerful engines. At the same time, a troubling problem called engine knock began to affect more and more cars. Motorists found that their car engines would knock loudly while going up hills or taking off rapidly, and they assumed that the declining quality of fuel had something to do with it. Meanwhile, geologists predicted that petroleum reserves would be exhausted within 20 to 30 years.

Detroit's response to fears of an oil shortage had traditionally been to help ensure that alternative forms of fuel would be available. In 1906, fears of an oil shortage were confirmed by the U.S. Geological Survey (U.S.G.S).[5] In response, legislation was proposed to free farm-produced ethyl alcohol from beverage taxes so that it could be used as a fuel. Representatives of the Detroit, Board of Commerce attended hearings in Washington and told a Senate hearing that car manufacturers worried "not so much [about] cost as ... supply."[6] By the 1920s, Detroit again was concerned. Although U.S. oil production doubled between 1914 and 1921, oil production did not kept pace with fuel demand as the number of cars increased.[7] Three million were on the road in 1918, and another 22 million would be produced within a decade.[8] With growing demand, the long term petroleum outlook was "precarious," as the director of the U.S.G.S. said in 1920.[9]

Compounding fears of a domestic oil shortage, international diplomacy in the wake of World War I had failed to secure any reliable foreign sources of oil for the United States.[10] Fear of oil shortages became the most important factor in international relations,[11] becoming so great that some analysts warned that the U.S. might go to war with Great Britain to secure access to oil in the Persian Gulf region.[12] In 1919, Scientific American noted that the auto industry could no longer ignore the fact that only 20 years worth of U.S. oil was left. "The burden falls upon the engine. It must adapt itself to less volatile fuel, and it must be made to burn the fuel with less waste.... Automotive engineers must turn their thoughts away from questions of speed and weight... and comfort and endurance, to avert what ... will turn out to be a calamity, seriously disorganizing an indispensable system of transportation."[13]

Charles Kettering's Solution to the Energy Crisis

America's leading automotive engineer in the post-World War I era was unquestionably Charles Franklin Kettering. Tall and ascetic, with a sense of dignity and humor sometimes compared with that of Abraham Lincoln, Kettering was able to rally a team of researchers around a host of apparently impossible tasks. He was born in 1876 in Loudonville, Ohio, and studied electrical engineering at Ohio State University. He graduated with honors and went to work for National Cash Register company, creating the first electric cash register. Although others had tried, no one had been able to come up with a mechanism that connected the electric motor to the register's gearing. The mechanism had to engage and disengage quickly. After Kettering solved that problem, he began thinking about other possibilities for the principle, and developed an electric self-starting mechanism for cars. It replaced the cumbersome and dangerous hand cranked magneto starter. In 1910, Kettering formed the Dayton Engineering Laboratories Co. (Delco) and a few years later, electric starters and batteries had become a common feature on millions of cars.

About the same time, the increasing demand for gasoline led to a decline in fuel quality and an increase in engine knock. No one knew what caused it, but many people blamed the electric starter motor. Kettering thought the rumors came from magneto manufacturers. "The Bosch magneto people had representatives out telling Cadillac dealers that if they had magnetos instead of battery ignition they wouldn't have all the trouble," Kettering recalled in an unpublished 1946 memoir.[14] As he travelled throughout the Midwest, demonstrating the electric starter to various skeptical automakers, he frequently thought about how to find the cause of engine knock in order to silence it -- and his critics.

The problem went on the back burner for several years as he worked on an electric generator for farm lighting powered by a small gasoline engine. Before it could be marketed, however, insurance companies insisted that Delco switch from gasoline to kerosene, which was less volatile and less likely to cause fires. But kerosene caused a profound knock in the Delco engine. One day in 1916, a young mechanical engineer fresh from Cornell University had finished another project for Kettering.

"What do you want me to do next, boss?" Thomas Midgley is said to have asked. Over the years, Kettering had accumulated some test equipment to look into engine knock, and he now suggested that Midgley try it out. The conversation was the beginning of a seven year trail of research that would lead to the discovery of Ethyl leaded gasoline. Midgley continued working on knock even when Kettering sold Delco in 1916 and formed a new company, Dayton Metal Products Co. Research Division. The new company would play with research, Kettering said, in much the same spirit as a person plays golf. (With typical humor, he added, "but I don't think we used the same proportion of profanity").[15]

Kettering recognized that engine knock represented an upper limit on the extent to which a given engine could produce power. An engine using a lower quality fuel would have to use a cylinder compression that produced less power. Otherwise, increasing compression would lead to violent knocking and rapid engine failure. In 1916, most engines ran at a four-to-one or five-to-one compression ratio. Racing cars, on the other hand, commonly used far more efficient engines fueled with more expensive fuels such as alcohol and benzene.

An early success put Kettering and Midgley on the track of an additive to eliminate knocking. In December 1916, the two men were discussing the knock problem when Kettering wondered whether it was related to the absorption of heat. He remembered a small red flower called the trailing arbutus that sometimes bloomed in the snow in Ohio and speculated that it was able to absorb more heat because of its red color. Perhaps if a red dye were added to kerosene it would absorb some of the heat of combustion and stop the knock.

This line of reasoning turned out to be completely off base, but it shows both how little was known about fuel chemistry at the time and how much the element of luck intervened in the antiknock research work. For, as luck would have it, no dyes were available that day, and a company chemist located a bottle of iodine. A few drops in the carburetor of the test engine noticeably decreased the knock. Later when some red dye was located, it proved to have no effect at all. The arbutus story is often recounted in the histories of Ethyl gasoline because it aptly demonstrates that luck favors the prepared researcher who can isolate the essential fact and discard encumbering theory.[16]

Almost overnight, Kettering and Midgley had taken fuel research to a new plateau. The oil industry was concerned with production, not end-use, and most of its research was focused on squeezing more gasoline from a barrel of oil. (It was, in fact, this tendency that led to increasing engine knock). The car industry was mostly concerned with metal, not fuel chemistry. Kettering and Midgley had worked their way into an important and unexplored terrain for research. They not only began trying different compounds, but they also tried to understand their effects by accurately measuring knock and graphically displaying it. This research was the beginning of a scientific process that resulted in uniform test procedures for measuring engine knock and also in a fuel quality measuring system known today as “octane number” based on iso-octane as a reference fuel.[17]

In 1917, America's entry into World War I shifted Midgley's early fuel research from automotive engine knock to high-powered aircraft engine fuels. He was soon working on a secret aviation fuel development project at Wright[18] airfield in Dayton using a single cylinder taken from a Liberty engine. Midgley found that some types of fuels could be used in high compression engines while others would knock violently. In the list of antiknock fuels, pure ethyl alcohol was given as most effective, followed by the “aromatic” petroleum compounds (benzene, toluene, xylene), then petroleum olefins, parafins and ethers. Since the most important target of the research was airplane fuel, Kettering and Midgley rejected some choices because they were not suitable for aircraft. Benzene, for example, froze at 40 degrees F above zero, while temperatures aloft could go as low as 76 F below zero. Olefins (heat-cracked petroleum) were eliminated because they tended to form gum after a few months in storage. Alcohol was eliminated because it had only about 80,000 BTUs per gallon as compared to gasoline with about 120,000 BTUs per gallon.[19] This meant that an airplane might have to take about one third again as much fuel to accomplish the same mission and thus would carry less cargo.[20] However, problems with the three alternatives could be overcome. Benzene could be made into cyclohexane, which had a very low freezing point. Olefin cracked gasolines could be used quickly or treated before use to remove gum. Alcohols could be mixed with benzene or gasoline to give an antiknock and anti-freeze effect without adding too much fuel weight. The antiknock approach with the most promise for airplane fuel seemed to be a mixture of 50 percent benzene and 50 percent gasoline, and Midgley applied for a patent on the mixture on Jan. 7, 1918.[21]

Working with the Army Air Corps, Kettering and Midgley settled on a blend of cyclohexane and benzene called “Hecter” fuel. They were prepared to go into production with the fuel when the 1918 Armistice was signed.[22] In a final report on the war research, Midgley wrote: “Engineers have heretofore believed knocking to be the unavoidable result of too high a compression, and while the fact that [ethyl] alcohol did not knock at extremely high compressions was well known, it was [erroneously] attributed to its extremely high ignition point[23] ...“ Instead, Midgley and Kettering said they believed that the effect involved the chemical structure of the fuel. Thus, high heating value fuels such as gasoline (which were preferred for aircraft because of relatively lighter weight) could, theoretically, run in high compression engines just as well as alcohol or benzene if some additive could be found to reduce knock. Lower heating value fuels, such as alcohol, would then not be needed for aircraft fuel.[24]

Kettering's shop becomes G.M.'s research division

Shortly after the war ended, G.M.founder William C. Durant had become interested in Kettering's work and reached an agreement with Kettering to turn Dayton Metal Products into G.M.’s Research Division. The merger was formalized early in 1919, and Kettering was made G.M.'s vice president of research. About the same time, in an effort to make the new acquisition appear efficient to the new management, Midgley was given two weeks to discover something to stiffen G.M.’s resolve to fund fuel research. “Mr. Midgley has tenaciously adhered to the opinion that it was possible to secure a so-called ‘pill’ to overcome motor knock,” said F.O. Clements, the lab’s manager. And yet, he observed, “the balance of the organization has given him very little encouragement.”[25]

According to T.A. Boyd, a research chemist working with Midgley who later documented some of the laboratory's work, Midgley's main research goal in the 1919-1920 era was to make alcohols out of olefins in petroleum by reacting the olefins with sulfuric acid. “But in view of the verdict setting a time limit on how much further the research for an antiknock compound might continue, work was resumed at once in making engine tests of whatever further compounds happened to be available on the shelf of the lab... or which could be gotten readily,” Boyd said.[26] Midgley lost no time trying everything he could find in his one-cylinder laboratory test engine. On January 30, 1919, just as his deadline approached, Midgley tried a few drops of aniline in his test engine and dramatically reduced the incessant knock. This haphazard approach was hardly the epitome of deliberately planned research.

Aniline "was the second real antiknock compound to be discovered," Boyd said in a confidential history of Ethyl leaded gasoline written in 1943. However, there were problems. Among them was the fact that aniline was toxic, had a distressingly bad smell, and that a 3.5 percent mixture in kerosene would separate into two distinct liquids (or "phase separate") at 35 degrees F.[27]

The idea that analine was a "real" anti-knock compound is confusing. Boyd never defines "real" and, in another part of his unpublished history, noted that "of course, antiknock agents had already been added to automobile gasoline.."[28]

It is also significant that a discrepancy seems to have existed between summary reports and actual test data at the time. For example, in a summary "Report of Fuel Research Work" regarding 1918 - 1919 G.M. - Bureau of Mines fuel tests, Midgley noted that ethyl alcohol blended at five percent strength into gasoline as an antiknock had only "slight effect" while analine had the best.[29] However, raw scores from these same tests appended to the report showed that 20 percent alcohol blends gave a markedly improved effect in tests that were not mentioned in the final report. Also omitted was any mention of analine's toxic nature, smell or propensity toward phase separation, which Midgley had discussed in other memos. Thus, an interest in what was called the "pill" approach was evident long before tetraethyl lead was discovered, and the summary report seems to have been written with conclusions supporting analine already in mind.

In late 1918 and early 1919, Kettering told fellow engineers that combined industry research efforts into the problem of developing better fuels and better engines was needed. He also made initial contacts with du Pont Corp. and Standard Oil of N.J. representatives and encouraged them to exchange research results with his own researchers at General Motors. He shared testing equipment and most of what his labs had learned, to the chagrin of the G.M. management and patent offices. Standard's interest had been piqued when, following a meeting with Kettering, Chicago patent attorney F.A. Howard wrote to Standard chairman E.M. Clark on April 16, 1919. "Unless the fuel producers themselves get into this work of investigating the properties of their fuels, there is a good chance that they may have to pay tribute to others," Howard said. "There would be such an insistent demand for (antiknock fuel) that any oil producer who had exclusive rights could absolutely dominate the entire motor fuel market."[30]

The lack of research in the oil industry reflected not only the preoccupation with exploration and production but also the idea that engine knock was an engine problem. The prevailing view was that a new kind of engine would be needed that was more tolerant of low-grade fuels, and this would probably mean a lower compression engine that was less fuel efficient. Although it would be wasteful, such an engine would be able to use lower grade fuels. Since higher grade fuels were running out, the oil industry would have to exploit increasingly poor quality oil fields and oil shale.

Even though oil was running out, Kettering felt the industry should refuse to compromise the design of the engine. In a talk to the Society of Automotive Engineers, he insisted that the route to conservation of fuel was through better quality fuel to be used in more efficient engines. This must have seemed contradictory, since declining fuel quality was the original problem, but Kettering took the longer view. In effect, he argued that low quality fuels would also run out, and low compression engines would use them up faster. If the fuel could be improved, the engine could be developed with higher compression ratios, which would give better mileage, which in turn would extend fuel supplies. However, even with conservation, experts believed that petroleum resources would decline in quality and eventually run out. Kettering and G.M.had a public short term approach and a secret long term approach to the problem.

In the short term, two "classes" of solutions to the engine knock problem were available, Kettering said: the "high percentage class" and the "low percentage class." The former involved adding large amounts of another liquid fuel to gasoline, such as 40 percent benzene, which "makes an engine operate entirely satisfactorily," Kettering said. The "low percentage class" of solution was represented in 1919 by the use of a one percent iodine solution in gasoline. (Aniline, although discovered, was still secret at this time). Iodine was expensive and corrosive, "entirely out of the question" as a commercial proposition, but it provided an interesting example of a possible "low percentage class" solution to the problem.[31]

Although the idea that iodine or some other "low percentage class" material could solve the knock problem opened up an entirely new avenue in engine development, historians dealing with the Ethyl controversy have not recognized that the "high percentage class" solution to the knock problem was well understood by European and American scientists in the 1920s. Probably the most important "high percentage class" solution to engine knock was the addition of 20 to 30 percent ethyl alcohol (ethanol), distilled from grain or root crops or made from wood pulp. Also well known in 1919 was the use of 20 to 40 percent benzine from coal and "cracked" higher grades of crude petroleum.

Ethyl alcohol as a fuel parallels and in some cases precedes gasoline.[32] In 1918, Scientific American cited war research in France and England and concluded: "It is now definitely established that alcohol can be blended with gasoline to produce a suitable motor fuel."[33] Harold B. Dixon, working for the British Fuel Research Board, summed up his group's conclusions that alcohol's greater useful compression ratio compensated for its lower BTU value. A mixture of alcohol with 20 percent benzene or gasoline "runs very smoothly, and without knocking," he said in 1920 in the Society of Automotive Engineers Journal.[34] The consensus, Scientific American said, was "a universal assumption that [ethyl] alcohol in some form will be a constituent of the motor fuel of the future."[35] Alcohol met all possible technical objections, and although it was more expensive than gasoline, it was not prohibitively expensive in blends with gasoline. "Every chemist knows [alcohol and gasoline] will mix, and every engineer knows [they] will drive an internal combustion engine," Scientific American said. The prevailing view in 1920, then, was that high percentage class additions to fuels would be necessary if higher compression ratios were to be achieved, and that engines that were more tolerant to low grade fuels would probably also be needed.

Meanwhile, as aniline and iodine proved expensive and complex to produce, Midgley and Kettering's investigation of fuel knock had come to a stalemate. The impasse was the "dark hour before a break in the clouds," Boyd later said. Midgley was depressed and wanted to drop the entire investigation.[36] In October, 1920, Midgley filed a patent application on an aniline injector for engines.[37] Still, the pungent aroma of aniline exhaust clung to the air in the Dayton labs, magnifying the sense of failure. "I doubt if humanity, even to doubling of fuel economy, will put up with this smell," Midgley wrote C.M. Stine of du Pont.[38] Stine had been asked to develop plans for a full scale production effort for aniline. Kettering conceded that du Pont was "out of sympathy with our point of view," and that they would have to do something "to stimulate interest in what is today the only known solution to the problem."[39]

In the spring of 1921, Kettering chanced across a newspaper article on selenium, a potential "universal solvent." Kettering laughed, remembering a joke about a farmer who asked a chemist what on earth would hold a "universal" solvent. He pocketed the news clip. When he returned to Dayton, out of the blue, Kettering gave it to Midgley and asked him to try selenium. On April 6, 1921, at the threshold of abandoning the project, Midgley discovered that selenium had an antiknock effect greater than aniline, although it smelled worse and was highly corrosive.

The research effort shifted into a somewhat more systematic and scientific approach. Guided by a periodic table of elements designed by Robert Wilson of MIT, Midgley began focusing on groups of elements with potential antiknock effect. He pasted a chart of 20 elements in four groups onto a peg board and mapped the antiknock values of each element as it was tested. By August, 1921, preliminary tests pointed to lead as the best "low percentage" antiknock additive. Historians would later see the peg board method as a turn from raw empiricism to a reasoned scientific method and as marking the broader industrial transition from the "heroic" style of invention in the mold of Edison to the more scientific, less personal corporate inventive approach.[40] Yet it is interesting that world famous German chemist Carl Bosch felt that his chemists would have rebelled at a method so crudely rooted in the empirical tradition. When he invited Kettering to his laboratory two years later, he smiled at the "cut and try" empiricism: "That might work in America, but I could never get my fellows to do it that way."[41]

Experiments on alternatives continue

As work continued on analine and other low percentage compounds in 1920 and 1921, the idea of what was needed in fuel research continued to evolve. The primary initial idea, according to Boyd's unpublished history, was that gasoline supply was inadequate in the short term. Rather than move to heavier and lower grade fuels, which would still be abundant after high quality oil was used up, it would be better to use more efficient fuels, as Kettering had told the Society of Automotive Engineers. Midgley and Boyd consulted with experts in the U.S. Bureau of Mines who said that the idea of improving low grade fuels seemed less urgent than the long range petroleum supply problem.[42]

Around 1920 and 1921, Kettering and his British counterpart H.R. Ricardo had began to believe that alcohol fuel from renewable resources would be the answer to the problem. "At almost the same time, both researchers [Kettering and Ricardo] settled on alcohol as the key to unshackling the internal combustion engine from non-renewable fossil fuels," said historian Stuart Leslie. "Ethanol (ethyl alcohol) never knocked, it could be produced by distiling waste vegetable material, and it was almost pollution-free. Ricardo compared alcohol fuel to living within a man's means, implying that fossil fuels were a foolish squandering of capital."[43]

Despite Ricardo and Kettering's optimism over the advantages of alcohol fuel, staff researchers had previously concluded that alcohol fuel from farm products would not satisfy the enormous fuel need if a total substitute for petroleum had to be found. In 1919 a du Pont study found that a nationwide switch to ethyl alcohol would take 50 to 60 percent of the entire grain and sugar crop.[44] Midgley's assistant T.A. Boyd also compiled statistics in the 1919-1920 period and reported that some 46 percent of all foodstuffs would have to be converted to alcohol to replace gasoline on a BTU for BTU basis.[45] In April of 1921, Boyd surveyed the steep rise in number of new cars and the increasing difficulty of providing new fuel supplies. The solution, Boyd said, would be to use other fuels, and benzene and alcohol "appear to be very promising allies" to petroleum.[46] Alcohol was the "most direct route ... for converting energy from its source, the sun, into a material that is suitable for a fuel..." Boyd said.

Despite advantages of cleanliness and high antiknock rating, there were supply problems. In 1921, about 100 million gallons of industrial alcohol supply was available. Overall, enough corn, sugar cane and other crops were available to produce almost twice the demand for gasoline, which was about 8.3 billion gallons per year. But the possibility of using such a large amount of food acreage for fuel "seems very unlikely," he said.[47] In a speech around 1921, Kettering noted that "industrial alcohol can be obtained from vegetable products ... [but] the present total production of industrial alcohol amounts to less than four percent of the fuel demands, and were it to take the place of gasoline, over half of the total farm area of the United States would be needed to grow the vegetable matter from which to produce this alcohol."[48]

The question in Kettering's speech and in the Boyd and du Pont studies is framed in terms of totally replacing gasoline although a related goal of the research was to create antiknock additives. It stands to reason that if a 20 percent blend of alcohol were to be used in all fuel, then (even using Boyd's questionable figure) only about nine percent of grain and sugar crops would be needed. Since grain was in surplus after the war, American farmers probably would have welcomed a new market for their crop, and the kinds of supply problems in the G.M. and du Pont studies would probably not have materialized. Also, with Prohibition, distillers would have welcomed a new use for their services. Another problem with Kettering's analysis demonstrates a lack of understanding of agriculture and the distilling industry. Grain is not "used" for fuel; it is fed to cattle after it is distilled with no loss in food value. This is as true of brewers' grains from beer distilleries as it is of fuel facilities.

Thus, supply of an additive would not have been the problem that G.M. and du Pont engineers apparently assumed that it would have been. The original du Pont and Boyd studies on fuel alcohol are missing from the archives, and it is difficult to fathom the reason for their narrow frame of reference. One reasonable explanation is that Kettering, Boyd and Midgley were preoccupied with the long-term replacement of petroleum. In 1920 and 1921 they were not technically or politically opposed to ethyl alcohol as a straight fuel or in blends with gasoline. Kettering spoke out against taxes on alcohol as an impediment to fuel research and helped overcome other obstacles.[49] For example, in 1920, K.W. Zimmerschied of G.M.'s New York headquarters wrote Kettering to note that the alcohol fuel use "is getting more serious every day in connection with export cars, and anything we can do toward building our carburetors so they can be easily adapted to alcohol will be appreciated by all." Kettering assured him that the adaptation "is a thing which is very readily taken care of," and said that G.M. could rapidly change the floats in carburetors from lacquered cork to metal.[50] Midgley also filed a patent application for a blend of alcohol and cracked (olefin) gasoline on February 28, 1920, clearly intending it to be an antiknock fuel.[51]

The problem of the long-term resource base for the fuel of the future continued to worry Kettering and Midgley. At one point they became interested in work on cellulose conversion to fermentable sugar being performed by Prof. Harold Hibbert at Yale University. Hibbert was a visionary, and pointed out that the 1920 U.S.G.S. oil reserve report had serious implications for his work. "Does the average citizen understand what this means?" he asked. "In from 10 to 20 years this country will be dependent entirely upon outside sources for a supply of liquid fuels... paying out vast sums yearly in order to obtain supplies of crude oil from Mexico, Russia and Persia." But the chemist might be able to solve the problem, Hibbert said, by working on abundant cellulose waste from farm crops, timber operations and seaweed as a source of ethyl alcohol.[52] In the summer of 1920, Boyd and his family moved to New Haven so that he could study with Hibbert. Boyd found Hibbert impressive but the volume of literature about cellulose hydrolysis and synthesis was overwhelming. When Midgley came east in late July, he was more interested in meeting Standard Oil Co. officials than with Hibbert, and Boyd left without a clear sense of where the cellulose research could go.[53]

Boyd did insist that a source of alcohol "in addition to foodstuffs" must be found, and that the source would undoubtedly be cellulose: "It is readily available, it is easily produced and its supply is renewable." Using it and returning farm crop residues to the soil would not harm soil fertility. But the problem of developing a commercial process for cellulose conversion to alcohol was serious, he had learned in his stay with Hibbert. A ton of wood yielded only 20 gallons of alcohol in the least expensive "weak acid" process, whereas a commercially profitable "weak acid" process would need a yield of at least 50 gallons, and possibly 60 to 65. Such yields had been achieved with the "strong acid" process, but that technology was complex and more expensive. Still, success might be found if the "strong acid" yield could be obtained in a weak acid process, and as a result, "the danger of a serious shortage of motor fuel would disappear," Boyd said. "The great necessity for and the possibilities of such a process justify a large amount of further research."

To promote such research among automotive and chemical engineers, Midgley drove a high compression ratio car (7:1) from Dayton to an October, 1921 Society of Automotive Engineers (SAE) meeting in Indianapolis using a 30 percent alcohol blend in gasoline only two months before tetraethyl lead was discovered. "Alcohol has tremendous advantages and minor disadvantages," Midgley told fellow SAE members in a discussion. Advantages included "clean burning and freedom from any carbon deposit... [and] tremendously high compression under which alcohol will operate without knocking... Because of the possible high compression, the available horsepower is much greater with alcohol than with gasoline..." Minor disadvantages included low volatility, difficulty starting, and difficulty in blending with gasoline "unless a binder is used."[54] Another unnamed engineer (probably from G.M., possibly Boyd) noted that a seven and a half percent increase in power was found with the alcohol-gasoline blend "... without producing any 'pink' [knock] in the engine. We have recommended the addition of 10 percent of benzol [benzene] to our customers who have export trade that uses this type of fuel to facilitate the mixing of the alcohol and gasoline."[55] In a formal part of the presentation, Midgley mentioned the cellulose project. "From our cellulose waste products on the farm such as straw, corn-stalks, corn cobs and all similar sorts of material we throw away, we can get, by present known methods, enough alcohol to run our automotive equipment in the United States," he said. The catch was that it would cost $2 per gallon. However, other alternatives looked even more problematic -- oil shale wouldn't work, and coal would only bring in about 20 percent of the total fuel need.[56]

Fellow engineers were clearly interested in Midgley's viewpoint, but there was yet another catch -- Prohibition of alcoholic beverages. Not only was it increasingly difficult to envision a network of industrial alcohol facilities given the problem of avoiding illegal diversion of the fuel, but Prohibition had also made it difficult even to experiment with alcohol fuel. A tone of frustration is evident in a memo from F.O. Clements, lab manager in Dayton, to the staff dated September 9, 1921. “We have finally managed to secure some 96 percent grain alcohol and a small amount of absolute alcohol...” With the laws against alcohol consumption, such a rare cache demanded vigilance, and the rest of the memo detailed complex security, requisition and reporting procedures.[57] In contrast, European researchers were not only unrestricted in this regard but positively encouraged by governments of countries without domestic oil reserves.

Midgley and Kettering’s interest in ethyl alcohol fuel did not fade once tetraethyl lead was discovered as an antiknock in December, 1921. In fact, not only was ethyl alcohol a source of continued interest as an antiknock agent, but more significantly, it was still considered to be the fuel that would eventually replace petroleum. A May, 1922 memo from Midgley to Kettering was a response to a report on alcohol production from the Mexican "century" plant, a desert plant that contains fermentable sugars. Midgley said he was "not impressed" with the process as a way to make motor fuel:

> Unquestionably alcohol is the fuel of the future and is playing its part in tropical countries situated similar [sic] to Mexico. Alcohol can be produced in those countries for approximately 7 - 1/2 cents per gallon from many other sources than the century plant, and the quantities which are suggested as possibilities in this report are insignificantly small compared to motor fuel requirements. However, as a distillery for beverage purposes, these gentlemen may have a money making proposition.[58]

Even as chemists tinkered with various processes to produce tetraethyl lead in a nearby lab, Midgley and Boyd continued working on alcohol for fuel. In a June 1922 Society of Automotive Engineers paper, they said:

> That the addition of benzene and other aromatic hydrocarbons to paraffin base gasoline greatly reduces the tendency of these fuels to detonate [knock] ... has been

> known for some time. Also, it is well known that alcohol ... improves the combustion characteristics of the fuel ...*The scarcity and high cost of gasoline in countries where sugar is produced and the abundance of raw materials for making alcohol there has resulted in a rather extensive use of alcohol for motor fuel.* As the reserves of petroleum in this country become more and more depleted, the use of benzene and particularly of alcohol in commercial motor fuels will probably become greatly extended."[59] (Italics indicate section used only in oral presentation).

Some G.M.officials encouraged Midgley to keep looking into alcohol fuel after the discovery of tetraethyl lead. In correspondence with the company's patent attorneys, for example, the question of a patent issued to Industrial Alcohol Co. for a combination of petroleum and an "ester" (made from ethyl alcohol) for antiknock effects had come up in the summer of 1922. Midgley was encouraged to experiment with the idea. "Try it out and see if the U.S. Industrial Alcohol Co. have opened up a valuable line of research," said J.W. Morrison in the G.M. Patent Dept. "Mr. Clements [the lab manager] stated some time ago that it might be worth our while to carry our investigations further on the problem of utilizing alcohols in motors. I think he mentioned more specifically combinations of alcohol and gasoline."[60]

In September, 1922, Midgley and Boyd wrote that "vegetation offers a source of tremendous quantities of liquid fuel." Cellulose from vegetation would be the primary resource because not enough agricultural grains and other foods were available for conversion into fuel. "Some means must be provided to bridge the threatened gap between petroleum and the commercial production of large quantities of liquid fuels from other sources. The best way to accomplish this is to increase the efficiency with which the energy of gasoline is used and thereby obtain more automotive miles per gallon of fuel."[61] At the time the paper was written, in late spring or early summer 1922, tetraethyl lead was still a secret within the company. It was about to be announced to fellow scientists and test marketed. The reference to a means to "bridge the threatened gap" and increase in the efficiency of gasoline clearly implies the use of tetraethyl lead or some other additive to pave the way to new fuel sources.

This inference is consistent with an important statement in N.P. Wescott's unpublished 1936 legal history of Ethyl Gasoline for the du Pont corporation:

> It is also of interest to recall that an important special motive for this [tetraethyl lead] research was General Motors' desire to fortify itself against the exhaustion or prohibitive cost of the gasoline supply, which was then believed to be impending in about twenty-five years; the thought being that the high compression motors which should be that time have been brought into general use if knocking could be overcome could more advantageously be switched to [ethyl] alcohol.[62]

Thus, even after tetraethyl lead was discovered in 1921 (as noted below), there were two "ethyls" on the horizon for General Motors: Ethyl leaded gasoline, which would serve as a transitional efficiency booster for gasoline, and the ethyl alcohol, the "fuel of the future" that would keep America's cars on the roads no matter what happened to the oil industry.

For years after tetraethyl lead was discovered, alcohol blends with benzene and gasoline were considered much more reliable antiknock agents. In 1923, for example, Midgley confidentially advised U.S. Navy fliers attempting a cross-Pacific flight not to use Ethyl leaded gasoline (which had only begun to be marketed).

> We have made great progress in overcoming the spark plug and valve trouble caused by (Ethyl lead) ... but we have not yet solved the problem to our entire satisfaction; and, in view of the fact that it is essential that no engine trouble of any kind develop, it seems wise not to risk the use of this material ... Probably the best possibilities are offered by a fuel consisting of a gasoline-benzol-alcohol blend...[63]

Kettering and Midgley may not have been vocally supportive of alcohol as a fuel after 1922, but it probably remained as a fall-back option. For example, in the summer of 1925, newspaper articles announced that G.M. would introduce a new blend of benzene and alcohol fuel called "Synthol" that would, like Ethyl, "double gas mileage."[64] The blend was never marketed.

Not everyone considered alcohol the "fuel of the future." G.M.'s partner in Ethyl, Standard Oil of New Jersey, would vehemently oppose alcohol fuel in the early 1930s in part because of its experiment with alcohol blends in 1923. According to the American Petroleum Institute, the experiment in Baltimore, Maryland with a 25 percent anhydrous alcohol blend with 75 percent gasoline caused "uneven and troublesome operation of motor cars" due to "instability of the alcohol-gasoline in the presence of water." It would be unlikely that Standard engineers would be unaware of the fact that a “binder” like benzene was routinely used with alcohol blends to prevent such instability, just as Midgley recommended to the aviators. In fact, as we have seen, Midgley met with Standard officials in New York City that summer. If the experiment was a failure as claimed, certainly no reports or reviews of the experiment were ever published in journals or made public; nor, for that matter, was the Baltimore public aware that it was taking part in an experiment.[65]

Tetraethyl Lead Discovered

In the summer and fall of 1921, Midgley and his lab assistants began a series of tests that would have enormous public health significance. The peg board with 20 elements pasted on it guided the Dayton researchers through tests on already known knock suppressors (such as bromine, iodine, tellurium, tin and selenium) and novel elements for fuel tests (arsenic and sulfur). The atmosphere in the labs grew more expectant as the pegboard seemed to point the way toward the heavy end of the carbon group: silicon, Germanium, tin and lead. Visiting his father in Massachusetts in late October, Midgley had antiknock results from each new test sent via telegraph daily. Tetraethyl tin proved effective, but even more exciting was the prospect of metallic lead at the bottom of the column on the peg board.

By this time, Midgley's “scientific foxhunt” of seven years had involved tests of hundreds or possibly thousands of compounds, although there is little agreement on the numbers and no way to check them, since the archives do not contain his daily laboratory records. The earliest 1925 reference to the number of compounds tested in the G.M. Dayton labs was 2,500,[66] while a sales manager for Ethyl told the New York Times on May 20, 1925 that 2,400 compounds had been tested.[67] An Ethyl sales pamphlet printed two years later put the number at 33,000.[68] In the 1950s, as G.M. public relations personnel prepared a history of the discovery, T.A. Boyd wrote "too much" in the margins of one of the manuscripts next to a note about 143 compounds tested. In 1960, a Kettering biographer quoted Midgley as saying 14,991 compounds were tested;[69] and an Ethyl official in 1980 put the number at 144.[70]

Whether hundreds or thousands of compounds were tested, when the research team got around to tetraethyl lead on the morning of December 9, 1921, the knock in the one-cylinder laboratory engine was utterly silenced. Even diluted to a strength of two or three grams per gallon, or one thousand to one, tetraethyl lead had a remarkable ability to quiet the relentless knocking. Midgley, Boyd and others in the lab "danced a very unscientific jig" and hurried off to include Kettering in their victory party. Holding a test tube full of the stuff in his fingers, Kettering suggested, perhaps ironically, the name "ethyl" for the chemical compound tetraethyl lead. Although the term referred to the ethyl alcohol solvent used to dissolve the lead and utterly confused the issue of using blends of ethyl alcohol as a "high percentage" solution as opposed to lead as a "low percentage" solution, the name Ethyl stuck.[71]

Dayton may have been dancing, but Detroit was yawning. Kettering's boss, G.M. president Alfred P. Sloan, simply could not get enthusiastic about the tetraethyl lead. An attorney for G.M. later recalled Sloan's attitude: "When Kettering found that the element iodine would do it, he [Kettering] said, this is the answer. And when he had aniline, he said, this is the answer. And when he had selenium, he said this is the answer... And so, when tetraethyl lead was discovered, Sloan thought: 'it won't be long before we get something better than this.'"[72] Perhaps in order to show Detroit just how interested people were, the Dayton labs announced in February 1922 that a new gasoline additive could double mileage. The announcement did not mention tetraethyl lead, but rather, the discovery which preceded it. The Associated Press story read: "Dayton, Ohio (AP) -- Discovery of a tellurium gasoline compound which increases gasoline mileage by one hundred percent over present gasoline fuel was announced at the research lab of the G.M.Co. here today." Several hundred enthusiastic letters, mostly from small companies with delivery services, landed on Midgley's desk.[73] He answered them with a standard response:

> The newspaper article, like most newspaper articles, does not give the whole story.

> We do have compounds that influence the rate of combustion of gasoline in an internal combustion engine; the savings to be effected have to do with doubling the compression of the motor. With the ordinary low compression motor we can do nothing, save to completely eliminate the knock.[74]

It is interesting that Midgley's letter reflects such disdain of the press even though someone in the G.M. research labs must have initiated the misleading publicity to promote the fuel group's position inside G.M. It is also interesting that similar statements would soon be made about tetraethyl lead doubling or tripling gasoline mileage and that other breakthrough fuels (such as "Synthol" in 1925) would mysteriously appear in announcements from Dayton and then just as mysteriously vanish.

If tetraethyl lead was the solution to the knock problem, troubles soon tested Kettering and Midgley's commitment. The compound was hard to make and it broke down quickly in the sunlight. Engine tests showed that particles of lead burned holes in the exhaust system and valve seats. Lead oxide also caked onto spark plugs, stopping the engine after a few thousand miles. There was also the problem of how to physically deliver the dangerous additive to the gasoline market.

Midgley believed all these problems could be overcome. Tetraethyl lead would be kept in light-tight containers. Valve seats and exhaust pipes would be made with harder alloys. Reactive lead particles could be neutralized with an additional chemical agent, for example, an acid or a radical that could combine with lead, such as chlorine, sulphur, selenium or bromine. "We may hope at almost any time to find a sufficiently satisfactory solution to the problem so that initial marketing at least may be started," Midgley said.[75] Midgley originally wanted to sell a "pill" made of tetraethyl lead and a waxy substance (paratoluidune) that would dissolve in gasoline. A patent application in April, 1922 covered the basic concept, and a specific patent application was made in October, 1922.[76] But "pills" to turn water into gasoline and other fraudulent schemes had made the public wary of such approaches, as Kettering noted in his memoirs, and the first product marketed in 1923 was concentrated "Ethyl fluid" blended by service station attendants at the service station pump.

Problems with tetraethyl lead were not fully discussed with other scientists when Midgley and Boyd presented their paper on the remarkable new antiknock fluid in September, 1922, partly because of a defensive attitude by G.M.'s patent attorneys.[77] Yet many other scientists inside and outside G.M. were enthusiastic about testing it. Sample batches were sent to du Pont, Standard Oil of N.J., Standard of Indiana, Sun Oil Co., the Bureau of Naval Aeronautics, and a variety of university researchers. Midgley's work was rewarded in December 1922 with news that he had won the prestigious William H. Nichols Medal from the New York section of the American Chemical Society (ACS). Wilson of MIT wrote that it was "just the beginning" of the recognition that Midgley would receive for his work.[78] In fact, Midgley would receive three more honorary ACS medals in 1937, 1941 and 1942 before he died in 1943. However, it was the Nichols medal that "had extraordinary importance," said Midgley's lab assistant T.A. Boyd, "... for the effect it had a few years afterwards when the addition of tetraethyl lead to gasoline was under attack by those who claimed that it would poison the whole nation. When that time came, those in technological circles, having been informed about the development and sympathetic to it, demanded and got a factual rather than hysterical consideration of the case."[79]

<u>Early warnings about the 'malicious and creeping poison'</u>

When Thomas Midgley accepted the Nichols Medal in March, 1923, he had almost returned to normal after fighting a winter-long battle with lead poisoning. He and three other lab employees[80] had experienced "digestive derangements, subnormal body temperatures and reduced blood pressure" from handling tetraethyl lead.[81] Midgley was exposed routinely but had also been caught in at least two laboratory explosions. In July, 1922, when Kettering and Midgley gave a demonstration of tetraethyl lead production to visiting du Pont engineers, the process "got entirely out of hand, and spewed all over the place, and we had to get out," said Willis F. Harrington of du Pont.[82] On another occasion in 1922, Midgley lost control of the process and fragments of lead embedded in his eyes. According to a note to his doctor, he used mercury as an eyewash to dissolve it.[83]

Midgley did not attempt to hide his problem. He wrote to decline speaking offers at three ACS regional panels in January, 1923, excusing himself by noting: “After about a year’s work in organic lead I find that my lungs have been affected and that it is necessary to drop all work and get a large supply of fresh air.”[84]

Despite his condition, Midgley was remarkably nonchalant about the dangers of tetraethyl lead. Throughout 1922, as the first plans were made to develop tetraethyl lead, Midgley had received alarming letters from four of the world’s leading experts in the field: Robert Wilson of MIT, Reid Hunt of Harvard, Yandell Henderson of Yale and Charles Kraus of Pottsdam in Germany. Kraus had worked on tetraethyl lead for many years and called it "a creeping and malicious poison" that had killed a member of his dissertation committee. Hunt had informed Henderson about the work at G.M. because the Yale researcher was considered America's leading expert on automotive exhaust.[85] Another warning came from a lab director in the Public Health Service (P.H.S.), who had heard about tetraethyl lead and wrote an October, 1922 memo to the assistant surgeon general warning of a "serious menace to public health." Several other memos traded hands and in November, Surgeon General Hugh Cumming wrote to Pierre S. du Pont about the public health question. The Surgeon General's letter was referred to Thomas Midgley, who answered that the problem "has been given very serious consideration .. although no actual experimental data has been taken."[86]

Yet in a December 2, 1922 letter to A.W. Browne at Cornell, who had been contracted for some analytical work, Midgley said noted that tetraethyl lead was irritating to the skin and should not be breathed or taken in the mouth. “It would not surprise me if in the course of using tetraethyl lead for a year that some of your men would experience a slight case of painter's colic. This is nothing to worry about as several of our boys have it.”[87] While in Miami recovering from "colic," Midgley also wrote to an oil industry engineer that poisoning of the public was “almost impossible, as no one will repeatedly get their hands covered in gasoline containing tetraethyl lead -- it stings and burns... The exhaust does not contain enough lead to worry about, but no one knows what legislation might come into existence fostered by competition and fanatical health cranks."[88] Midgley believed this primarily because an early study of an engine testing center that had handled tetraethyl lead gasoline showed the lead content of a month's accumulation of dust in the garage was not enough to poison a person.[89] Yet he ignored warnings from experts and the evidence of his own health condition.

The question of how and why the warnings were ignored is important relative to what was to come. In April, 1924, two G.M.employees working to produce tetraethyl lead in a pilot plant died of lead poisoning. Several more died at du Pont's Deepwater, N.J. plant located in the southern part of the state across the bay from du Pont's headquarters in Wilmington, Del. And, in October, 1924, five sensational deaths from tetraethyl lead occurred at Standard's Bayway, N.J. plant located in northern New Jersey. In 1925, Midgley claimed that the hazard of tetraethyl lead "has been recognized and has been guarded against always to the full extent of the knowledge then available."[90] However, this statement reflects none of the disregard evident in earlier memos. When the two G.M. employees died in April, 1924 from the effects of lead, Midgley was said to be deeply grieved and "depressed to the point of giving up the whole tetraethyl lead program."[91] Yet a month or two later, Kettering spurred du Pont to double and triple production, which added the loss of four more workers.

Clearly, Midgley and Kettering had underestimated the severity of the poison and the difficulties inherent in building medium and large scale tetraethyl lead factories in Dayton, Ohio and Deepwater and Bayway, New Jersey. One factor in this oversight probably had to do with Kettering's research style. Kettering achieved results in areas where others had not because he challenged authority and was willing to attempt what the theoreticians and other experts said was impossible. This approach may have led him to disregard many of the warnings his group received from academics. Historian Stuart Leslie noted that Kettering's group had a similar problem in that they "grossly underestimated" the difficulty of converting a prototype copper-finned air-cooled engine into a reliable mass production article in the same 1923-25 time period. Subjective considerations such as "pride, jealousy and simple petulance" played a large role in determining the fate of the copper-cooled engine project, which was abandoned in 1925. Hidden motives and subjective evaluations "concealed behind technical jargon and well ordered equations" were perhaps part of the inevitable tensions in corporate research, Leslie said.[92]

Even before two of its employees died, G.M.had been searching for authoritative research consultants to help "refute any false propaganda," as Midgley put it. Both Yale and Harvard were approached, but no agreement was reached. Meanwhile, apparently unconvinced by Midgley's December 30, 1922 response to their inquiry, the P.H.S. decided that an investigation was necessary and contacted the Bureau of Mines. Midgley and Kettering were familiar with the Bureau of Mines petroleum experts based in Pittsburgh, Pennsylvania, and also asked them to perform a health study of Ethyl gasoline.

Bureau employees felt that the agency was in an uncomfortable position. In June, 1923, A.C. Fieldner, a bureau chemist, said that an investigation would be inadvisable: "The relations of the Bureau of Mines with some of the gasoline interests or motor interests will be imperiled regardless of our decision in the matter. The results promise to be so doubtful, the investigation will take so much time and cost so much money and chances for getting into trouble with some commercial interests are so great that I believe it is inadvisable to take on this investigation."[93] Yet in September, 1923, an agreement was finalized between G.M. Research Corp. and the Bureau of Mines in Pittsburgh. Ironically, the agreement was finalized the same week that the first worker died of lead poisoning in du Pont's large-scale tetraethyl lead production facility in Deepwater, N.J.[94]

The bureau agreed to Kettering's demand that it "refrain from giving out the usual press and progress reports during the course of the work, as [Kettering] feels that the newspapers are apt to give scare headlines and false impressions before we definitely know what the influence of the material will be." Kettering and the bureau were so worried about the press that all official correspondence used the trade name Ethyl rather than the word "lead" to avoid leaks to the newspapers, "as this term is apt to prejudice somewhat against its use," according to the superintendent of the Pittsburgh field station.[95]

The actual tests began in the fall of 1923 with a small Delco motor provided by G.M..

Various animals were exposed to Ethyl gasoline exhaust from the motor, and five puppies were born in the test chamber and returned there with their mother each day "without harm of any kind," Boyd later wrote. The dogs were called the "Ethyl Gas Hounds."[96] The investigation continued through July, 1924 and was first reported in the news media on November 1, 1924. This report, and any other, would have been approved by G.M. because the contract between G.M. and the bureau, signed in June, 1924, specified that manuscripts were to be submitted to G.M. "for comment, criticism and approval."[97]

The arrangements with the bureau provide a contrast with the attitude expressed by Midgley when he approached Harvard Medical School in 1923: "We would of course render this assistance without any strings attached whatever to the full understanding it is for the purpose of increasing the total of human knowledge and with no ulterior motive in mind whatsoever. Freedom to publish all results and everything also would of course be quite the same as in other pieces of academic research work."[98] Yet other researchers did not believe such freedom would be permitted. As research proceeded at the Bureau of Mines, R.R. Sayers of the P.H.S. wrote Yandell Henderson at Yale in 1924 asking to join their research effort. But Henderson pointedly rejected the offer, noting: "I should want a greater degree of freedom of investigation and funding -- in view of the immense public, sanitary and industrial questions involved -- than the subordinate relations which you suggest would allow."[99]

Henderson was not the only person with misgivings. On June 23, 1924, G.M. president Alfred Sloan, "gravely concerned about the poison hazard," and reeling from two deaths in Dayton and one in Deepwater, approved the formation of a medical committee with W.G. Thompson of Cornell University, a consulting physician to Standard Oil, as chairman. A few days later, Irenee du Pont wrote to Sloan saying that the development of tetraethyl lead "may be killed by a better substitute or because of its poisonous character or because of its action on the engine."[100] The medical committee issued a report described as negative and highly cautionary on August 20, 1924 and Irenee du Pont reassured Sloan: "I have read the doctors report and am not disturbed by the severity of the findings." Nitroglycerin was even more hazardous to make, and lead dust from car exhaust would be only a fraction of that from erosion of paint, he said.[101] The committee also began a second research project at Columbia University that proved controversial in April, 1925, as researchers and university authorities disagreed on the nature of the research animal deaths from tetraethyl lead treated gasoline and the extent of poisoning of lab workers themselves.

Thus, even as G.M. and Standard were about to form a partnership and greatly expand Ethyl's role in the gasoline market, its fate was quite uncertain. Health research supporting the decision to begin mass marketing was shallow and overtly manipulated. And yet G.M., Standard and du Pont proceeded. Why? One clue is found in a note sent from Midgley to Kettering on March 2, 1923, as he recuperated from lead poisoning.

> The way I feel about the Ethyl Gas situation is about as follows: It looks as though we could count on a minimum of 20 percent of the gas sold in the country if we advertise and go after the business -- this at three cent gross to us from each gallon sold. I think we ought to go after it as soon as we can without being too hasty[102] ...

With gasoline sales around six billion gallons per year, 20 percent would come to about 1.2 billion gallons, and three cents gross would represent $36 million. With the cost of production and distribution running less than one cent per gallon of treated gasoline, more than two thirds of the $36 million would be annual gross profit. Of course, within a decade 80 percent of the then 12 billion gallon market used Ethyl, for an annual gross of almost $300 million.

Manufacturing the New Product

Three manufacturing efforts got under way in 1923 and 1924 to bring large volumes of tetraethyl lead to market. The first was a small operation in Dayton, Ohio, which made 160 gallons of tetraethyl lead each day and shipped it out in one-liter bottles. Each liter would treat about 300 gallons of gasoline. When the two workers on the assembly line packing the bottles died in April, 1924, the line was shut down. Kettering later blamed the lack of safety on the workers themselves. “We could not get this across to the boys,” he said. “We put watchmen in at the plant, and they used to snap the stuff [pure tetraethyl lead] at each other, and throw it at each other, and they were saying that they were sissies. They did not realize what they were working with."[103]

The second and by far the largest manufacturing operation was built at du Pont's dyestuffs division in Deepwater, N.J., across the bay from Wilmington, Delaware. Du Pont began with a 100 gallon per day "bromine" process unit in August of 1923, and increased production in the summer of 1924 to 700 gallons per day. A second 1,000 gallon per day unit using Standard's "chloride" process began operations in January, 1925. The first du Pont worker died in September, 1923; three more died over the summer and fall of 1924 when bromine unit production was stepped up; and four more died in the winter of 1925 in the new chloride unit. Workers who were aware of the effects of tetraethyl lead called the factory the "House of Butterflies" for the hallucinations they experienced.

The third and smallest manufacturing unit was a 100 gallon per day "semi-works" built in the summer of 1924 at the Standard Oil of N.J. refinery in Bayway, N.J. It began operations in September, 1924 and within two months, the violently insanity and death of five workers set off a storm of controversy.

Conclusion

The idea that the development of Ethyl leaded gasoline is exemplary of "a beautiful piece of pure research" might be reconsidered in light of new information. Certainly the initial insight into the antiknock value of iodine, which came not from its color but some intrinsic property, represents the isolation of the essential fact from the encumbering theory, as has been noted by Hughes and other historians. Leslie, Robert and other lead us to expect steady progress through systematic testing of all available compounds toward an eventual solution to the knock problem. Instead, the available documents give a rather different picture. First,the knock problem already had several widely recognized solutions before and after tetraethyl lead was discovered, and research on these fuel constituents continued through the mid-1920s. Secondly, Kettering and

Midgley showed a clear preference for the low percentage class "pill" solution. Third, the research effort was incredibly haphazard and ad hoc. The anti-knock fuel research between 1919 and 1921 was sandwiched between research on producing cheap alcohol from cellulose and petroleum olefins as G.M.'s gateway into the fuel of the future. Which project had priority is difficult to determine without detailed documentation, but clearly Kettering and Midgley's progression from iodine to selenium, then tellurium, and finally lead as "the" solution is a vast oversimplification.

There was not one solution to one problem; instead, there were many potential solutions to a variety of problems in a range of conceptual frameworks -- all well known to Midgley and Kettering. Why they later claimed that nothing worked but tetraethyl lead (as we will see) is difficult to fathom. G.M.'s own research showed that the alternatives, especially ethyl alcohol blends, were technically quite practical. It is apparent that Kettering and Midgley deliberately avoided informing the public about the research directions. It would be consistent with the attitudes of the times if they felt that they had an absolute right to avoid technical debate, although as we shall see, more candor was expected by the public, the government and the news media.

In addition, the overarching frame of the problem, as historian Leslie noted, was the exhaustion of petroleum supplies within two to three decades, which had been the automotive industry's biggest concern. Kettering's idea of improving existing gasoline to run in high compression engines does not make sense if lower and lower grades of crude petroleum would be the only fuels available in the future. The conclusion of Wescott's 1936 history that the original motivation for the antiknock research was to pave the way for alternative fuels seems to be well corroborated by other documents.

With alternatives in existence and the possible long term need for them to replace petroleum, why did G.M. persist with a well known poison? It is difficult to account for the premium placed by Kettering and others on the prestige invested in particular products. Kettering's research style, which might be described as headstrong and uncompromising, was probably one factor. Also, as du Pont's manufacturing expanded and Standard's gasoline markets began to be developed, the momentum of financial investment and institutional prestige began to accumulate. By the time the controversy became public, the companies had made an enormous investment. Then too, Midgley's rough calculations showed that the use of tetraethyl lead was appealing from an economic point of view because production costs were low and profits were high.

Historian George Basalla once said: "The history of technology would be written far differently if, instead of concentrating on the winning innovations perpetuated by selection and replication, we were to make a diligent search for viable alternatives to those innovations."[104] Tetraethyl lead was a winning invention, and history has followed success. Ethyl leaded gasoline worked, it was cheap to make, it was easy to distribute and it was profitable to sell. This chapter has shown, however, that Kettering, Boyd and Midgley were well aware that a patented blend of benzene or alcohol or other octane boosters would have also been technically viable. Whether the history of automotive technology would have been significantly changed had tetraethyl lead been banned by the P.H.S. is an open question.

The original special motive for fuel research work was not only aimed at an antiknock additive but also at long-term survival for the automotive industry in an oil-short future. Ongoing investigations of alternative fuels could be interpreted as a sensible long-term business proposition, rather than, as historian Stuart Leslie interpreted it, the pursuit of a "will o' the wisp."

---

1. Thomas P. Hughes, "Inventors: The Problems They Choose, The Ideas They Have and the Inventions They Make," in eds., Patrick Kelly, et al., Technological Innovation: A Critical Review of Current Knowledge (San Francisco, San Francisco Press, Inc., 1979), p. 177.

2. T.A. Boyd, Professional Amateur (New York: E.P. Dutton, 1957); Rosamond Young, Boss Ket: A Life of Charles Kettering, (New York: Longmans Green & Co., 1961); Joseph C. Robert, Ethyl, A History of the Corporation and the People Who Made It (Charlottesville, Va.: University Press of Virginia, 1983); Harold F. Williamson, et al., The American Petroleum Industry, The Age of Energy, 1899-1959 (Evanston, Ill.: Northwestern University Press, 1963).

3. John M. Staudenmaier, Technology's Storytellers: Reweaving the human fabric (Cambridge, Mass.: Society for the History of Technology, 1985), p. 175.

4. Carroll Pursell, "The History of Technology as a Source of Appropriate Technology," The Public Historian 1, Vol. 1 (Winter, 1979), pp. 15 - 22.

5. James Ridgeway, Powering Civilization (New York: Pantheon, 1982), p. 90.

6. Free Alcohol Hearings, US Senate Finance Committee, 1906, Statement of James S. Capen, Detroit Board of Commerce, p. 59. Capen also said: "Alcohol can be produced from any old thing that has sugar or starch in it, and once given our American inventor a chance at a market as great as this, in a very short time he will have processes that will do away with any fear of scarcity of fuel." Capin said alcohol was "preferable to gasoline" because it was easier to make and harder to control than gasoline, and thus artificial shortages could not raise the price in the future. Capen also said alcohol was much safer than gasoline, as well as being "absolutely clean and sanitary."

7. U.S. Dept. of Commerce, "World Petroleum Production 1900-1925," cited in Ludwell Denny, We Fight For Oil (NY: Knopf, 1928), p. 279.

8. Scientific American, Dec. 4, 1920, p. 570. Scientific American believed these figures called for alternative fuels: "The use of alcohol as a motor fuel will probably increase, as well as the use of benzene produced from coal tar."

9. Anthony Sampson, The Seven Sisters (New York: Viking 1975), p. 60

10. John M. Blair, The Control of Oil, (New York: Random House, 1976), p. 32, citing 66th Congress, 2nd Session, Senate Document No. 272. Romanian fields and refineries had been sabotaged prior to a German invasion in 1917, and had to be rebuilt.

11. Blair, The Control of Oil p. 32.

12. Denny, We Fight For Oil,p.274; also see E.H. Davenport and S.R. Cooke: The Oil Trusts and Anglo-American Relations, London 1923.

13. "Declining Supply of Motor Fuel," Scientific American, Mar. 8, 1919, p. 220.

14. Charles F. Kettering, "The Story of Ethyl Gasoline," Experimental draft based on interviews in 1946, GMI Alumni Foundation Collection of Industrial History, Flint, Mich. (Hereafter cited as GMI).

15. T. A. Boyd, The Early History of Ethyl Gasoline, Report OC-83, Project # 11-3, Research Laboratory Division, GM Corp., Detroit Michigan, (unpublished) June 8, 1943, GMI, p. 2. (Hereafter cited as Boyd, Early History).

16. Hughes, "Inventors and the Problems They Chose," p. 177.

17. As an interesting sidelight, Kettering was so adamant about the value of the his research plan that he believed that Henry Ricardo copied his plan when Ricardo began fuel research for the British air force in 1918. In Boyd's Early History, p. 27., an early draft says "Ricardo used" Kettering's Bureau of Mines report. Pencilled in between Ricardo and the word "used" are the words: "may possibly have."

18. It was called McCook airfield at the time.

19. BTU stands for British Thermal Unit, the amount of energy it takes to raise one pound of water one degree Fahrenheit. It is the extra oxygen in alcohol and the relatively fewer carbon molecules that make it a lower-BTU fuel. Some aviation engineers believe that the presence of oxygen should be considered an advantage relative to moderately high altitude flight for piston aircraft.

20. The correspondence between performance and heat value is not linear. A pure alcohol engine has what Riccardo termed a "higher useful compression ratio" and will deliver the same power at the same fuel consumption rate as a comparable gasoline engine with a lower useful compression ratio. It is possible that Midgley was not aware of this; however, the basic thrust of his research was to create a high BTU fuel that could withstand high compression. This initial

bias toward high BTU aviation fuels was one reason why alcohol was later discounted as an automotive fuel in the U.S.

21. Application Serial No. 210,687 filed Jan, 7, 1918; Patent No. 1,296,832 issued Mar. 11, 1919, assigned to GM Research Corp.; Also, Chemical Abstracts 13, (1919), p. 1636. Ironically, a patent issued the same day to another researcher was for a 50 percent blend of ethyl alcohol and gasoline with 2 percent castor oil as a binder. (Patent No. 1,296,902).

22. Patent application Serial No. 256,874, filed Oct. 4, 1918, Patent No. 1,491,998 issued April 29, 1924.

23. "A Report of Fuel Research by the Research Division of the Dayton Metal Products Co. and the U.S. Bureau of Mines," July 27,1918, Midgley unprocessed files, GMI.

24. Ibid, cited in Boyd, Early History. Boyd said that this showed the advantages of high compression "were pretty clearly understood at the outset."

25. F.O. Clements to H.E. Talbott, Feb. 4, 1919, Midgley unprocessed files, GMI. It was not clear whether Clements meant this as a criticism of Kettering or of the organization as a whole.

26. Boyd, Early History, p. 41.

27. Ibid, p. 41.

28. Ibid, p. 61.

29. "Report of Fuel Research Work," Research Division, Dayton Metal Products Co., US Bureau of Mines, July 27, 1918, p. 11, Midgley unprocessed, GMI.

30. Trial transcript, p. 3500, U.S. v. v du Pont. The Dept. of Justice would later cite these contacts as evidence of anti-trust activity by the three giant corporations in the 1953 anti-trust suit. However, Kettering insisted that his motive was scientific. The federal courts agreed that scientific contacts and "concerted action" did not necessarily constitute conspiracy to restrain trade and violate the Sherman Anti-Trust Act. Also, it seems unlikely that at this stage of developments Howard could actually expect any one antiknock to dominate the fuel market; his rhetoric was obviously designed to interest Standard.

31. Charles F. Kettering, "Studying the Knocks,: How a Closer Knowledge of What Goes on In

the Cylinder Might Solve the Problems of Fuel Supply," Scientific American, Oct. 11, 1919, p. 364.

32. For example, alcohol ran the first internal combustion engine, built in 1826 in Connecticut, and Carl Banz's first horseless carriage experiments in Germany in 1860, according to Lyle Cummins, Internal Fire (Warrenton, Pa.: Society of Automotive Engineers, 1989), p. 81.; also, Horst Hardenberg, Samuel Morey and his Atmospheric Engine SP 922, (Warrendale, Pa.: Society of Automotive Engineers, Feb. 1992), p. 51.

33. Scientific American, April 13, 1918, p. 339.

34. H.B. Dixon, "Researches on Alcohol as an Engine Fuel," Society of Automotive Engineers Journal, Dec. 1920, p. 521. (Hereafter cited as SAE Journal).

35. Scientific American, Dec. 11, 1920 p. 593.

36. Stanton P. Nickerson, "Tetraethyl Lead: A Product of American Research," Journal of Chemical Education, Vol. 31 p. 560 Nov. 1954, reprinted by the Ethyl Corp.

37. Application Serial No. 417,126, filed Oct. 15, 1920, Patent No. 1,501,568 issued July 16, 1924.

38. Boyd, Early History pp. 75-76.

39. Kettering to Midgley, Sept. 14, 1920, Midgley files, unprocessed, GMI.

40. For example, Stuart Leslie, Boss Kettering, (New York: Columbia University Press, 1983), p. 158.

41. Testimony of Charles F. Kettering, Trial transcript p. 3573, US v. du Pont.

42. Boyd, Early History, p. 60-61, also p. 70.

43. Leslie, Boss Kettering , p. 155. Ethyl alcohol was "income" rather than "capital" because it could be produced from renewable resources.

44. The report is not found in archives; Boyd recalled it in the Early History, p. 54.

45. Boyd, Early History p. 54. That is, crediting alcohol with only two thirds the BTU value as gasoline, which does not take into consideration possible increases in compression ratio and efficiency.

46. Large-scale production of benzene was questionable. Even if all the coal mined in the U.S. in 1920 were used to supply benzene, only about 900 million gallons, or one-fifth of the U.S. gasoline supply would be replaced, he said.

47. T.A. Boyd, "Motor Fuel From Vegetation," Journal of Industrial and Chemical Engineering 13, No. 9 (Sept. 1921), pp. 836 - 841.

48. C.F. Kettering, "The Fuel Problem," undated, probably 1921, Kettering collection unprocessed, GMI.

49. Leslie, Boss Kettering, p. 156.

50. Zimmerschied to Kettering, Feb. 27, 1920; Kettering to Zimmerschied, March 3, 1920, Kettering collection, GMI. Note that carburetors had been built with lacquered cork floats before this time, which was not a problem with gasoline. However, alcohol was a solvent for the lacquer. Therefore, GM switched to metal carburetor floats to accommodate the new international fuel blends.

51. Application Serial No. 362,139, Patent No. 1578201, issued Mar. 23, 1926. The patent covers blending alcohol and unsaturated hydrocarbons, particularly olefins formed during the cracking process.

52. Harold Hibbert, "The Role of the Chemist in Relation to the Future Supply of Liquid Fuel," Journal of Industrial and Chemical Engineering 13, No. 9 (Sept. 1921) p. 841.

53. Boyd to Midgley, July 8, 1920, Midgley unprocessed files, GMI.

54. This is an important point in technical discussions. Many who object to alcohol fuel, ostensibly on technical grounds, will omit any mention of the possibility of a "binder." Such was the case, for example, in the American Petroleum Institutes attacks on the technical qualities of alcohol blends in the early 1930s.

55. "The Discussion" transcript of SAE meeting discussion, Indianapolis, Oct. 1921. Midgley unprocessed files, GMI.

56. Thomas Midgley, "Discussion of papers at semi-annual meeting," SAE Journal, Oct. 1921, p. 269.

57. F.O. Clements to staff, Sept. 9, 1921, Midgley unprocessed files, GMI.

58. Midgley to Kettering, May 23, 1922, Factory Correspondence, Midgley unprocessed files, GMI.

59. Thomas A. Midgley and T.A. Boyd, "Detonation Characteristics of Some Blended Motor Fuels," SAE Journal, June 1922, page 451. Note: italics indicate a section used at the oral presentation at a June 1922 SAE meeting but not published in the SAE paper; oral presentation from Midgley unprocessed files, GMI.

60. Morrison to Midgley, July 25, 1922, Kettering collection, unprocessed Midgley files, GMI.

61. Thomas Midgley and Thomas Boyd, "The Application of Chemistry to the Conservation of Motor Fuels," Industrial and Engineering Chemistry, Sept. 1922, p. 850.

62. N. P. Wescott, Origins and Early History of the Tetraethyl Lead Business, June 9, 1936, Du Pont Corp. Report No. D-1013, Longwood ms group 10, Series A, 418-426, GM Anti-Trust Suit, Hagley Museum & Library, Wilmington, Del., p. 4.

63. Midgley to Lt. B.G. Leighton, Mar. 16, 1923, Kettering collection, Unprocessed Midgley files, GMI.

64. "New Auto, Fuel to Save Costs Are Announced," United Press Service, Aug. 6, 1925, Kettering collection press clipbook No. 2, GMI.

65. American Petroleum Institute Industries Committee memo, April 15, 1933; Box 52, Pew collection, Hagley Museum & Library, Wilmington, Del. No record of the experiment is found in the archives of the Baltimore Sun, in Society of Automotive Engineers papers, or in American Chemical Society papers. The first mention in any public document is 1939, in a broadly circulated American Petroleum Institute speech by Conger Reynolds against alcohol fuel to be found in the API archives. The price of alcohol at 20 cents per gallon following Prohibition was apparently a factor in the decision to try ethyl alcohol blends. Details of the experiment -- such as the precautions taken with water, the percentage of alcohol in the blend, or the use of blending agents -- have never been revealed, and no internal or external reports are available. It is difficult to know whether the "experiment" was a deliberate hoax or a botched local fuel blending

operation.

66. "To Learn the Truth about Leaded Gas," Literary Digest , April 18, 1925, p. 17.

67. "Scientists to Pass on Tetra-Ethyl Gas," New York Times, May 20, 1925, p. 1.

68. The Story of Ethyl Gasoline, pamphlet (New York: Ethyl Gasoline Corp., 1927), American Petroleum Institute Library, Washington, D.C.

69. Rosamond Young, Boss Ket (New York: Longmans, Green & Co., 1961).

70. John C. Lane of Ethyl Corp., "Gasoline and Other Motor Fuels," Encyclopedia of Chemical Technology, (New York: John Wiley & Sons, 1980), p. 656. The crucial series of tests that were run between August 25 and December 7, 1921 involved 16 elements. Some of these were prepared with different solvents, so that a total of 24 test compounds were run. Dozens of trials were run on each of these under various conditions. This is probably what Boyd had in mind when he said 143 was "too much." If Midgley kept count of every test he ever ran over the seven year period, the number 14,991 might not be questionable. The source of the confusion is simply that the actual day-to-day test diaries used by Midgley, Boyd, Hochwalt and others have not been turned over by Ethyl or GM to the public GMI archive.

71. Rosamond McPherson Young, Boss Ket : A Life of Charles F. Kettering (New York, Longmans, Green, 1961); Joseph C. Robert, Ethyl, A History of the Corporation and the People who Made It (Charlottesville, Va.: University Press of Virginia, 1983). Standard Oil and General Motors officials outside the research labs did not want to use the name Ethyl for the company or the product in 1924, but did so to accommodate Kettering and Midgley.

72. Ferris E. Hurd, G.M. Attorney, summary argument, US v du Pont, p. 7986.

73. Enthusiasm was so contagious that even William J. Hale, the prestigious Dow Chemical Co. chemist, offered in 1923 to bid on production of tetraethyl lead. Hale was not oblivious to the fact that Dow's main rival, du Pont, was at this point a partial owner of General Motors; but he believed that a process based on magnesium, which Dow had in abundance, would be cheaper for making tetraethyl lead. Kettering wrote him: "Don't go to too much trouble" in preparing a bid. Hale bid $4 a pound, or twice what du Pont had contracted for. Ironically, 11 years later

Hale would become the Ethyl Corp.'s chief antagonist, denouncing "poison-spreading gasoline" and promoting 10 percent ethyl alcohol as the safe anti-knock alternative. See Hal Bernton et al., The Forbidden Fuel, p. 14.

74. Midgley to Joseph L. Wood, The Orange Tip Co., Feb. 9, 1922. About 50 other identical letters are found in the Kettering collection, unprocessed Midgley files, GMI.

75. Midgley to Kettering, "Summary of Present Situation on Antiknock Material," Nov. 20, 1922, Factory Correspondence, unprocessed Midgley files, GMI.

76. Application Serial No. 553,040 filed April 15, 1922, Patent No. 1,605,663 assigned Nov. 2, 1926; Application No. 592,435 filed Oct. 4, 1922, Patent 1,492,953 issued July 20, 1926.

77. Thomas Midgley, "The Chemical Control of Gaseous Detonation with Particular, Reference to the Internal Combustion Engine," Industrial and Engineering Chemistry, Oct., 1922.

78. Boyd, Early History, p. 193.

79. Ibid, p. 179.

80. Listed in Early History as Hochwalt, Calingaert and Mead (no first names).

81. Boyd, Early History, p. 192.

82. US vs. du Pont, testimony of W.F. Harrington, p. 3814,

83. Midgley to Dr. R.L. Allen, Sept. 9, 1922, Unprocessed Midgley files, GMI.

84. Midgley to H.N. Gilbert, Jan 19, 1923, Unprocessed Midgley files, GMI.

85. Boyd, Early History, p. 164 - 170.

86. William M. Clark to A. M. Stimson, Oct. 11, 1922, A. M. Stimson to R. N. Dyer, Oct. 13, 1922, Dyer to Surgeon General, Oct. 18, 1922, N. Roberts to Surgeon General, Nov. 13, 1922, H.S. Cumming to Pierre Du Pont Dec. 20, 1922, and Thomas Midgley to Cumming, Dec. 30, 1922, all in US Public Health Service Record Group 90, National Archives, Washington, D.C.

87. Midgley to A.W. Browne, Dec. 2, 1922, Unprocessed Midgley files, GMI.

88. Midgley to G.A. Round, Vacuum Oil Co., Feb. 14, 1923, unprocessed Midgley files, GMI.

89. Charles F. Kettering, "The Story of Ethyl Gasoline: Growth History of a New Product, Experimental Draft," unpublished manuscript, Dec. 1946, GMI. Kettering also mentions the

Bureau of Mines study and the consulting work of Dr. Robert A. Kehoe of the University of Cincinatti. He does not mention Krause, Hunt or Wilson.

90. Thomas Midgley, "Tetraethyl Lead Poison Hazards," Industrial & Engineering Chemistry, Aug. 1925, p. 827.

91. Joseph C. Robert, Ethyl, p. 121

92. Stuart W. Leslie, "Charles F. Kettering and the Copper Cooled Engine," Technology & Culture 20, No. 4 (Oct 1979), p. 752.

93. Joseph A. Pratt, "Letting the Grandchildren Do It: Environmental Planning During the Ascent of Oil as the Major Energy Source," The Public Historian 2, No. 4 (Fall, 1980), p. 35, citing correspondence between R.R. Sayers and A.C. Fieldner, file 182, General Classified Files 1923, US Bureau of Mines, National Archives, Washington, D.C.

94. Frank W. Durr, operator, from Wescott, "Origins and Early History," p. D1.

95. David Rosner and Gerald Markowitz, "A Gift of God?" in Dying For Work: Workers Safety and Health in 20th Century America, (Bloomington, Indiana: Indiana University Press, 1989), p. 123. The authors describe in detail the progress of the research work and the correspondence between GM and the Bureau. Citations here include A.C. Fieldner to Dr. Bain, Sept. 24, 1923; S.C. Lind to Fieldner, Nov. 3, 1923; and the agreement between the Dept. of Interior and General Motors; all in Record Group .70, 101869, File 725, US Bureau of Mines, National Archives, Washington DC.

96. Boyd, Early History, p. 268.

97. Rosner & Markowitz, "A Gift of God?" p. 124.

98. Verbatim from Joseph C. Robert, p. 121. Run-on nonsensical context may be that of Robert and not Midgley.

99. Henderson to Sayers, Sept. 27, 1924, Record Group 70, 101869, File 725, Bureau of Mines, National Archives. Cited in Rosner & Markowitz, Dying for Work., p 125.

100. Irenee du Pont to Sloan, June 28, 1924, NP Wescott, "Origins and Early History," p. 21

101. Irenee du Pont to Alfred Sloan, Aug 29, 1924, included as appendix to N.P. Wescott,

"Origins and Early History," B-3. Note that the medical report itself, like many original documents referred to in GM reports, is not available in the archives.

102. "Midge" to "My dear Boss:" March 2, 1923, Factory Correspondence, Kettering Collection, unprocessed Midgley material, GMI.

103. Testimony of Charles F. Kettering, US v. Du Pont, p. 3565. The idea that workers were to blame for poisoning deaths would be frequently repeated by Kettering, Midgley and Standard officials, although not by du Pont chemists.

104. George Basalla, The Evolution of Technology, (Cambridge: Cambridge University Press, 1988), p. 204.

CHAPTER FOUR
THE NEWS FROM BAYWAY

William McSweeny left work early feeling queasy and frightened as he stumbled home to 315 Fulton Street from the Standard Oil refinery in Bayway, New Jersey, just west of Staten Island. The sweet smell of a new gasoline additive called Ethyl spiced the dry and dusty air at the plant that Tuesday afternoon in late October of 1924 . McSweeny worked in a building where lead, sodium and ethyl chloride reacted to form the additive in a large tubular vat. The vat tumbled on rollers so that the ingredients could be mixed. Then McSweeny and fellow workers distilled a thick, clear liquid from the top of the vat and dumped a gummy grey residue from the bottom through an open grid in the factory floor. McSweeny and the other men would push the lead residue through the grid with pikes, boots and their own hands. McSweeny also worked on the bottling line where he poured the liquid into two-liter containers. He must have been puzzled at how quickly his skin absorbed the thick clear liquid and the strange hallucinations it sometimes caused.

McSweeny had come to America to see his brother and to get away from Ireland's "troubles" with the British. As a young brigadier general in the Irish Free State Army, he had seen enough fighting. Perhaps he felt lucky to have survived. Ironically, he would be the first refinery worker to feel the effects of Ethyl lead, and one of the first victims of the most controversial public health crisis of the 1920s.

After what was probably an uneasy night's sleep, McSweeny awoke Wednesday morning, October 22, 1924, shaking uncontrollably. He was deluded and fearful, witnesses said. When his hallucinations became violent, his sister-in-law called for a policeman, who had to call out to neighborhood men for help. It took three of them, plus the policeman, to wrestle McSweeny into a police van, screaming and writhing. He must have seemed suddenly possessed to the bewildered neighbors who stood in the street gawking as the van lurched off to the hospital. The next day at the same Bayway refinery, a handsome young Swede named Ernest Oelgert began shrieking. He could see three hooded figures. "They're coming after me," he howled, scrambling across the factory floor in terror. Workers stuffed Oelgert into a straitjacket and took him to a hospital.

The plant foreman brought in a doctor to look at the remaining 43 workers. Two more men who complained of a strange sickness were sent home. Friday morning, one of them jumped headlong from the second story window of his home. The other began threatening his family. Again, police and neighbors had to fight him into an ambulance. A fifth man checked into the local hospital with the same strange illness. On Saturday, all five were taken to New York city's Reconstruction Hospital, which specialized in what were called "occupational diseases." Oelgert died there Saturday evening, convulsing in his straitjacket, "violently insane," his blood literally boiling from an unknown gas. The Elizabeth, New Jersey medical examiner who had been called in to examine Oelgert's blue-black body was horrified. He contacted the Union County New Jersey district attorney, who began an investigation.

Once public officials stepped in, news of the incident spread. On Sunday, October 26, reporters from New York City's major newspapers raced to cover an unusual incident across the Hudson River. The incident occurred on what might have been called a slow news day: ten days away from the 1924 presidential elections, a collection of political barbs and run of the mill police stories were the only competition for the strange mystery gas that killed workers by driving them crazy. The articles appeared the next day, Monday, October 27, 1924, on the front pages of the major New York City daily newspapers -- the New York Times, Joseph Pulitzer's World, the newly merged Herald-Tribune, the newly created Daily News, the old evening Sun, the Brooklyn Daily Eagle and the city's sensational, best-selling paper, William Randolph Hearst's Evening Journal. Within three days, as more workers died, news articles about the strange sickness at the Standard refinery ran on the front pages of newspapers across the country.

First Reports of the Sudden Disaster

No one knows how reporters first learned about something unusual happening around the Standard Oil refinery. Perhaps a public official or a sick worker's relative called, or perhaps a beat reporter heard about it on routine assignment. It would have been unusual if reporters had missed it. Bayway and Elizabeth N.J. were just across New York harbor from the world's largest and most competitive newspaper market, and the story, as an internal du Pont history said later, was a "natural."[1]

What they learned was that five men who worked at the refinery had to be dragged away from home and work in screaming fits, having gone barking, fighting mad. One died Saturday. Reporters questioned county officials and local hospital physicians who did not understand the strange refinery worker's sickness. The officials had no idea what kind of poison was involved, although they knew it was connected with the refinery. The refinery managers had no comment, and referred all questions "to 26 Broadway," Standard's international headquarters. Reporters managed to track down the chief chemist of the Bayway works, Dr. Matthew D. Mann. When asked for a comment by a pair of reporters from the Times and World, Mann went into another room to think it over for about 15 minutes. He returned with the following written statement: "These men probably went insane because they worked too hard." The World carried the statement verbatim, and the Times found the statement so extraordinary that Mann was quoted in a headline on the front page. The reporters probably did not know that Mann himself was suffering from the same "mystery gas" and had probably made the statement while in a delirious state of mind.[2] Standard's consulting physician at Reconstruction Hospital, Dr. W. G. Thompson, claimed that he had no knowledge of what had happened but simultaneously insisted: "Nothing ought to be said about this matter in the public interest."[3]

Oelgert's father vowed: "The Standard Oil will hear more of this." He told the Times that doctors had assured Oelgert that he couldn't be hurt working at the plant. "They said he'd have to get used to it," Oelgert's father said.[4] Enterprising Times and World reporters found others who worked at the plant who told a slightly different story: volunteers for the higher paying jobs knew they would be working in what the workers openly called the "loony gas building." Other workers frequently gave them farewells with mock-solemnity, seriocomic funerals and jokes about going insane.

The headlines on the first day indicated a high level of alarm:

• "Odd Gas Kills One, Makes Four Insane," read the Times headline.

• "Gas Madness Stalks Plant; 2 Die, 3 Crazed," read the headline in the World, which scooped the Times on the second death, probably by keeping a reporter at the hospital to relay any early-morning developments.

• The Herald Tribune headlined a story "Mystery Gas Crazes 12 in Laboratory," following up on the new additions to the hospital sick list that the Times and World missed.

• The Brooklyn Daily Eagle reported on the "Gas Mystery Probe," focusing on an interview with Oelgert's attending physician.

• Hearst's afternoon Journal, well known for "yellow journalism," published an article heavily plagiarized from other newspapers that featured an apparently exclusive interview with Oelgert's undertaker who described the blue and black bruises on the body.

• The aging afternoon Sun wrote: "Company Denies Negligence Led to Gas Deaths," primarily quoting Standard Oil's Thompson.

Other newspapers, such as the Daily News and the Daily Worker, missed the story the first day, and like the Eagle, the Journal and the Sun, followed the three major papers in a weak and passive role during most of the controversy.

Although he was the first of the five Bayway employees to show the effects of the mystery gas,[5] McSweeny fought the poison for eight days. He died on Wednesday, the 29th. Three more workers, for a total of five, died by Friday, and 32 more were hospitalized.

What exactly was the mystery gas? Standard wasn't saying, and the garbled first-day accounts quoted Union County officials as saying it was "ethylene" and "ethyl chlorid" (instead of *chloride*). The Times account included a paragraph that cautioned that ethylene gas was an unlikely poison, as it had been proven safe as an anaesthetic at the University of Chicago. This attention to scientific detail is consistent with Times editor Carr Van Anda's reputation as an expert in scientific matters. The World and most other papers simply reported "ethylene" gas was the cause of the "gas madness." The Herald Tribune reported "ethylchlorid," and scientifically, this was the closest any of the newspapers would come to the truth on the first day of the crisis.[6] Technically, the substance in question was tetraethyl lead being manufactured through a process employing ethyl chloride. (An alternative but less efficient process using ethyl bromide was employed at the du Pont facility in southern New Jersey).

Monday morning, as gates were locked and confused silence reigned at the Bayway refinery, Thompson spoke with reporters at Standard's headquarters at 26 Broadway in downtown New York. Thompson confirmed that two men were dead and five others seriously ill as a result of chemical "experiments" at Bayway. Although Thompson said that the chemical poison was some kind of gasoline additive, he could not tell reporters its exact nature, nor could Standard tell local physicians. Thompson also said Standard "has given a great deal of attention to safety measures and no expense has ever been spared to safeguard employees against illness or accidents."[7] The clear impression was that Thompson had no way of knowing about the process. However, as noted in Chapter Three, Thompson was in fact the chairman of a medical committee of company physicians from Standard, du Pont and G.M. who were specifically charged with ensuring worker safety in connection with the previous secret deaths of workers at G.M.'s Dayton, Ohio plant and du Pont's Deepwater, New Jersey Ethyl gasoline plant.[8]

Reporters returning from Thompson's press conference might well have been disappointed with the small amount of information he provided. Then a new angle on the story emerged from a labor group called the Workers Health Bureau, located uptown at 799 Broadway. It turned out that Yandell Henderson, a Yale University professor who was an expert on World War I gas poisoning and auto exhaust, knew something about the mystery gas. Henderson had read that morning of the refinery deaths and sent a telegram to the Workers Health Bureau, which in turn alerted newspapers. The mystery gas was called "tetraethyl lead," and it was "one of the most dangerous things in the country today," the Times quoted Henderson as saying in its Tuesday, October 28 issue. While other newspapers, including the World, were vague about the exact health threat, the Times provided ample space for

Henderson's ideas. Since tetraethyl lead was already being sold around the country, Henderson said, an incident could happen on the streets of Manhattan any day. A car with problems on Fifth Avenue could "release a quantity of gas with the lead mixture, (and) it would be likely to cause gas poisoning and mania to persons along the avenue." Similarly, the escape of such gas fumes in a garage "probably would have disastrous results on those who breathed it." The danger of mania appeared to be quite different from anything ever encountered before. Someone exposed to the gas would not know it from the odor, and the symptoms would not occur immediately. As a result, Henderson said, a person "does not know his danger and the damage may take place later."[9]

Henderson's initially inaccurate view had been formed by G.M. 's original plans to use tetraethyl lead at full strength in a second gas tank to be installed in every car,[10] and he was not familiar with the exact nature of the gradual impacts on people exposed to relatively small amounts of lead. Two days later, on October 30, Henderson revised his view of the immediate danger, and the World quoted him as saying that a ton of lead powder would be discharged on Fifth Avenue per day. This alone would be dangerous, he said.

With silence from Standard headquarters, one newspaper turned to published scientific information to interpret events. On Tuesday, October 28, the Herald Tribune noted that, some 10 months beforehand, G.M. 's Thomas Midgley had presented an American Chemical Society paper on the new product's novel dangers and benefits. "He said at the time that the dipping of one's finger into ... tetraethyl lead brought on insomnia and loss of appetite, and its further seeping into the body produced wild hallucinations of persecution, the nature of which never varied."[11] This was the only time, it should be noted, that newspapers consulted scientific papers or journals in the controversy, despite the fact that they were readily available in public libraries. The Herald Tribune also noted that Standard had also refused to speak with local authorities, and that the authorities reacted with indignation when they discovered that Standard was "engaged not with experimentation ... but in regular manufacture" of tetraethyl lead.

The next day, Wednesday, October 29, the Herald Tribune reported that local authorities were beginning to figure out what had happened. "Little by little the Union County officials are picking their way through the maze of heretofore contradictory assertions that followed the disclosures of the wholesale poisoning," the Herald Tribune said.[12] Lead poisoning from tetraethyl lead remained the leading suspect in the search for chemical culprits, although the local New Jersey medical examiner told several reporters he had never known lead poisoning to act so violently. As late as Thursday, October 30, nine days after McSweeny was taken to a hospital, Standard did not tell health authorities what they were dealing with.

Meanwhile, victims had been rushed to Reconstruction Hospital and put under Thompson's care in a closed-off ward. No information about the ward was ever printed, except for official statements about treatments being attempted. There were no "lurid details" in any of the press, with the possible exception of some mildly descriptive material in Hearst's Journal. Nor was there any follow up, then or in months to come, on the condition of the 32 Bayway men who survived but endured life-long brain damage.

Standard Oil's Blue Funk

Standard Oil Co. directors were frozen in fear when they realized what had happened at Bayway. "They were in a blue funk over the whole thing, and the directors were very much afraid about it," said Kettering 30 years later. "They didn't know what was going to happen to them."[13] The implication was that they may have feared criminal prosecution for their role in the disaster. In any event, Standard issued only short, guarded comments. A flurry of telegrams flew between Kettering, who was then in Paris on business, and Standard headquarters in New York. Meanwhile, New Jersey authorities banned leaded gasoline; then state legislatures in New York, Pennsylvania and others in New England had condemned the new additive and forced gasoline dealers to take it off the market. The bright future for G.M. 's new invention lay in ruins, and five men were known to be dead. The effect was "disaster -- sudden, swift and complete," said du Pont's unpublished history of the incident.[14]

Midgley rushed to New York from the General Motors research labs in Dayton, Ohio. On Thursday, October 30, 1924, after five deaths and five days of silence, Midgley was introduced to a press conference at 26 Broadway to discuss the "mystery gas." Midgley's reputation for demonstrating the safety of leaded gasoline had preceded him, and on Tuesday the World had cited dispatches from Detroit saying that Midgley "frequently bathed" in tetraethyl lead to prove its safety to industry skeptics. Now the inventor used the same trick to impress the cynical New York press corps. He poured a thick stream of a clear liquid over his hands and then rubbed the excess off with a handkerchief, according to the Times.[15] Then he held a bottle of liquid under his nose "for more than a minute," the Herald Tribune said, and "insisted that the fumes could have no such effect as was observed in the victims if inhaled only a short time." Midgley insisted the injuries were "caused by the heedlessness of workers in failing to follow instructions" rather than by the danger of the poison itself.[16]

The news media was openly skeptical. Reporters asked Midgley whether it was true that other workers had been hospitalized and had died in Dayton, Ohio. He admitted two deaths had occurred in April, 1924, and that over 50 G.M. workers had been "under observation" for the effects of lead poisoning. He acknowledged that the du Pont corporation had also had "similar problems," which was the first time that du Pont had been mentioned in the affair.

Standard physician Thompson was also present at the press conference and noted that the tetraethyl lead was used only in diluted amounts in gasoline, and could not have the same effects on motorists as it did on refinery workers. Standard's formal statement written by the public relations office was passed out. It read:

> Tetraethyl lead is a substance first known to chemists in 1854. Since that time it frequently has been experimented with in chemical laboratories where it was known to be, in concentrated form, poison. It is a compound of metallic lead and one of the alcohol chemical series. Its recently discovered use for greatly promoting the efficiency of gasoline engines has let to its manufacture on a commercial scale through processes still more or less in a stage of development. This has occasioned unforeseen accidents which as processes and apparatus are further perfected should be avoidable in the future.
>
> One of these has been the sudden escape of fumes from large retorts and the inhalation of such fumes gives rise to acute symptoms, particularly congestion of the brain, producing a condition not unlike delirium tremens. Although there is lead in the compound, these acute symptoms are wholly unlike those of chronic lead poisoning such as painters often have.
>
> There is no obscurity whatsoever about the effects of the poison, and

> characterizing the substance as 'mystery gas' or 'insanity gas' is grossly misleading... It should be emphasized that the product as destined for final use in gasoline engines has to be greatly diluted, usually with 1,000 parts of gasoline. This extremely dilute product has been for more than a year in public use in over 10,000 filling stations and garages and no ill effects thus far have been reported."[17]

It is understandable that Standard would say the term "mystery gas" was misleading, but Standard's own reticence had been the original source of the mystery, not only with the press, but among public health officials, doctors and other state and local New Jersey officials. The symptoms of chronic lead poisoning in the plumbing and printing trades were like those of acute lead poisoning from tetraethyl lead, although not so violent. And tetraethyl lead was not frequently "experimented with" -- it was considered to be a scientific curiosity.[18] These minor discrepancies are probably due to a lack of communication between the public relations department and scientists such as Midgley, who probably would not have ventured so far from basic facts.

It is also interesting to note the contrast between Midgley inhaling tetraethyl lead fumes and the statement in the press release about "the sudden escape of fumes from large retorts." If the fumes were not harmful enough to suddenly poison Midgley at the press conference, and by Midgley's inference, the workers in the refinery, then there must have been not one but many "sudden escapes" of fumes.[19] If reporters wondered at the contradiction, their skepticism emerged obliquely. For example, the Herald Tribune quoted Reconstruction Hospital doctors saying "the violent insanity and nervousness that gripped the sufferers (was) brought on by the gradual infiltration of lead into their systems."

The discrepancy shows that despite the amount of time that had passed, Standard had not coordinated statements between the public relations office, its engineers and its doctors. Moreover, despite the "public information" policy of public relations pioneer Ivy Lee, who was closely associated with Standard and the Rockefeller family, an official silence left the field open to speculation. One New York World editorial writer at this time was historian Allen Nevins, who later wrote: "Business feared that its relations with the government would be injured by the full truth... The whole province of business-government relations was enveloped in a haze that is even yet (the 1950s) not entirely dispelled. This being so, companies were loath to open their records to the public gaze. ... Secrecy seemed to many businessmen desirable and to some indispensable."[20]

By November 1, even after Midgley's press conference, secrecy and mystery still surrounded Ethyl gas. Reconstruction Hospital doctor C.K. Flynt said "it had not been established whether the lead or the higher alcohol in the tetraethyl lead was the cause of the illness and deaths." Another physician of uncertain connection to Standard or the hospital thought the Ethyl gas would be reduced to pure alcohol in the blood and cause "acute alcoholism."[21] The mystery as reported in the Times is surprising in contrast with the Herald Tribune of two days before, which reported in a headline: "Cure Found for Mystery Gas." The discoveries "are considered a signal triumph of medical skill," the Herald Tribune said. The cure -- hyposulfite of soda -- was photographic "hypo" injected into the veins of the poisoned men to help them metabolize the lead. Hypo is not used in the 1990s as a "chelating" agent, nor are modern agents considered to be particularly effective.[22] The effects were probably small but greatly exaggerated by both public relations agents and reporters who may have been equally hopeful for some positive or heroic aspect to the ghastly story.

By the end of the first week, the press was inclined to take Standard at its word, and report without comment or contradiction claims that every precaution had been taken to protect workers; that the "mystery gas" was merely "Ethyl," which was nothing new to science; that it was safe for motorists; and that Standard, G.M. and du Pont were simply trying to improve the efficiency of automobiles. The Herald Tribune reported without comment Thompson's October 31 statement that this form of poisoning "was nothing new to science."[23] The statement contradicted its own enterprising report on Midgley's American Chemical Society paper two days before.

Editorial reaction

Despite front page coverage around the city, the New York Times editorial staff was almost alone in following the issue in its first week. On Tuesday, October 28, in an editorial entitled "Better Let it all Come Out," a Times editorial referred to the "mysterious poison" and said: "Concealment or even an attempt at it will result in making a bad matter worse." This was a lecture that noted public relations consultant Ivy Lee could very well have been giving Standard officials the same day. The Times also said the "experiment" at Bayway would result in the increase in the store of knowledge "... not for the first time at deplorable cost."[24]

By Wednesday, October 29, it became clear that production, not "experimentation" was going on at the refinery, and the editorial frame of reference shifted from scientific progress to public health and the unique nature of the disaster. Still, the Times maintained that there was a need for public acceptance of inevitable technological risks. "What chiefly concerns public safety is not what happened in the laboratory but the possibility, by some experts called the probability, that the use in automobiles of gasoline thus modified may diffuse through the streets of heavy traffic the same deadly form of lead that had such terrible results in the laboratory." The Times also observed dryly: "It may be assumed that Standard Oil Company does not intend to poison its customers."[25]

The most significant editorial in the Times appeared October 31, as the implications of the incident were fully recognized. "In all the history of chemistry, no case like this is recorded," it said. "Laboratory workers, of course, have been killed before now, but in each instance the number has been small, and usually they have died while experimenting with known explosives or seeking to find new ones. The Bayway disaster has many entirely novel features... For many days workers showed no signs of illness. The fumes evidently were cumulative in their effects ... (and) mental disturbance ... soon turned to outright mania with wild and violent delirium in the worst cases."[26]

On the same day, a separate editorial said the liability of the company toward workers was a "Question for the Courts." The editorial said: "The men did know the danger and they risked it voluntarily in the belief that all the resources of chemical science would be used for their protection and that these resources would suffice. That they did not suffice, the event demonstrated, but did not demonstrate of itself that the failure was anybody's fault. The obligation (by the company) to guard against risks unknown and therefore unexpected is not like that to ward off those that are known."[27] Of course, the Times could not know just how well the risks were appreciated in the years before the Bayway disaster took place.

The Sun, on November 1, weighed in with a conservative editorial statement that the "startling and tragic" loss of life at Bayway should make readers alert to danger that was probably similar to that posed by carbon monoxide. "Tetraethyl lead can probably be used safely if there is a real effort to surround its use with the proper precautions."[28]

A little less than a month later, the Times decided that there was "No Reason for Abandonment" of tetraethyl lead. In a November 28, 1924 editorial, the Times noted that the American Chemical Society saw the deaths at Bayway "not a sufficient reason for abandoning the use of a substance by means of which a large economic gain could be effected -- that is, a considerable increase in the value of gasoline as a source of power... As there is no measurable risk to the public in its proper use as a fuel, the chemists see no reason why its manufacture should be abandoned. That is the scientific view of the matter, as opposed to the sentimental, and it seems rather cold-blooded, but it is entirely reasonable. The making of explosives is not stopped merely because it necessarily is a dangerous industry, and nobody suggests that the building of airplanes should cease, though every flight is at some risk of life."[29]

In other words, a modern society will have to accept some risk. The scientific view, as opposed to the sentimental view, was in favor of progress if the public would not be hurt by the product. This one-dimensional view of progress was clearly not shared by populist papers such as the World and the Journal, that focused more on the public safety perspective than did the Times or Herald Tribune. As the week of news about Ethyl gas ended, even the more liberal newspapers became less and less critical in their news columns, and more inclined to give Standard the benefit of the doubt. No editorials were run, and as the alarming headlines of the first few days gave way to reassuring headlines at the end of the week, the prospect of immediate danger gave way to more remote and less probable risk.

Poison gas and the resonance of fear

There was one sticking point in the entire episode that made it difficult to entirely dismiss the risk. In the age of normalcy, of the triumph of hard-nosed Republican pragmatism over war-weary Progressive ideals, the press and public could ignore the occasional deaths of workers in dangerous trades in the name of Progress. But if tetraethyl lead was so benign, why was the Army studying it for use in trench warfare? Why, indeed, was it a focus of research at Egdewood Arsenal, the home of the Army Chemical Warfare branch?[30]

According to a World story on October 31, the arsenal had tested tetraethyl lead in previous years and found that 100 drops on the skin would probably prove fatal in 24 hours. If applied in smaller amounts, the effect might be cumulative and death might not come for weeks, the World quoted Army chemical warfare experts as saying.[31]

Gas warfare was the subtext of the New York Journal's editorial cartoon published October 31 -- a cartoon that was certainly the most "lurid" report of the entire episode. Cartoonist Hal Coffman's regular daily six-panel strip at the top of the Journal's second page frequently lampooned public officials and industry. On October 31, Coffman accurately depicted refinery workers tearing out their hair, wrapped up in straitjackets and dying in agony in a hospital. One was jumping from a window with a bizarre look on his twisted face. "Just as doctors thought they had discovered the antidote for the deadly Ethyl gas, another victim dies in agony," Coffman wrote. "The terrible 'looney gas' affects the victims differently -- they will be perfectly normal, then suddenly burst into insane fury."

Coffman usually wrote a personal comment under his daily cartoon. This one said:

> Chemists of the Standard Oil Co. little realized what they had discovered in the deadly and horrible ethyl gas. Originally intended to mix with ordinary gasoline to help eliminate carbon from automobiles, it has proven itself the most diabolical thing yet discovered by man. Imagine, if possible, what the next war will be like, with such stuff, and other gasses, perhaps even worse, being dropped by airplanes over cities and wiping out multitudes in an instant. Will there be other wars? Of course there will be. But for downright fiendishness, all past wars will be like a little boy playing with his soldiers. May the time when foolish men declare it be far off..

It is important to note that Coffman's cartoon was always provocative; it was not especially so for the Ethyl controversy. A few days before the "loony gas" cartoon he dealt with a half-witted boy sentenced to hang for a suspicious death. He depicted the judge with his face in his hands and the boy sucking a lollypop as the verdict was read, and poignantly indicted "our half-baked civilization." Coffman's strangely sensible message of peace at the end of an obviously "lurid" description of the dangers of tetraethyl lead, and his concern for justice for the mentally retarded, shows that what may be seen as "sensationalism" is not easily dismissed as mindless recreation at the expense of facts, but rather that it incorporates a wide mix of motives and is used to promote ostensibly good causes when other techniques seem weak.[32]

The poison gas issue lingered over the controversy. On November 1, the Times quoted Brigadier General Amos O. Fries, chief of the Army Chemical Warfare Service, reporting that an investigation of the use of tetraethyl lead gas for warfare had shown that tetraethyl lead was an effective agent. "Samples of the so-called 'loony gas' were used at the Edgewood Arsenal six months ago to see whether this reason-destroyer had any promising possibilities for war and also to discover antidotes and other protections against it," the Times report said. "It was found that it was dangerous unless the greatest precautions were taken in handling it." How the danger might differ from or exceed that of other chemical agents typically used at Edgewood Arsenal was not reported.[33]

These stories and cartoons illustrate one of the underlying themes of the coverage and the difficulty faced by Standard Oil and General Motors: the idea of an invisible poison gas driving people suddenly mad, without warning, was one that resonated strongly with the problem of gas warfare in World War I. Nation's Health noted that tetraethyl lead was a more sensational topic than the many thousands of industrial accidents and poisoning that occurred routinely. "There is something that appeals to the editorial imagination in the idea of inhaling a gas that will cause a period of violent insanity followed by death."[34]

Aside from leaded gasoline, poison gas itself had become a controversial issue with a life of its own after World War I, partly due to the war stories that continued to surface from veterans and partly due to the continued discussions in Geneva during 1924 and 1925 on banning chemical weapons . By coincidence, League of Nations activities on poison gas directly coincided with the Ethyl controversy in the U.S. The Ethyl controversy began in late October, 1924, peaked again in May, 1925 with a Washington Public Health Service (P.H.S.) conference, then stopped in 1926 following a report from a P.H.S.-appointed board of experts. The chemical warfare controversy began with a July, 1924 report that warned "that all nations should realize to the full the terrible nature of the danger which threatens them." By the end of September, 1924, the League circulated a draft document. And in June, 1925, the conference approved a protocol against poison gas. The U.S. Senate debated but did not ratify the protocol until 50 years later, in 1975.

Both sides in World War I used a total of 124,200 tons of poison gas. About 70,000 soldiers, for a total of 27 percent of all U.S. casualties but only two percent of U.S. deaths, were from poison gas. Around four percent of all deaths of British, French and German soldiers was from gas. Gas was “never a decisive element in the war,” according to historian Edward M. Spiers. Some have argued, however, that the horror of gas warfare was concealed by statistics, and many tens if not hundreds of thousands of gas deaths were listed in categories such as missing in action or death on the battlefield.[35]

Banning poison gas was a bipartisan issue in the 1920s. Presidents Woodrow Wilson, Warren Harding and Calvin Coolidge, joined by General John Pershing, all hoped to end its use.[36] In Britain, politics stopped use of poison gas by the British army against troublesome Afghan tribesmen in the 1920s. Using gas would have "very serious political and moral consequences,” according to Edwin Montague, Secretary of State for India. He was supported by Lord Fisher, who wrote: "The British public thought that poison gas was a low game and they think so still." Sir Edward Thorpe said use of poison gas was a "degradation of science," and he told the British Association for the Advancement of Science that “civilization protests against a step so retrograde." German scientists were not always so sentimental, and when one young German chemist argued that science was a force for good that should not be diverted to inhuman purposes, a senior scientist, Fritz Haber, "... overreacted and accused his younger colleague of conduct unbecoming to a German."[37] In the U.S., the American Chemical Society (ACS) and the Army's chemical warfare service opposed measures to restrict chemical warfare research, calling those opposed pacifists, ignorant politicians and military dunderheads. Fear of the unknown, of the new and incomprehensible, was at the root of the anti-scientific opposition, according to the ACS.[38]

The deep-seated fear was hardly an irrational anti-scientific behavior. Ordinary people understood all too rationally that gas attacks on cities would be likely in wartime. They dreaded gas warfare in the same way that people dreaded nuclear warfare in the second half of the 20th century. "Expert opinions added to apprehensions which were further increased by newspaper reports, novelists and not the least by alarmist forecasts based on scientific rubbish disseminated by people who knew better," said historian L.F. Haber. "The mixture of bizarre fantasies and plausible scenarios, together with the common experience shared by thousands of ex-soldiers, had an enhancing effect, so that poison gas held the public attention through the 1920s and '30s. The particular issue which touched a sensitive area ... was that of civilian protection against gas..."[39]

Some organizations used the sensitivity about the issue to reach their audiences. For example, the Workers Health Bureau published a warning to garage workers in 1924 entitled: "Carbon Monoxide: Poison Gas War on the Job."[40] Other groups began to see a direct connection between military poisons and industrial poisons. Dr. Alice Hamilton, the Harvard professor who led the opposition to Ethyl gasoline, was among those attending an open house at the Army Chemical Warfare Service headquarters at Edgewood Arsenal, Md. sometime in the summer of 1924, before the Bayway incident. This demonstration, which may have involved tetraethyl lead as a military poison, accelerated rather than calmed the group's opposition to gas warfare experiments. "The effect was the opposite of what the Chemical Warfare Service intended to achieve by the open day, and the WILPF grew into an active lobby... (whose job it became to tell the public) very vividly indeed, what chemical warfare against civilians entailed."[41]

America's leading expert on industrial toxins and lead poisoning, Hamilton had travelled to Europe in October, 1924 when the Bayway disaster occurred, and was not able to participate in the public debate until she returned in February, 1925.

Public Relations Fails to Relieve the Fear

Thomas Midgley's October 30 press conference in New York did little to relieve the growing pressure on Standard, and by Halloween, the company's second wave of public relations efforts moved into high gear. First, Rockefeller's personal public relations agents issued a "joke" from the oil tycoon. It had nothing at all to do with leaded gasoline; perhaps it was only coincidence that it appeared in a boxed sidebar next to the Ethyl gasoline story in the Times November 1:

> Nobody enjoys a joke better than John D. Rockefeller and he doesn't mind telling one on himself. This is the latest he is telling his friends. 'I was in the central part of the state this summer to visit some of the spots where I spent my childhood. My car had stopped and I was looking around when an old farmer came up to the car and started to talk to me. He didn't know who I was. We chatted together for about five minutes and then he asked me where I was going. 'I'm going to heaven,' I replied with a smile. 'Get out,' he said. 'You ain't got enough gas.'[42]

Rockefeller's joke would not have become known to the press if it was not intended to be. If there was a subtext, perhaps something about Ethyl boosting efficiency and stretching oil reserves, it was probably lost on readers. But the tone of the joke is very much in character for Rockefellers under pressure. It is similar to the tone employed by public relations agent Ivy Lee following the Ludlow, Colorado massacre in 1914, when 53 striking miners, women and children were killed by the state's national guard. Even conservative newspapers called Ludlow a disaster and blamed Standard Oil Co. and John D. Rockefeller (Sr.). Ivy Lee's strategy was to have John D. Rockefeller, Jr. project a more humane image. Rockefeller went to a miner's church, danced with miners' wives, and descended briefly into the mines themselves. These public relations efforts were meant to convey the impression that despite the tragic loss of life, despite the toil and travail of this world, the Rockefellers were ordinary people who enjoyed dancing and a good joke and who were bound by the same sense of morals as most people. In the months following the Ludlow massacre, Lee began to transform the Rockefeller name from an object of hatred to one with neutral and often pleasant connotations.[43] The Bayway disaster did not necessitate a full-blown rehabilitation of the Rockefeller image. But John D.'s "joke" may have been part of the image maintenance effort of the public relations group, and is certainly in character for Ivy Lee.

Aside from the joke, the substance of the public relations response was a hasty U.S. Bureau of Mines report on experiments that had been conducted at its Pittsburgh, Pa. lab for General Motors. On October 31 the bureau issued a statement in Washington, D.C. concluding that the danger of the public breathing lead in the exhaust of automobiles is "seemingly remote" based on observations of animals exposed to leaded gasoline exhaust. None of the animals apparently had any problems that could be detected, even though a few of them had been exposed to leaded gasoline exhaust for six hours a day for eight months. Critical reaction came almost immediately from the scientific community, but nothing about it was published in the press until April, 1925. As it turned out, the bureau kept animal cages well ventilated and did not allow lead dust to accumulate, and critics from Harvard Medical School soon charged that this avoided real-world study conditions. Research contracts between the bureau and General Motors show that G.M. had control over the release of any information the bureau's study of tetraethyl lead, and the report was undoubtedly released at G.M. or Ethyl's request since contracts stipulated that G.M. would have final control over all information released from the study.[44]

<u>The public controversy smolders: November 1924 - April 1925</u>

News reports of the Bayway disaster were overshadowed by other events, especially the presidential election. Ethyl gasoline continued to be sold in the Midwest, but sales stopped in New York City, Philadelphia, New Jersey and in many other East Coast areas where it was officially banned or unofficially discouraged.

The New York <u>Times</u> continued to follow the controversy. On November 9, the <u>Times</u> quoted a New Jersey chemical society president Carleton Ellis saying that simple improvements in petroleum refining could improve the antiknock value of gasoline in the future "without resort to additions such as lead ethyl." The chemist also noted that many gasoline additives discovered through an "empirical" trial-and-error method had been proposed, "but this criticism does not apply to tetraethyl lead, which rests on a true scientific foundation." Presumably, Ellis had been informed about the peg board method. His view was common among chemists and engineers, although historians later said Ethyl research had been "proceeding mostly on an empirical basis."[45] Ellis' comment is significant because it reveals the deep investment of credibility that many in the scientific community had already made in the new "scientific" gasoline additive, despite, as he noted in the same breath, commonly known alternative methods to control engine knock .

The public controversy also continued around the danger of tetraethyl lead. In a November 13 Times article about the autopsy reports on Bayway refinery workers, a New York City medical examiner said that tetraethyl lead had been discovered in Germany in 1854 "and it has not been used in industry during most of the 70 years since then because of its known deadliness."[46] This statement was probably a reaction to the Standard press release of October 30, which claimed that tetraethyl lead had been a frequent subject of experimentation.[47]

Two weeks later, on November 27, 1924, both the Times and World quoted the New Jersey Labor Commission saying that worker health could not be safeguarded at the Bayway refinery and it would have to be shut down. (Du Pont's Deepwater, New Jersey plant continued operations until May, 1925, and then resumed again in 1926). Both articles also noted a statement by Harrison E. Howe, editor of the journal of the American Chemical Society, saying it would be "folly" to discontinue the use of a substance that would so greatly improve the conservation of petroleum. While the public may be concerned about small amounts of lead in gasoline, Howe said a far greater concern was felt by manufacturers "who realize to what extent they would be the subject of attack should it develop that the public is endangered by the use of this fuel."[48]

One of the few positive articles about Ethyl appeared around this time. A speech by Thomas Midgley explaining the process of discovering tetraethyl lead was printed in the January, 1925 issue of Motor magazine. In his speech, Midgley attributed success to "luck and religion, as well as to the application of science." He told the story of the false trails that led to iodine, aniline, selenium, tellurium and then to lead. He did not mention any of the alternatives such as benzene, alcohol or iron carbonyl that G.M. had investigated.[49]

Meanwhile, the Ethyl controversy continued simmering. The Times wrote about a "six-month progress report" from the Bureau of Mines on January 7. The World ignored the report that day, but reported on February 11 Henderson's negative reaction to the report.[50] On February 12, the Times reported that a grand jury cleared Standard Oil Co. of criminal charges in the Bayway accident . The World ignored the grand jury but reported on February 18 that another Deepwater worker for du Pont had died from tetraethyl lead poisoning and no inquest was planned. The Times on February 24 noted two recent deaths at Deepwater.

This journalistic ping-pong illustrates the competitive approach to news taken in the late 19th and early 20th century. Before most American newspapers became monopolies in their own cities, it was common for competing newspapers to be aware of each others' "scoops," to let them go unacknowledged, and then try to beat the competition to fresh information. To get a complete view of events, readers often read more than one paper. The Times ostensibly attempted to transcend the "ping-pong" approach. In its motto -- "all the news that is fit to print" -- is the implicit claim that as the newspaper of record it could be trusted to follow the details of important issues. Editor Carr Van Anda, well known for his insight into scientific questions, had probably been consulted by Times editorial writers who called it an "episode without precedent," and the Times commitment to continuing coverage shows that unprecedented nature of the Ethyl controversy was understood. Thus, the Times attempted to cover the issue fully and fairly. And yet, it is clear that the agenda of the Times in the Ethyl controversy was aligned with the other, less heralded objective stated by founder Adolph Ochs: "to allay rather than excite agitation."[51] Thus, "all the news" did not always include voices of agitation and dissent that the World's editors not only heeded but, on occasion, championed. Thus, while the content of the news articles was in itself accurate, and while reporters remained in non-interpretive and passive roles, the editors of the two great New York newspapers clearly had different agendas in assigning coverage and placing news items in the papers.

In the spring of 1925 the contrast between the Times and the World continued to grow, as the Ethyl controversy continued to build momentum. In March, the Times carried stories about a European controversy over leaded gasoline. A Swiss scientist said lead was already detectable in street dust, but an Ethyl spokesman countered a day later by saying that leaded gasoline had not been marketed in Switzerland. It is likely that the Swiss scientist had measured industrial lead contamination. The article is significant because it shows the concern of Europeans about what the Swiss scientist called the "death-dealing liquid."[52]

The Times also covered Thomas Midgley's speech to the American Chemical Society April 6, in which he claimed a number of benefits for tetraethyl lead and, significantly, that there was no alternative to its use:

> ... Conservation of petroleum due to the increased mileage obtainable by using a non-knocking gasoline in high compression motors; the reduction of carbon monoxide contamination of the atmosphere due to increased efficiency of combustion and reduced first cost of automotive apparatus are some of the benefits ... So far as science knows at the present time, tetraethyl lead is the only material available which can bring about these results, which are of vital importance to the continued economical use by the general public of all automotive equipment... [italics added][53]

News accounts of the statement ran in the Times without contradiction or question, although other newspapers ignored it. The claim that "science" knew of no alternatives must have surprised many chemists and automotive engineers, who would have known about other antiknock fuels from articles that had appeared in automotive and chemical journals. Midgley himself had been an enthusiastic leader for other fuel alternatives, as already seen in Chapter Three. Yet no reporter questioned his ACS speech, and the only scientists who publicly broke ranks and criticized Midgley were those who were experts in public health, not automotive engineering. It is interesting to note that the ACS may have come to regard Midgley with some coolness. His defense of tetraethyl lead at the ACS meeting may have been headlined in the New York Times, but was noted among many hundreds of reports in only 17 words in an ACS conference report a month later: "Midgley, in his characteristic style, discussed the poison hazards in the manufacture and use of tetraethyl lead."[54] ACS apparently did not believe that the fortunes of the chemical industry were tied to G.M. 's latest antiknock fluid.

On April 5, the Times also carried a guest column by a Mellon Institute scientist concerning the research vessel “S.S. Ethyl” that had been commissioned to extract the element bromine from sea water. The article noted that tetraethyl lead “is needed to silence the knock in automobile motors” and that bromine was needed in turn to keep tetraethyl lead from fouling spark plugs. In glowing and heroic terms typical of 1920s science writing, the author noted: “It is curious how one industry gives rise to another. Twenty years ago, no one could have foreseen that the search for a better motor fuel for the automobile would lead to the extracting of valuable minerals from the sea.” The article rambled into a broad discussion of the riches of the sea, including the amount of gold to be found in sea water and the sources of bromine in Germany and in Midland, Michigan. The article is an example of the subtle public relations Ethyl and its parent corporations were pursuing. The premise that leaded gasoline was “needed” is carefully embedded throughout the article. So, too, is the idea that du Pont could become independent from other bromine suppliers.[55] These suppliers included I.G. Farben and Dow Chemical Co. of Midland, Michigan. Although the S.S. Ethyl experiment cost $400,000 and the ship was only at sea for a few weeks, du Pont later said in an internal history: “There was undoubtedly a large measure of compensation in the effect of this well publicized experiment in the minds of the established domestic and foreign producers of bromine, who set the prices that the new consuming industry was forced to pay.”[56]

The World did not cover the S.S. Ethyl, the Swiss controversy or Midgley's speech. It did cover scientific criticism of the November 1924 Bureau of Mines report by two Harvard University medical school faculty members, Cecil Drinker and David Edsall. On April 4, the World reported their February, 1925, paper in the Journal of Industrial Hygiene. Drinker and Edsall said that the bureau’s study of lead’s effect on animals did not reflect real-world conditions. The chambers where animals were kept had been constantly ventilated, and thus lead particles did not settle, they said. This would tend to keep lead absorption rates artificially low. The World quoted Drinker as saying the experiments “do not show the substance safe for general use.” A follow-up World editorial April 12 said a new investigation "must begin at once." It is likely that the report came to the attention of editorial page editor Walter Lippmann through his friendship with Harvard Professor Alice Hamilton.[57]

The Bureau of Mines also came under fire in late April in a speech by Yandell Henderson to the American Society of Safety Engineers. The Times, the World and most other newspapers covered the inflammatory speech. Henderson insisted that the issue was not one of immediate lead poisoning, and yet the Bureau of Mines experiments were designed as if that were the threat. Rather, the serious public health danger was that "breathing day by day of the fine dust from automobiles will produce chronic lead poisoning on a large scale..." The problem was "... the greatest single question in the field of public health which has ever faced the American public," Henderson said. "Perhaps if leaded gasoline kills enough people soon enough to impress the public, we may get from Congress a much needed law and appropriation for control of harmful substances other than foods. But it seems more likely that the conditions will grow worse so gradually and the development of lead poisoning will come on so insidiously ... that leaded gasoline will be in nearly universal use and large numbers of cars will have been sold that can only run on that fuel before the public and the government awaken to the situation." The question, Henderson said, was whether "commercial interests are to be allowed to subordinate every other consideration to that of profit. It is not a matter of millions or even hundreds of millions of dollars, but literally billions."[58]

Most New York newspapers carried at least some of Henderson's remarks. The Sun carried a modest five-inch article covering the highlights of the speech.[59] The Journal carried a full banner headline with text across the top of the flag: "Looney gas auto exhaust threatens health of nation."[60] The World reported far less of the speech than the Times, but noted that Henderson "attacked the powerful commercial interests which he says are preparing to make poisonous ethyl gasoline the universal fuel." A World editorial said the next day: "There must be a new investigation, an immediate investigation, and an investigation which makes use of the best scientific opinion in the country."[61]

The New York Times, the Sun and the Journal carried Thomas Midgley's response April 23, but the World apparently did not think it deserved the space. Midgley attacked Henderson's integrity, asking why he "unsuccessfully sought a retainer" from G.M. to investigate leaded gasoline. Midgley claimed G.M. "preferred to entrust such an investigation to an arm of the government than to a private investigator paid by it."[62] Henderson's rejoinder was carried April 24 only in the New York Times; rather than seeking money, he had "foretold" his "attack" on ethyl gasoline and he believed the results of any investigation "would scarcely fail to show that the public use of leaded gasoline would involve an intolerable hazard to public health."[63]

Meanwhile, another research controversy had developed at Columbia University. Two researchers had apparently been poisoned by tetraethyl lead in the laboratory, and the research director talked with reporters from the World, Herald Tribune and Sun on April 28. He noted the "collapse of the investigators from fumes" that was "evidence of the deadly effects of the poison."[64] Again, the New York Times missed a story that the World's enterprising work had uncovered, but the next day, the Times ran a university official's angry denial without delving into the details of the original story: "The reports were evidently spread by some person whose imagination exceeds his sense of responsibility," the Times quoted Horatio B. Williams, physiology department chairman, as saying. The "sensational story ... is absolutely without foundation in fact," he said.[65] The Journal followed the Columbia story with a banner headline above the flag, proclaiming: "Early Verdict on Looney Gas." The Journal's article was balanced by a statement by Dr. Haven Emerson, a senior faculty member, saying the reports of lead poisoning of researchers had been exaggerated, and that they have "not been compelled to give up their work."[66]

The World stood the April 29 Columbia denial on its ear. While Columbia said the report was utterly false, the World reported, "it was admitted that lead was found" in fecal samples taken from lab workers. The headline echoed the contradiction: "Columbia, denying ethyl poisoning, admits 2 cases in researchers." The World also defended its previous reporting, noting that the sources had been Emerson and one of the affected researchers, Frederick B. Flinn. "Asked about the death rate of animals subjected to dilutions of ethyl gas and air, Dr. Flinn replied: 'Well, a few of them haven't died yet.'"[67]

The accelerating controversy took a new turn when, on May 1, U.S. Surgeon General Hugh Cumming announced that an unprecedented conference of all interested parties would take place in Washington on May 20, 1925. All New York newspapers and most around the country carried the story. The conference was a response to Harvard university professor Cecil Drinker's review of the Bureau of Mines report, Cumming told the news media.

On May 3, the World presented an in-depth look at the Ethyl controversy in a Sunday opinion section. The headline asked whether Ethyl would poison everyone and underscored a theme that would be repeated many times in the decades to come: "Scientists Disagree." An artists sketch showed Yandell Henderson holding a rather elaborate piece of analytical equipment with an inset of a jowly Thomas Midgley. The article by reporter John E. Mitchell[68] primarily summarized Henderson's opinions on leaded gasoline and Midgley's defenses. The article observed that lead poisoning is a "nasty, serious business" that had been known since the Roman Empire. It quoted Henderson as calculating that with cars burning two gallons of fuel per hour, the deposit of lead on a New York street would be in about a pound per hour per block. The dusty rain of lead on Fifth Avenue alone, Henderson said, would be 30 tons per year.

The World article also gave readers background on the two protagonists. Henderson was not a spurned consultant. Rather, he had been employed by the Bureau of Mines labs to help develop poison gas in World War I. "The mental pictures that he carried with him in wartime of the havoc his gases would play with the German Army have made him acutely sensible of the possibility of mass poisoning and eager to protest against it," the World article said. The article also quoted Midgley telling a story about eating dinner with a friend who ordered Camembert cheese after dinner. The friend peeled back the tin foil and said with mock horror that the acid in the cheese would have dissolved some of the lead. "My friend pretended to leap up from the table, asking in mock anger if I intended to give him lead poisoning," Midgley told the World. Although we don't know who the friend was, the jest would have been in character for Charles

Kettering.

In later years, industry scientists would argue (erroneously) that a certain amount of lead in the human body is "normal," but Midgley's attempt to calm the alarmed public had fallen completely flat. In a board of directors meeting in late April, 1925, Kettering and Midgley were removed as president and vice president of Ethyl Gasoline Corp., and the decision was made to suspend all sales. Although the shake-up in the company was kept secret, on May 4, the company announced that leaded gasoline sales would be stopped until some resolution was reached by the P.H.S. on the issue. All New York city newspapers carried the story on May 5; the Times merely reported the announcement, but the Herald Tribune and the Daily News erroneously claimed that the main reason for Ethyl's retreat was the lack of supply. "It is understood that the difficulty of obtaining deliveries was because of the war being waged against the product here," the Herald Tribune said.[69] The Sun attributed the suspension of sales "to the controversy being waged among scientists as to whether Ethyl gasoline is dangerous."[70]

In a self-congratulatory tone, the World attributed the suspension of sales to itself. "Dangerous leaded gasoline sale stopped after fight by the World," the World headline said. The article described "the World's successful fight to stop the sale of tetraethyl gasoline pending a thorough inquiry into its danger." A second story noted that "Dr. Yandell Henderson of Yale took a large part in the crusade." In a sidebar, Henderson said: "I congratulate the World heartily for the high service it has rendered, for without the intelligent support given this undertaking no such victory could have been achieved."[71]

Not to be excluded, the Daily News the next day claimed a little of the glory for itself, saying "Journalistic vigilance has accomplished what the paid servants of the people failed to do."[72]

Reaction against journalistic vigilance came quickly. "The fortunes of one of (our industry's) branches have been rudely thrown into the balance by the hysteria of a newspaper and a physiologist..." the Times quoted H.C. Parmelee, editor of Chemical & Metallurgical Engineering on May 7. "The research and development that produced tetraethyl lead were conceived in a fine spirit of industrial progress looking toward the conservation of gasoline," Parmelee said. "One can imagine how chemical progress in the past might have been hampered by a similar crusade by self-appointed guardians of the public health."[73]

Parmelee's attitude, however, was hardly universal among scientists. Industrial & Engineering Chemistry, in a June 1925 editorial, said there was a danger that "another lead trade hazard" could be introduced. Backing away from Harrison Howe's original support for Ethyl in November, 1924, the American Chemical Society's journal said that the attitude of industrialists was not that far afield from academics, labor organizations and other groups. The editorial also said that the idea of increased government regulation over chemicals "is a subject worthy of further discussion."[74] Strong backing for Ethyl is also missing from the Society of Automotive Engineers Journal and other scientific journals of the era.

At the World, coverage continued with a May 8 story noting that Ethyl gasoline was still being sold despite the company's decision to voluntarily withdraw it from the market. On May 8 a World reporter wrote of an interview with Midgley in Dayton, Ohio. Midgley said the best proof of the safety of Ethyl gas was in the lack of complaints from users. Midgley also rubbed a thick, clear liquid on his hands, saying it was tetraethyl lead: "I'm not taking any chances whatever. Nor would I take any chance doing that every day."[75]

One of the fascinating sidelights of the Ethyl controversy shows up in a cryptic Times article published on May 8. Entitled "Synthetic Marvels Arouse Scientists," the article is based on an interview with then-Secretary of Commerce Herbert Hoover.[76] The future president was at that moment preoccupied with large amounts of synthetic methanol made from coal in Germany, which, he said, could bankrupt U.S. methanol producers who made the alcohol out of wood using a process three times more expensive. The article noted that methanol was a paint thinner and base for a variety of chemicals. Without drawing any direct connection, the Times also quoted Hoover as saying that the Commerce department "had not been asked to take an investigation of the poisonous or non-poisonous qualities of tetraethyl and did not contemplate entering into the present controversy." The article does not mention any particular reason or context for Hoover's statements. The juxtaposition of two apparently unrelated items may have simply been an artifact of the reporter's technique, but methanol was related to the tetraethyl lead controversy by professional journals. Methanol was among the "Liquid fuels of the future" noted in an April, 1925 brief in Industrial & Engineering

Chemistry.[77]

Moreover, Commerce was a few days away from issuing a report on the widespread use of methanol and ethanol fuels in Europe, as pure fuels or more often as antiknock additives. The report provided detailed statistics on use of alcohol blended fuels in France, Germany, England, Italy and other countries.[78] It could have contradicted the statements of Ethyl officials, especially Midgley, who claimed that "so far as science knows" no other substance could combat engine knock. Opponents of tetraethyl lead such as Yandell Henderson and Alice Hamilton frequently insisted that alternatives were available but apparently had very few specifics. About this time, two letter writers to the Times reflected the general public misinformation. One noted that "lead is a most insidious poison ... (and) a harmless substitute should be sought." The other claimed that the "ultimate aim should be total electrification."[79]

The letters are significant because they reflect the "information gap" between science and public policy. Indeed, throughout the entire controversy before the Public Health Service conference, between October 1924 and May 20, 1925, no newspaper article took notice of unleaded antiknock fuels already being sold in the U.S. and Europe.

Very few people were aware of both the policy problem and the scientific information. The Commerce Dept. alcohol fuel report was never publicized, and no references to the report appear in any newspapers during this period. It is possible that Hoover was in a position to shift the focus of debate to an area that might have proven troublesome for Ethyl, but he did not. His lack of action at a critical moment kept the focus of public attention away from alternatives and on the narrower question of proof of public health problems. As a result, public health advocates carried a greater burden of proof as the stage was set for the Surgeon General's May 20 conference.

---

1. N. P. Wescott, Origins and Early History of the Tetraethyl Lead Business, June 9, 1936, Du Pont Corp. Report No. D-1013, Longwood MS Group 10, Series A, 418-426, G. M. Anti-Trust

Suit, Hagley Museum & Library, Wilmington, Del., p. 22. (Hereafter cited as Wescott, Origins and Early History).

2. "Chief Chemist Escapes As 'Loony Gas' Victim," Brooklyn Daily Eagle November 2, 1924, p. 1. The article simply says that Mann had been among those hospitalized but was by then probably out of danger from the most acute stage of lead poisoning. Since Mann must have been poisoned before the plant closed, he probably had lead intoxication at the time of the interview.

3. "Odd Gas Kills One, Makes Four Insane," N.Y. Times, Oct. 27, 1924, p. 1.

4. Ibid.

5. A sixth Bayway employee had died in September, 1924, but his related suicide was not connected with lead poisoning until the end of October.

6. In fact, it was ethyl anti-knock compounds being made by a Standard process using chloride, which was Standard's patented improvement over the General Motors bromide process. This improvement was Standard's rationale for entering the manufacturing operation and insisting that General Motors work with it, according to Wescott's Origin and Early History, pp. 3 - 6.

7. "Company Denies Negligence Led to Gas Deaths," New York Sun, Oct. 27, 1924, p. 1. This was contrary to facts, as later documents would show.

8. Wescott, Origins and Early History, p. B-3.

9. "Another Man Dies from Insanity Gas," New York Times, Oct. 28, 1924,
p. 1.

10. General Motors abandoned this plan sometime in late 1922 after facing several serious impracticalities, not the least of which was the pure consumer inconvenience of having two fuel tanks. Henderson had been in touch with GM in 1922 and 1923, before it was decided to use the "ethylizer" at the service station pump. By late 1924, Ethyl ordered the mixing to be done higher up the fuel stream at bulk distribution plants. That Henderson had heard about ethylizers is noted by a Science Service article "Ethyl Gasoline" in the monthly supplement in Science magazine of December 1924. Henderson was also aware of tetraethyl lead as an agent of

poison gas warfare from US Army Chemical Warfare Service experiments.

11. Although the paper which Midgley presented is not in the archives, this account is consistent with the fact that he had rather freely informed fellow scientists of his case of lead poisoning. He turned down at least three speaking engagements to take time off in Florida to recuperate from lead poisoning in February, 1923. Midgley to H.N. Gilbert, January 19, 1923, unprocessed Midgley papers, GMI , Flint, Mich. Also see Midgley to G.A. Round, Vacuum Oil Co. [later Mobil], Feb. 14, 1923, unprocessed Midgley papers, GMI. Also see Stuart Leslie, Boss Kettering (New York: Columbia University Press, 1983) p. 165.

12. "Ethyl Gas Sale Stopped Today by Standard Oil," Herald Tribune, Oct. 28, 1924, p. 1.

13. Trial testimony, p. 2169, United States v. du Pont, US District Court, Chicago Ill., Nov. 18, 1952, 126 F. Supp. 235. (Hereafter cited as US v. du Pont).

14. Wescott, Origins and Early History, p. 22.

15. "Bar Ethyl Gasoline as 5th Victim Dies," New York Times, Oct. 31, 1924, p. 22.

16. "Bar Death Gas in City as 5th Victim Dies," Herald Tribune, Oct. 31, 1924, p. 1.

17. “Use of Ethylated Gasoline Barred Pending Inquiry,” The World, October 31, 1924, p. 1; also see the New York Times, the Sun, and the Herald Tribune of the same date; all four carried the statement verbatim.

18. T.A. Boyd notes that “no such compound was in existence” when Midgley first decided to try tetraethyl lead in Dayton in November, 1921, and it took three weeks to produce it in the Dayton lab. Boyd, Professional Amateur, (New York: E.P. Dutton, 1957) p. 145.

19. Kettering later insisted that the Bayway refinery had experienced an “explosion.” U.S. v. du Pont, transcript. p. 3578.

20. Allen Nevins, Allen Nevins on History, ed. A.R. Billington, (New York: Scribners 1975), p. 77.

21. “No Peril to Public Seen in Ethyl Gas,” New York Times November 1, 1924. Note also that ethyl alcohol is not considered a “higher alcohol,” and it is possible that the Times mistakenly interviewed an uninformed physician or employed an inaccurate reporter.

22. Michael R. Moore, “Lead in Humans,” in Richard Lansdown and William Yule, eds., Lead

Toxicity: History and Environmental Impact (Baltimore: Johns Hopkins University Press, 1986), p. 63.

23. "Bar Death Gas in City as 5th Victim Dies," Herald Tribune, Oct. 31, 1924, p. 1.

24. "Better Let it All Come Out," New York Times, Oct. 28, 1924, p. 22.

25. "Precautions Not Sufficient," New York Times, Oct. 29, 1924, p. 20.

26. "An Episode Without Precedent," New York Times, Oct. 31, 1924, p. 18.

27. "Questions for the Courts," New York Times, Oct. 31, 1924, p. 18.

28. Editorial, New York Sun, Nov. 1, 1924.

29. "No Reason for Abandonment," New York Times Nov. 28, 1924, p. 20.

30. "No Peril to Public Seen in Ethyl Gas," New York Times, Nov. 1, p. 17.

31. "4th Mystery Gas Victim Dies While Doctors Disagree," New York World, Oct. 31, 1924, Second Section, p. 1.

32. For example, milk pasteurization. See Bill Kovarik, "Dr. North and the Kansas City Newspaper War," presented to the Association for Education in Journalism and Mass Communications, Washington D.C., August 1989.

33. "No Peril to Public Seen in Ethyl Gas," New York Times, Nov. 1, p. 17.

34. C.M. Stalls, "Tetraethyl lead a menace to garage workers," Nation's Health, March 1925, p. 171.

35. Edward M. Spiers, Chemical Warfare (Chicago: U. of Ill Press, 1986)

36. New York Times January 8, 1922, p. 17.

37. L. F. Haber, The Poisonous Cloud: Chemical Warfare in the First World War (Oxford: Clarendon Press,1986) p. 292.

38. Spiers, Chemical Warfare , p. 50.

39. Haber, The Poisonous Cloud, p. 289

40. Angela Nugent Young, "Organizing Trade Unions to Combat Disease: The Workers Health Bureau, 1921-1928," Labor History, 1983, p. 424-446.

41. Haber, The Poisonous Cloud p. 294.

42. “John D. Warned He Needs More Gas to Get to Heaven,” New York Times, November 1, 1924, p. 17.

43. Ray Hiebert, Courtier to the Crowd: The Story of Ivy Lee and the Development of Public Relations (Ames, Iowa: Iowa State University Press, 1966); also, Bill Moyers, “The Image Makers,” from the PBS series “A Walk Through the 20th Century,” 1984.

44. Rosner & Markowitz, "A Gift of God," p. 122.

45. Harold F. Williamson, et al., The American Petroleum Industry, The Age of Energy, 1899-1959 (Evanston, Ill.: Northwestern University Press, 1963), p. 411.

46. "Tetraethyl Lead in Victim's Brain," New York Times, Nov. 13, 1924, p. 20.

47. "Bar Ethyl Gasoline as 5th Victim Dies," New York Times, Oct. 31, 1924, p. 22.

48. "Report Condemns Making of Lead Gas," New York Times, Nov. 27,

49. Thomas A. Midgley, "How We Found Ethyl Gas," Motor Magazine, Jan. 1925, p. 92 - 94.

50. "Animals Withstand Gas Fumes Test," New York Times, Jan. 7, 1925, p. 35; "Ethyl Gas is Held a Menace Despite Bureau's Findings," New York World, Feb. 11, 1925, p. 1; "Absolved of 5 Gas Deaths," New York Times, Feb. 12, 1925; "Tetraethyl Lead Claims a Victim," New York World, Feb. 18, 1925, p.1; "To End Ethyl Gas Peril," New York Times, Feb. 24, 1925, p. 20.

51. Meyer Berger, The Story of the New York Times 1851-1951 (New York: Simon and Schuster, 1951).

52. “Charges Our Gasoline Poisons Cities Abroad,” New York Times, March 18, 1925, p. 33; "Denies there is Danger From Lead in Gasoline," New York Times, March 22, 1925, p. 7.

53. "Radium Derivative $5,000,000 an Ounce; Ethyl Gasoline Defended," New York Times, April 7, 1925, p. 23.

54. “Division of Industrial and Engineering Chemistry,” Industrial & Engineering Chemistry, News Edition, American Chemical Society, April 20, 1925, p. 5.

55. Donald Tressler, Mellon Institute of Industrial Research, “New quest for riches of the Sea,”

New York Times, April 5, 1925.

56. Wescott, Origins and Early History, p. 8. Also, Irenee du Pont said that the German dye industry (I.G. Farben) cut the price of bromine immediately after the ship succeeded in making it. US v du Pont, p. 2183.

57. "Tetraethyl Gas to be Sold in Face of Hostile Report," New York World, April 4, 1925, p. 3; "Need for a Prompt Investigation," New York World, April 12, 1925, p. 2E.

58. "Sees Deadly Gas A Peril in Streets / Dr. Henderson Warns Public Against Auto Exhaust of Tetraethyl Lead / Worse than Tuberculosis," New York Times, April 22, 1925, p. 1.

59. "Warns Against Ethyl Gasoline," New York Sun, April 22, 1925, p. 5.

60. "Looney gas auto exhaust threatens health of nation," New York Journal, April 23, p. 1.

61. New York World April 23, 1925, p.1.

62. "Ethyl Gas Official Denies Monopoly," New York Times, April 23, 1925, p. 3. In fact, GM first approached Henderson about a study in 1922 after being referred to him by Harvard Prof. F.O. Wilson. Henderson's idea of a substantial investigation would have involved $5,000 in fees per month for at least three months. GM did not pursue it. Long after Ethyl gasoline was on the market, G.M. convinced the Bureau of Mines in 1923 and Columbia University in 1925 to conduct animal toxicity experiments. See Boyd, Early History, pp. 165, 191 and 263.

63. "Foretold His Attack on Ethyl Gasoline," New York Times, April 24, 1925, p.3.

64. "Columbia Experts Assert Ethyl Gas is Public Menace,"New York World, p. 1; "Report Condemns Ethyl Gas," New York Sun, p. 12; "Leaded Gasoline Held Menace," Herald Tribune; all April 29, 1925, p. 1.

65. "Research Workers Were Not Poisoned," New York Times, April 30, 1925, p. 1.

66. "Early Verdict on Effect of 'Loony Gas,'" New York Journal , April 30, 1925, p. 5.

67. "Columbia, Denying Ethyl Poisoning, Admits 2 Cases in Researchers," New York World, April 30, 1925, p. 1.

68. "Will Ethyl Gas Poison Us All? Scientists Disagree," New York World, May 3, 1925, p. 1E. Unlike news reports today, bylines were rare in newspapers of the era. This was the only bylined

story on leaded gasoline printed in the World.

69. "Ethyl Gas Sale Stopped Today by Standard Oil," Herald Tribune, May 5, 1925.

70. "Sale of Ethyl Gasoline Stopped," New York Sun, May 5, 1925, p. 5.

71. "Dangerous Leaded Gasoline (Tetraethyl) Sale Stopped After Fight By World," New York World, May 5, 1925, p. 1.

72. "Ethyl Gasoline Out," New York Daily News, May 6, 1925, p. 11.

73. "Demands Fair Play for Ethyl Gasoline," New York Times, May 7, 1925, p. 10.

74. "The Surgeon General's Conference," Industrial & Engineering Chemistry 17, No. 6, (June 1925), p. 552.

75. "Dealers in Other Cities Still Sell Leaded Gasoline," New York World, May 8, 1925, Section 2, p. 1.

76. "Synthetic Marvels Arouse Scientists," New York Times, May 8, 1925, p. 21.

77. "Liquid Fuels of the Future," Industrial & Engineering Chemistry,. 17 No. 6, (April, 1925), p. 334.

78. Homer S. Fox, "Alcohol Motor Fuels," Supplementary Report to World Trade in Gasoline, Minerals Division, Bureau of Domestic & Foreign Commerce, Trade Promotion Series Monograph No. 20, (Washington, D.C.: U.S. Dept. of Commerce, May 15, 1925).

79. "Lead Poisoning in Gasoline," New York Times, May 17, 1925.

Text

CHAPTER FIVE
THE INTERNAL CONTROVERSY OVER ETHYL

During the fall of 1924 and spring of 1925, as public health scientists battled industrialists in the pages of the nation's newspapers, a private controversy raged among the corporations directly connected with leaded gasoline: General Motors and Standard Oil of New Jersey, which created the Ethyl Gasoline Corp., and E.I. du Pont de Nemours, which was a one-third owner of General Motors and the primary manufacturer of tetraethyl lead. This internal controversy concerned safety standards in manufacturing, the availability of raw materials, the possibilities of alternatives to lead, and the tenure of Kettering and Midgley as president and vice president of Ethyl Gasoline Corp. These behind-the-scenes arguments show some of the real problems at issue.

Industry historians have not acknowledged any internal debate. For example, Joseph C. Robert's 1983 corporate history of Ethyl claimed that following the Bayway disaster, the manufacturing process "was discovered to be a hazardous operation that required new and stringent safety regulations," and that tetraethyl lead was "lethal far beyond original estimates."[1] Actually, the original estimates were quite serious, as we have seen in Chapter Three. In addition, the private debate about the speed of production, the number of lives being lost and the alternatives have not before been acknowledged in print, although many of the historical documents cited here have been available for over two decades.

In 1922, letters from scientists at Harvard, Yale and Pottsdam (in Germany) universities warned Charles Kettering and Thomas Midgley that tetraethyl lead was a "creeping and malicious" poison that had already had deadly effects.[2] These warnings were tossed off lightly, as we have seen. Midgley, for example, told a Cornell professor that lead colic was "nothing to worry about."[3]

Du Pont corporate executives were first informed about tetraethyl lead in March of 1922 when Pierre du Pont, on the board of General Motors, wrote that tetraethyl lead is "a colorless liquid of sweetish odor, very poisonous if absorbed through the skin, resulting in lead poisoning almost immediately."[4] By October, the du Pont corporation contracted with G.M. to produce 1,300 pounds of tetraethyl lead per day for $2.00 per pound. Those 1,300 pounds would amount to 100 gallons of pure tetraethyl lead or enough to boost the octane of 120,000 gallons of gasoline per day by about seven points. Planning began immediately for a new process line at the extensive du Pont chemical and gunpowder works at Deepwater, New Jersey, across the Delaware River from Wilmington, Delaware.

Meanwhile, General Motors set up a 7 gallon per day manufacturing line in Dayton, Ohio in 1922 to produce samples for prospective customers. G.M.'s product went into the first leaded gasoline to be sold at a service station, an event that occurred in Dayton, Ohio, on February 1, 1923. By late spring 10 more stations had begun using Ethyl gasoline.

In April of 1923, construction began on the large scale du Pont plant. Irenee du Pont wrote du Pont's technical director, W.F. Harrington: "It is essential that we treat this undertaking like a war order so far as making speed and producing the output, not only in order to fulfill the terms of the contract as to time but because every day saved means one day advantage over possible competition..."[5]

As an important aside, this note to Harrington establishes that du Pont, Ethyl and G.M. officials were worried about competition in 1923. The problem was not other sources of tetraethyl lead which, of course, would have infringed on G.M.'s patents, but rather other types of antiknock additives and refining processes which were beginning to come into the market at the time. The point is important because officials with G.M., Ethyl and Standard publicly claimed that no alternatives existed to tetraethyl lead.

Meanwhile, the du Pont plant's opening was delayed because "a considerable number of men had been more or less seriously affected" in the trial runs of the new system. By September, 1923 the 100 gallon per day operation was in full production, although at least one worker was in the hospital and others had begun to complain of strange hallucinations of flying insects. Workers began calling the plant the "House of Butterflies."[6] On September 21, Frank W. Durr, a 37-year-old process operator who had worked for 25 years for du Pont, became the first of eight du Pont employees to die of lead poisoning over the next two years. Du Pont took additional precautions and no other workers died of lead poisoning in Deepwater until the summer of 1924, when production was stepped up to meet new demands. Altogether, between 1923 and 1925, eight du Pont workers died. Du Pont's official unpublished history of the Ethyl controversy, written in 1936 in preparation for an anti-trust suit, contrasts its eight deaths in two years with Standard's five within one week:

> The available records seem to show plainly enough that there was no reckless rush [to get out production]... When the full measure of the peril became apparent, it seems not too much to say that protection against it was put ahead of every other consideration... [The du Pont deaths] represent no sudden holocaust due to the neglect of precautions that should clearly have been taken but rather the slow and gradual toll which humanity has always paid, and perhaps must always pay, for the conquest of new and dangerous ground. [Also] against the price which was paid, definite and permanent progress in bringing this humanly valuable new art to a basis of assured and permanent safety was accomplished. And finally, there was no public hysteria; and within the du Pont Company, there was no panic and no despair of the final outcome.[7]

Du Pont's pride that no public hysteria greeted developments at Deepwater is interesting in light of the secrecy surrounding the tetraethyl lead production unit. According to the New York Times, the death of veteran employee Frank Durr was not mentioned in any of the local newspapers, although two days later, as a point of contrast, the accidental electrocution of another man employed by du Pont for two months was reported on the front page of the local newspaper. "They suppress things about the lead plant at Deepwater," said the editor of the Penn's Grove Record, according to the Times.[8]

Demand for Ethyl fluid grew rapidly in 1923 and skyrocketed in January 1924 when

G.M. signed exclusive contracts with Standard Oil Co. of New Jersey (now Exxon), Standard Oil Co. of Indiana (now Amoco) and Gulf Oil Co. to distribute the new antiknock fluid on the East Coast, the Midwest and the South, respectively. The contracts stipulated that adding three grams of Ethyl fluid per gallon would have the same antiknock effect as adding 40 percent benzene.[9]

Du Pont had continual problems meeting G.M.'s increasing demands for tetraethyl lead through its bromine-based process. In June 1924 Kettering complained that the "whole program is prejudiced" because du Pont was moving too slowly.[10] At the same time, the G.M. Dayton staff was said to be "depressed to the point of giving up the whole tetraethyl lead program."[11]

Standard Oil Co., meanwhile, had developed and patented a new kind of tetraethyl lead manufacturing process based on ethyl chloride rather than bromine. Alfred P. Sloan, chairman of G.M., believed that competition would help hold du Pont back from potential price increases in the future and that the Standard patent position would force concessions from G.M. Standard's new process, then, was seen by G.M. as something that had to be brought into the operation. From another perspective, it might be said that Standard used its new process and patent position with ethyl chloride to get in on the ground floor of the Ethyl business. According to court testimony in later years, du Pont officials were unaware that G.M. was about to forge a partnership with Standard that would create the company called the Ethyl Gasoline Corp. in August, 1924.[12]

Standard's chloride process was slightly cheaper than du Pont's original bromide process by about four cents per pound (about 52 cents per gallon) of pure tetraethyl lead that would be diluted 1,200 times in gasoline. The retail level difference would be one-twentieth of a cent ($0.0005) per gallon of gasoline. However, the chloride process involved higher temperatures and pressures, which made it far more dangerous than the bromine process that had already killed six or seven workers and poisoned hundreds of others. Du Pont engineers had serious reservations when G.M. decided to allow Standard Oil Co. to build a tetraethyl lead plant using the chloride process at their refinery in Bayway, New Jersey, as the du Pont internal history emphasizes.[13] Because du Pont Corp. owned one third of G.M. stock and was a partner in everything G.M. did, Du Pont engineers felt they had a right to insist that manufacturing be kept in one place for safety's sake, especially considering the severe safety problems they already faced.

When du Pont's use of the new chloride process came up for consideration in the spring of 1924, a du Pont engineering committee insisted on approaching it with the idea of a closed system. Du Pont engineers wanted to keep the entire series of highly volatile chemical reactions closed off and isolated from workers from start to finish. Planning began in April, 1924 and construction began in September, 1924, but the du Pont ethyl chloride plant did not start operating for ten months. In contrast, Standard took less than three months to design and build the Bayway, N.J. plant, beginning in June 1924.

As demand accelerated in the summer of 1924, du Pont stepped up the older bromide production line from around 200 gallons per day to 400 in June, then 500 in July, and then 700 by August. As a result, Guiseppe Cianci, 24, a sludge laborer, died of lead poisoning on July 30; Frank A. Hanley, 28, a pipefitter, died August 12; and a 47-year-old janitor, Sim Jones, died October 20 after absorbing lead into his feet through the holes in the soles of his shoes. Du Pont engineers were alarmed at the deaths that, like those to come in Bayway, were preceded by wild and violent hallucinations.

The internal controversy came to a head when a delegation of du Pont chemists led by W. F. Harrington visited Standard's newly opened Bayway plant in September, 1924. The contrast between the du Pont approach and the Standard approach was evident from the moment Harrington and his team walked through the door. The internal du Pont history said the engineers were "greatly shocked at the manifest danger of the equipment and methods [and] at inadequate safety precautions," but their warnings were "waved aside."[14]

Harrington and the du Pont engineers saw a large, open factory floor with three main work areas. In the first area, an enormous iron vessel shaped like two ice cream cones top to top was rotating on its side. From within the vessel came the muffled sound of explosions as sodium reacted violently with ethyl chloride and lead. As the double cone rotated, steel balls which had been placed on the inside churned through the boiling sodium to ensure proper mixing. When the reaction calmed down, a crane moved the double cone to the second work area, where men unbolted the hatches over the narrow ends, releasing pungent concentrated fumes from inside. They attached steam lines and condensers, and tetraethyl lead was distilled in much the same way that whiskey is distilled from a vat of beer. When the distillation was over, workers opened the iron vessel once again and scraped the steaming, leftover lead mush through a grate in the floor with shovels, gloves and boots. As the mush went through the grate, workers recovered the steel balls that would be used to agitate the next batch. Workers were directly exposed to the toxic fumes at every stage of production, and the sole precaution taken by Standard was to issue rubber gloves and boots. Du Pont engineers were surprised, in the end, that so few of the 49 workers died at Bayway.

Kettering and Midgley at General Motors not only refused to listen to du Pont's warnings, they actually wanted du Pont to adopt Standard's process in order to produce as much as possible for the market. Harrington protested. "I personally thought it was too dangerous a process for us to use," he said, and du Pont got permission in the summer of 1924 to proceed with a closed ethyl chloride system that had been in the planning stages since April.[15] Du Pont's new closed process involved a stationary reactor with permanent agitators, a contained transfer system to a distillation unit in the floor below, and finally a contained recovery system for the leftover sludge. Irenee du Pont felt that, had the company been given more time, the more dangerous ethyl chloride process could have been made much safer. "In due course the more dangerous trip [technical development] could have been made safe, but it was an expensive trip to have tried it more or less prematurely in the hands of novices," du Pont said, referring to Standard's Bayway engineers.[16]

Although a grand jury acquitted Standard of criminal negligence at the refinery in February 1925, Irenee du Pont and his engineers believed that Standard had made a serious error of judgement. "Notwithstanding ... foreknowledge of the peril, the precautions taken in the small manufacturing operation at Bayway were grossly inadequate," said du Pont's unpublished history of the event.[17] Probably a better reflection of the tone of the internal controversy, however, was this closing statement concerning Standard's Bayway plant by a General Motors attorney in the 1953 anti-trust suit:

> They put up a plant that lasted two months and killed five people and practically wiped out the rest of the plant. The disaster was so bad that the state of New Jersey entered the picture and issued an order that Standard could never go back into the manufacture of this material without the permission of the state of New Jersey. In fact, the furor over it was so great that the newspapers took it up, and they misrepresented it, and instead of realizing that the danger was in the manufacture, they got to thinking that the danger was exposure of the public in the use of it, and the criticism of its use was so great that it was banned in many cities and they had to close down the manufacture and sale of Ethyl....[18]

The state of New Jersey had also forbidden du Pont to manufacture tetraethyl lead. Following an investment of $60,000 in a ventilating system that changed the air every 40 seconds, however, the governor of New Jersey allowed du Pont to continue.

Kettering Examines Potential Alternatives in Europe

As Standard built a new tetraethyl lead plant, the giant oil company also built a new relationship with General Motors. On August 18, 1924, officials of both companies signed contracts creating a joint venture called the Ethyl Gasoline Corporation. Charles F. Kettering was appointed president and Thomas A. Midgley was made second vice president and general manager. "The whole thing was in an evolutionary stage," G.M. President Alfred P. Sloan said later, "and it had to be accepted by the oil industry... The fact that they [Standard] were in the thing in an important way would give the stamp of approval of the biggest oil company on the material. It would give us enormous prestige."[19]

The name of the new Ethyl company was "argued out at length" in board meetings at Standard's headquarters at 26 Broadway, New York City. Alfred Sloan said the company "ought to inject into the name [the idea] that we were working on standards rather than that it was a commercial proposition."[20] In other words, the name should reflect that a new, higher quality fuel would become the "standard." Kettering, however, had already been using the name Ethyl in early marketing, in the Bureau of Mines study and other correspondence. Over Howard and Sloan's apparently mild objections, Kettering's "Ethyl" won.

Yet there was no doubt about who was really in charge of the new Ethyl Corp. On October 8, 1924, as Kettering prepared to leave for Europe, he must have been reminded of this fact as he went to Sloan's office to pick up his passport, tickets on the White Star Line's ship Homeric, express checks, letters of credit, letters of introduction, and memos about the process and profitability of tetraethyl lead. Kettering also carried six copies of one memo, the "tetraethyl lead chart of receipts."[21]

Although they had a new company to handle the antiknock compound, the still-tentative nature of G.M.'s commitment to tetraethyl lead at this point is evident in the du Pont history of leaded gasoline.

> In the summer of 1924 [when Kettering planned the European trip] the extremely hazardous nature of tetraethyl lead was already known to G.M., du Pont and Standard Oil; and the peril which this might involve for the commercial future of the joint enterprise was appreciated. Fatal results in a total of five cases had already attended the handling of the material at Deepwater and Dayton.... Irenee du Pont, in writing to (G.M. president Alfred) Sloan, commented ... 'It [tetraethyl lead] may be killed by a better substitute or because of its poisonous character or because of its action on the engine.'[22]

The "better substitute" was probably Kettering's main reason for going to Europe in the fall of 1924, but the ostensible motive was that, as full scale production and marketing geared up for tetraethyl lead in the summer of 1924, a secondary raw material turned out to be in short supply. The element bromine was desperately needed to market Ethyl because, as Midgley had found in 1923, pure tetraethyl lead would form a glaze over spark plugs after a few thousand miles unless a "scavenger" was used to clean it off. Bromine, used as ethylene dibromide (EDB), was the best material available. Made mostly from brine water or dried sea salt, the annual world production of bromine was less than would be needed for a month's production of Ethyl fluid, although some European and North African facilities apparently had room for growth. The major source of bromine in the U.S. was Dow Chemical Co., du Pont's major rival, and the major international source was I.G. Farben, the German chemical conglomerate. Although bromine could be acquired from Dow, it was not cheap. A one million dollar short-term contract with Dow had been approved in 1924, but G.M. and du Pont were not happy about the price.

Kettering sailed in mid-October and stayed at the Hotel Cecil in London, where he met with British colonial officials about bromine from the Dead Sea in Palestine. On October 26, 1924, he left for Paris and signed in at the Hotel de Crillon. There he received a telegram informing him of the disaster at Bayway. Beginning that day and continuing through the week, a flurry of telegrams were charged to his room. The telegrams have been removed from the archives, but some of the mail correspondence survives. G.M. patent attorney James McEvoy, in Paris with Kettering, reported to Sloan that Kettering "is very upset and worried, and neither he nor I can understand how Standard allowed this matter [the Bayway disaster] to obtain such broad publicity. The situation was just as at Dayton, and I do not see why it could not have been handled in the same way."[23] Sloan returned McEvoy's letter November 11:

> Unfortunately, something like five men were lost and we received a very great deal of unfortunate publicity. Fortunately for us, although our name was connected with it, the Standard Oil Company's name was more involved than ours... However ... nothing has in any way developed as a result of the accident to throw into the picture anything that we did not know four or five months ago when we sat around the table and analyzed the hazard. Therefore, logically, we should in no way make any change at all in the development of the project. On the other hand, it must be recognized that psychologically we are in a very much different position and it is much more important than it was four or five months ago not to have a repetition of this kind.. Therefore, we have all agreed that we should immediately withdraw the ethylizers and go to bulk distribution.

"Ethylizers" were one-liter bottles of Ethyl fluid that would be poured by hand into the clear glass tops of retail service station gasoline pumps of the era. Sloan wrote that no one had reported injury from the ethylizers and added that since the company was "more on the defensive than we were before" the company should blend Ethyl into gasoline at the "bulk distribution" level, not the retail service station.[24]

It is interesting that Kettering was travelling with McEvoy, the patent expert, when he was ostensibly looking only for sources of bromine to produce. "I went over to Europe with two things in mind: the brines of the Dead Sea and the French bromine plant in Tunisia," Kettering said in his private 1946 memoir. He did go to Tunisia to examine the bromine production operations there for eight days in mid-November, and he was in touch with British officials whose permission would be needed for trade with Palestine. However, Kettering had more than bromine on his mind. He was also in touch with Standard's president Frank Howard, who coincidentally was in Europe at the same time, and Carl Bosch of I.G. Farben. A telegram from Bosch was waiting when he returned from Tunisia to Paris.

The meeting between Kettering and Bosch, possibly with Howard and McEvoy present, took place at one of I.G. Farben's research laboratories in Manheim, Germany on November 28 or 29. Bosch "was naturally very interested as to how we would be in the chemical business at all," Kettering later said.[25] Quoting Bosch, Kettering continued: "'I cannot understand what you are doing in chemicals. The thing that worries me is how you fellows stumbled onto tetraethyl lead.' I said, 'You being one of the great chemists of the world, how would you have set the hurdles for people to stumble over?' And he said, 'That is what worries me.' I told him we did it with the atomic table and a pin board. He said, 'That might work in America, but I could never get my fellows to do it that way.'"[26] At the time, it should be remembered, German chemical industries were by far the world's leaders. It was widely believed that the U.S. had the petroleum, but that Europeans understood its composition and technology. However, most European researchers had left fuel knocking alone, according to one view, considering it the "happy hunting ground of those who deal in magic."[27]

However, concern about military defense led to development of strong alternative fuels production programs in many nations without oil reserves such as Germany, France, England, Italy, Hungary, Czechoslovakia, Poland, and others.[28] The alternatives included coal-derived benzene and methanol and agriculturally derived ethanol. Blended with gasoline in 20 to 50 percent proportions, the fuel blends did not produce the knock that straight American gasoline did. Since beverage alcohol was still legal in Europe, the complicating problems of Prohibition did not deter alternative fuels production. On the contrary, the fuel and chemical business was specifically encouraged in this direction by government research, tax incentives and, in some cases, mandatory blending programs. All of these fell into the category Kettering had previously called the "high percentage class solution."

In addition, German chemists were working on low percentage class solutions. In their November, 1924 meeting, Bosch gave Kettering a secret new antiknock substance to try out in his engine, but he did not tell him what it was, even when Kettering correctly guessed the secret. The substance was iron carbonyl, and Kettering fired off a telegram, probably to Sloan. The undated draft telegram, written on Hotel de Crillon stationary, and reproduced here with strikeouts, aptly demonstrates Kettering's excited state of mind:

> Badiche (Farben) have new ~~compound~~ antiknock. ~~Co~~ saw demonstration and made ~~few~~ rough measurements -- Requires about two and one half times ~~as much as~~ ours. ~~Cost very low.~~ Can produce their material at 21 cents per pound. ~~This would make a lead~~ I figure that with duty included freight etc. ~~The~~ Their compound would cost seventy cents for equivalent one pound lead. Their proposition is to furnish material at cost and take half the difference between our ~~lead~~ mixture cost and their equivalent as profit. Their compound byproduct of nitrogen fixation plant. They will disclose nature of product after commercial agreements have been made. It is metallo-organic and they feel is covered by our patents. This is ~~so very~~ interesting ~~as~~ must be considered prior to ~~any~~ other things. May be a carbonyl of cheap metal. Non-poisonous. (Kettering to Sloan, 1924, GMI Archives).

Kettering's level of interest in iron carbonyl indicates that he was ready, after the deaths in Dayton, Deepwater and now Bayway, to abandon lead and move forward with iron. Tetraethyl lead at the time cost \$1.66 per pound from the bromine process and \$1.16 from the chloride process.[29] To pay an equivalent price of 70 cents would clearly be attractive.

Kettering tried iron carbonyl on a Buick engine while in Europe and (in later years) said he had been disappointed. Apparently, iron carbonyl caked onto the spark plugs like tetraethyl lead without bromine, and it may have affected the lubricating ability of engine oil. Aware of Ethyl's troubles in the U.S., Bosch stressed that iron carbonyl was "practically non-poisonous and much cheaper to manufacture than tetraethyl lead." In any event, "we weren't as interested in [licensing] iron carbonyl as the IG Farben Co. was in selling it to us," Kettering said later.[30]

Bosch and other Farben chemists insisted that iron carbonyl did not cause the lubrication problems and cylinder wear that Kettering suspected. "During our own experiments and those made by motor car manufacturers and other reliable people," said a 1926 Farben memo, "these troubles in the lubricating system have never -- not even by way of intimation -- been found. Generally speaking it could be ascertained that the prejudice against the use of iron carbonyl was caused by the -- in itself -- harmless red coating, which is found in the compression chamber... It has been proven by many experiments that a grinding action is not in evidence."[31]

Ethyl, du Pont and Farben signed several agreements covering sale and manufacture of iron carbonyl antiknock additives in the U.S. in February and August, 1925, but not all was amicable. " I don't blame BASF [a Farben subsidiary] for feeling sore," Irenee du Pont said in June, 1925. "They know Kettering saw a sample of iron carbonyl though they didn't disclose what it was... He was keen enough to recognize what the material was, return home and file a patent application thereon. Without knowing the prior history that appears to them to be a rather sharp practice, though it would have been avoided ... if they'd been candid with Kettering under a pledge not to apply for patent."[32] Kettering later said he did not remember personally applying for a patent on iron carbonyl, but "we knew I.G. Farben had been making iron carbonyl long before I went over there." The patent activity behind the scenes raises doubts about Kettering's conclusion that problems with iron carbonyl were insurmountable. Contacts continued over use of iron carbonyl until in 1927, du Pont signed an agreement with I.G. Farben to market it in the U.S. Yet ignition and lubrication problems were said to have never been solved.[33]

In meetings with chemists and in his glimpses of the Farben plant where iron carbonyl was made, Kettering was also probably aware that Farben was manufacturing synthetic methanol from coal at a cost of around 10 to 20 cents per gallon. This, too, could have been a competitive element in the struggle for the antiknock market. Certainly, Ford Motor Co. was aware of it, and provided information about the process to the Surgeon General's committee looking into leaded gasoline in August of 1925.[34] Synthetic methanol as a fuel substitute was also mentioned in Industrial & Engineering Chemistry in August, 1925 and in a New York Times article in May, 1925.[35]

Kettering Returns with Possible Alternative

Kettering returned without a good source of bromine but with a possible alternative to tetraethyl lead. He wasted no time catching up with the researchers in the Dayton labs. A memo on December 22 dealt with the need for weekly reports and a focus on specific problems in copper-cooled engine research and other areas.[36] Waiting on his desk was a memo from T.A. Boyd describing new British attitudes toward tetraethyl lead. British researchers were skeptical about lead and had been more committed to blends of ethyl alcohol, benzine and gasoline; although, Boyd noted, the attitude was changing. W.R. Ormandy and E.C. Craven had written in an October report that tetraethyl lead had helped create a fuel capable of withstanding high compression, but "as lead salts are cumulative poisons, the results of large-scale employment might lead to trouble." Henry Ricardo said that while most fuel mixtures had been fully characterized, the new fuel "dopes" still needed research. "Those known at present have, it is true, some serious drawbacks, but there is no reason to suppose that other more practicable substances may not exist."[37] This was, apparently, an improvement over earlier more negative attitudes.

Bayway and the public controversy dominated the Ethyl board of directors meeting held December 23, 1924, at Standard's headquarters at 26 Broadway. Frank Howard and two other Standard board members "were in a blue funk over the whole [Bayway] thing," recalled Irenee du Pont, who became a member of the board at the meeting. "The directors were very much afraid about it. They didn't know what was going to happen to them."[38] According to du Pont's memo of the meeting, iron carbonyl had been set aside a year or two beforehand "because it was doubtful if the material could be produced commercially at a reasonable figure." Technical problems were not mentioned in du Pont's memo, but discussions on methods of negotiation with I.G. Farben and patent positions held by the two companies clearly indicate an ability and desire to go forward.

Also at the December board meeting, Standard billed the Ethyl Corp. for its net losses from Bayway, which included $100,000 in damage suits from workers and families that Standard was apparently ready to settle out of court. In effect, G.M. and du Pont agreed to share the cost of the Bayway disaster. Since Standard had been acting as an agent for the Ethyl Corp. at the time, Ethyl should pay the entire bill, du Pont said, "unless there had been gross carelessness [and] we could hardly take that position..."[39]

On Christmas Eve, 1924, the day after the board meeting, Kettering, Howard and du Pont chief engineer Harrington visited Surgeon General Hugh Cumming in Washington and asked him to hold a public hearing after the Bureau of Mines and Columbia University reported their findings. "In the prevailing state of strong prejudice and excited fears, the new industry was fortunate in having the question of the health risk in the use of tetraethyl lead actively taken up ... by the U.S. Public Health Service," according to the du Pont history of leaded gasoline. By this time, Yandell Henderson had already asked the Surgeon General for a conference on tetraethyl lead. At some point in late 1924 or early 1925, Kettering also visited with Commerce Dept. Secretary Herbert Hoover. The future president was interested in the Ethyl dilemma, although later the New York Times quoted him as saying that the Commerce department "had not been asked to take an investigation of the poisonous or non-poisonous qualities of tetraethyl and did not contemplate entering into the present controversy."[40] A Commerce Department report dated May 15, 1925 on alcohol fuel use worldwide shows that Hoover was aware of the alternatives.[41]

Over the holidays and during the winter of 1925, Public Health Service (P.H.S.) representatives visited the Bayway and Deepwater refineries, talked extensively with engineers, and became convinced that safe manufacturing was at least theoretically possible. Du Pont engineers, especially, believed that if given the chance they could create an entirely closed environment safe for workers who handled deadly chemicals. However, during February and early March of 1925, four more workers died in the new ethyl chloride process tetraethyl lead refinery.[42]

This time, the names of the workers and the circumstances of the deaths were disclosed by the company. The plant was repeatedly started up and shut down in an attempt to improve process safety. Finally, on May 2, 1925, the Deepwater plant was completely closed, and in June, 1925, the news that eight (or possibly nine) employees had died in the tetraethyl lead plant came out in the New York Times. "It is absurd to say that the du Ponts have suppressed anything," said C.K. Weston, head of the du Pont publicity bureau, to a Times reporter in June, 1925. The four or five deaths from September 1923 to October, 1924 were not treated as "news" because there was no public interest until after the Bayway disaster, he said. Weston also said that the du Ponts were "well known for their interest in their employees" and "spared no expense" to protect their health. He said that he had heard "Butterfly Factory" was the workers name for the plant. "Some of them drew pictures of butterflies on the walls of the plant," he said.[43]

Ethyl's Public Relations in the Winter of 1925

With a few months to go before the Surgeon General's hearing, Kettering and other Ethyl officials began to think about public relations. A banking associate put Kettering in touch with Allan Hoffman, editor of Scientific American, who expressed a "desire to be helpful to you." The associate, Seward Prosser of Bankers Trust, also said "it is important to have him (Hoffman) on our side."[44] Within a few months, public relations expert Rex F. Harlow would also be working on Ethyl publicity.[45] And by 1926, Columbia University journalism teacher James T. Grady, who was part-time editor of the American Chemical Society's news service and a veteran of the Herald Tribune, would also work with Kettering and Midgley to get the Ethyl story out in speeches and press releases.

Most important at this stage would be the scientific defense of tetraethyl lead to fellow scientists. Midgley took on the defense at the American Chemical Society conference in April, 1925. Midgley's discussion began by listing his discovery's benefits -- conservation of petroleum, reduction of carbon monoxide, improved mileage and lowered initial cost of cars. Although most of Midgley's arguments were self-serving, scientists may have been surprised when he arrived at the central premise of his discussion and flatly claimed that no alternatives existed to Ethyl gasoline. Midgley's conference paper, as quoted by a New York Times reporter and printed in Industrial & Chemical Engineering, said:

> So far as science knows at the present time, tetraethyl lead is the only material available which can bring about these [antiknock] results, which are of vital importance to the continued economic use by the general public of all automotive equipment, and unless a grave and inescapable hazard exists in the manufacture of tetraethyl lead, its abandonment cannot be justified.[46]

The sweeping claim was strange in a number of respects, but especially because, as many scientists knew, it directly contradicted Midgley's own work and that of his associates.[47] Also, as noted above, the rush to manufacture tetraethyl lead had been based on the concern about competition from other sources of antiknock additives.[48] In fact, Midgley's paper was riddled with contradictions. It put the focus of controversy on the manufacture of tetraethyl lead, although public health was the primary concern. It exaggerated the potential for conservation (although not as much as other partisans did).[49] It said the cost of cars would decrease, but higher compression engines (despite advantages) were heavier and inherently more expensive, as Midgley himself had acknowledged in conversations at Society of Automotive Engineers meetings.[50] In short, very little about Midgley's 1925 ACS paper seems in synch with his previous work. Either Midgley was a clumsy liar or his ACS paper had been subject to heavy handed editing by someone who was not very familiar with his work. Either way, no journalists and apparently none of his fellow scientists took public notice of the contradictions.

What was really going on behind the scenes? If eliminating engine knock was vital to the continued economic use of automobiles, did that mean that General Motors was afraid that oil might be running out? Was the company preparing for the day when the oil wells ran dry by boosting compression to the point where alternative fuels could be effectively used? This would be consistent with the du Pont history that, as noted in Chapter Three, mentions this transition to alternative fuels as the "important special motive" for the original antiknock research.[51] It is consistent with Kettering, Midgley and Boyd's 1920-22 interest in alcohol fuel as "of course, the fuel of the future" and especially in Yale University research into cellulose feedstocks for alcohol fuel. It is consistent with the "universal assumption" (noted by Scientific American in 1920) that alcohol would be the fuel of the future. It is also consistent with the concern over the depletion of oil reserves and market conditions of the era, in which alcohol sold at a cost within the same economic range as gasoline.

The idea of using tetraethyl lead to pave the way for alternative fuels is not consistent with existing histories of Ethyl Corporation or the oil industry. Research into ethyl alcohol fuel is not mentioned in Joseph C. Robert's corporate history of Ethyl, in Rosamond Young in Boss Ket or in T.A. Boyd's Professional Amateur. Nickerson's history mentions a "synthetic knock-free fuel" from cellulose without naming it. Williamson and Daum do not use the word alcohol in their history of the oil industry. Stuart Leslie noted ethyl alcohol as one of the many useful possibilities Kettering found while studying the knocks, but Leslie said the expense of alcohol and the supply possibilities led Midgley and Kettering to conclude it was "a will o' the wisp."

However, it is not at all inconceivable that Detroit would keep its eyes on the horizon of foreseeable oil reserves if they were expected to run out in 20 years. Nor is it inconceivable that existing alternative fuels -- ethyl and methyl alcohol, benzene, and others -- would be considered as the most likely alternatives when oil ran out. On the other hand, it is possible that alternatives were largely forgotten after tetraethyl lead was discovered, despite the papers written by Boyd and Midgley, or seen as difficult to use given the extraordinary regulations surrounding Prohibition, or, perhaps, seen as too threatening to Standard Oil Co., which had become a partner in G.M.'s a fuel venture. Unfortunately, many of the records that might help settle the question, such as the Lead Diary, day-to-day records of the Dayton labs, minutes of the Ethyl board of directors and others are not in the archives.

Kettering and Midgley Forced out of Ethyl

On April 21, two weeks after Midgley's ACS paper was delivered, he and Kettering attended another board of directors meeting of the Ethyl Corp. in Standard's headquarters at 26 Broadway. One step that had to be taken was to suspend the sale of Ethyl brand leaded gasoline until the P.H.S. inquiry was over. Ethyl announced the move May 5, 1925.

Another step involved a surprise reorganization of the management by the board of directors. As the General Motors and Standard executives discussed the upcoming P.H.S. conference, they pointedly noted that Midgley and Kettering had not confronted many of the business problems of building the Ethyl Gasoline Corp. "I have felt from the very beginning of the formation of this company, in fact, I felt a year before it was formed, that we would make progress much more rapidly and more constructively if we had more of a business side to the development," G.M. President Alfred Sloan had written to fellow board member Irenee du Pont just before the board meeting. The letter to Sloan described a meeting with the third principal party in the Ethyl triangle, Standard Oil president Walter Teagle. Sloan told du Pont that he and Teagle agreed that Kettering had to go. Sloan warned du Pont that Kettering had been "violently opposed" to losing control of Ethyl Corp. Sloan said that he had left "the boys" (as he called Kettering and Midgley) in place despite serious misgivings, believing that his point would eventually become so obvious that it would have to be recognized. "We felt that it was a great mistake to leave the management of the property so largely in the hands of Midgley who is entirely inexperienced in organization matters."[52] Kettering and Midgley should go back into research, where they belonged, he said. Sloan proposed Earl Webb, a G.M. lawyer, as the new president. Whether or not Kettering and Midgley argued against their firing, the board accepted Webb as the new president of Ethyl.

The reorganization of Ethyl was not publicly announced. In fact, Kettering was introduced to the May 20 Surgeon General's conference as the "president" of Ethyl Gas Corp.

even though he had been officially replaced a month before. Company historian Joseph C. Robert noted Kettering later said that he had been "fired to create a position for a man who would make more money." Robert's interpretation is that Kettering made a "jocular oversimplification," and in effect, agreed that a management-oriented president would help G.M. and Standard make more money.[53] An alternative interpretation is that Kettering was disappointed about (or even as Sloan said, "violently opposed" to) losing control.

Kettering's genius lay not in manufacturing but in organizing research, and it is no surprise that he was let go. No picture of the situation is available from his perspective and he never mentioned it in his unpublished Ethyl memoirs. However, Kettering may have wanted to take the corporation in different and potentially less profitable directions which had been blocked at the research level. The announcement from G.M.'s Dayton labs of a new synthetic alcohol "Synthol" fuel in the summer of 1925 is one indication of alternative technical directions. The fuel was said by the United Press to be a mixture of benzene, alcohol and iron carbonyl, or, by the New York Times account, benzene, tetraethyl lead and alcohol. Both methyl and ethyl alcohols may have been involved. Used in combination with a new high compression engine much smaller than ordinary engines, "Synthol" would "revolutionize transportation"[54] the articles said, and motorists would get 40 or 50 miles per gallon. Perhaps Kettering would have continued other antiknock research, broadening the field instead of letting it stagnate around one product. Other oil companies, especially Sunoco, made a point of finding substitutes for Ethyl leaded gasoline in the mid to late 1920s.[55] By October, Kettering noted that t the search for a substitute for petroleum had become problematic: "Many years of development may be necessary before the actual development of such a substitute," he said.[56] However, Kettering always held out hope, his friend Charles Stewart Mott said later, "that if a time ever came when the sources of heat and energy were ever used up ... that there would always be available the capturing of the amount of energy that comes from the sun... One of the ways was through growth of agricultural products[57] ..."

<u>Conclusion</u>

Although many of the details are hazy, some generalizations about the internal controversy over the future of the Ethyl Gasoline Corp. emerge from legal histories, unprocessed archive documents and trial testimonies. Clearly, Du Pont engineers understood the danger of the chemical and showed some concern for their workers. At one point, du Pont engineers refused outright to adopt Standard's grossly inadequate manufacturing techniques, despite a great deal of pressure from G.M. Standard was concerned with maximizing profits on the ground floor of the new enterprise, and having designed a new chemical process for making Ethyl brand leaded gasoline, rushed to make it. However, the manufacturing plant was so unsafe that it operated only two months before workers started dying. General Motors pushed Standard and du Pont to move as quickly as possible because G.M. officials were privately worried about the competition from alternative anti-knock fuels which they publicly claimed did not exist.

The motives of the man at the center of all the action are hard to discern. Although a practical man and a proud scientist, Charles F. Kettering must have been disappointed at the public outcry over Bayway and the subsequent loss of control over what was essentially his creation. The supreme irony must have been to go through the motions of defending the corporation and speaking as its president at the Surgeon General's conference on May 20, 1925 after he had been secretly replaced a month before. The announcement of a "revolutionary" new type of fuel in August, 1925, would appear to be the kind of trial balloon that had been floated in 1922, when Kettering wanted to impress Detroit with the public interest in a fuel-saving additive. Whether or not Kettering was able to force concessions out of Detroit in response for backing off the "Synthol" fuel revolution is unknown, but "Synthol" was never heard from again. For the rest of his life, Kettering confined his ideas about alternative fuels to abstract discussions about photosynthesis and did not initiate concrete research programs. For G.M., du Pont, Standard and Ethyl, the internal controversy was ending even as the Surgeon General's committee had begun its study. Kettering and Midgley had been removed from the picture, the engineering process had been made safer, and as they knew, the Surgeon General's committee of experts would not find any problems affecting workers in Ohio.

---

1. Joseph C. Robert, Ethyl: A History of the Corporation and the People Who Made It (Charlottesville, Va.: University Press of Virginia, 1983), p. 119 and p. 120. Italics added.

2. T. A. Boyd, The Early History of Ethyl Gasoline, Report OC-83, Project # 11-3, Research Laboratory Division, GM Corp., Detroit Michigan, (unpublished) June 8, 1943, GMI, Flint, Mich., p. 2. (Hereafter cited as Boyd, Early History).

3. Midgley to A.W. Browne, December 2, 1922, Unprocessed Midgley collection, GMI, Flint, Michigan.

4. P.S. du Pont to Irenee du Pont, March 24, 1922, "Memo RE: Doping of Fuel," Exhibit C, N.P. Wescott, Origins and Early History of the Tetraethyl Lead Business, June 9, 1936, Longwood MS Group 10, Series A, Hagley library and Museum, Wilmington, Delaware.

5. Ibid, p. 9.

6. Silas Bent, "Tetraethyl Lead Fatal to Makers," The New York Times, June 22, 1925. Harry Zanes became ill September 9 but survived the tetraethyl plant. Another employee, John Demesse, died September 11 of a combination of typhoid and lead poisoning. Some 300 other workers were poisoned at the Du Pont plant, according to officials Bent quoted.

7. N.P. Wescott, "Origins and Early History," p. 12.

8. "Tetraethyl lead fatal to makers," New York Times, June 22, 1925.

9. Ethyl Gasoline Corp. et al. v. United States, 309 U.S. 436, (1940), Dept. of Justice records, National Archives, Washington D.C. See also U.S. v. E.I. Du Pont de Nemours and Co., 126 F.

Supp. 235. (cited as U.S. v du Pont), 1952.

10. Testimony of W.F. Harrington, US v du Pont, p. 6487.

11. Robert, Ethyl, p. 121

12. Testimony of Alfred P. Sloan, US v. du Pont, p. 2941.

13. Wescott, Origins and Early History, p. 20.

14. Ibid, p. B-4.

15. Testimony of W.F. Harrington, US v du Pont, p. 6487.

16. Memo in response to Wescott's Origins and Early History from Irenee du Pont, June 29, 1936. Govt trial exhibit 775, transcript p. 1852, U.S. v Du Pont.

17. Wescott, "Origins and Early History," p. 21.

18. Ferris Hurd, closing statement, US v du Pont, p. 7986.

19. Testimony of Alfred Sloan, US v du Pont, p. 2941.

20. Ibid, Government Trial Exhibit 666, Memo dated July 21, 1924.

21. Memos and charts themselves not available in GMI collection.

22. Wescott, Origins and Early History, p. 21.

23. David Hounshell and John Smith, Science and Corporate Strategy: Du Pont R&D, 1902-1980 (New York: Cambridge University Press, 1988), p. 154. How exactly the two deaths were handled in Dayton is not known, since memos have not survived. The similarity between the incidents is difficult to judge, but at Bayway, five men suddenly went berserk from a sudden onset of severe lead poisoning in a most dramatic manner, an in close proximity of a highly competitive news market. The Dayton, Ohio and Deepwater, N.J., newspapers were far more willing to defer to their corporate neighbors and not ask embarrassing questions about the accidental deaths of workers.

24. Sloan to McEvoy, Nov. 11, 1924, unprocessed Kettering collection, GMI. Accidental injury from ethylizers may well have taken place with or without Sloan's knowledge. Service station attendants typically poured a few shots of the material directly into a high glass tank where gasoline had been pumped before being released into the gas tank. The small glass tank at the

top of the pump would allow customers to see what they were getting, but it also meant an awkward reach for attendants who would be affected if only a few drops of the material got on their hands.

25. As a subsidiary of Standard Oil, Ethyl must have been an awkward element in Standard and Farben's discussions over how to carve up international markets in fuel and chemicals. At some point in the mid-1920s, Howard raised the idea with I.G. Farben officials of a "full marriage" between their companies to carve up dominance in world markets. If Kettering had a role in the larger deal, it would have been from the standpoint of Ethyl's involvement and overall technology assessment. Standard was mostly interested in keeping new processes to synthesize methanol and other fuels from coal off the international markets for the present but available in the future in case oil ran out. Farben wanted investment funds and protection for its patents in the U.S. Farben was known to be interested in production of tetraethyl lead. Standard, G.M. and Ethyl were positioning themselves to "outlast the war" no matter which side won, and were considered by British intelligence leaders to be "hostile and dangerous elements" of the enemy. See William Stephenson, A Man Called Intrepid (New York: Ballentine, 1976), p. 284; Joseph Borkin, The Crime and Punishment of I.G. Farben (New York: Free Press, 1978), p. 79. Note also that memos around this time show Kettering was privy to many corporate secrets. For instance, a du Pont director, A. Sparre, wrote Kettering October 23, 1926 asking about the German chemist Bergius (inventor of a coal process for liquid fuel) addressing a professional society; "I do not want you to tell me anything which I am not entitled to know..." Sparre said deferentially in recognition of Kettering's access to a realm of privileged information to which a du Pont board of directors member was not entitled.

26. Testimony of Charles Kettering, US v du Pont, p. 3622.

27. S.D. Heron, Development of Aviation Fuels, (Cambridge, MA: Harvard University Graduate School of Business Administration, 1950), p. 560.

28. Bill Kovarik, Fuel Alcohol: Energy and Environment in a Hungry World (London: Earthscan, 1982), p. 62.

29. By 1937 it would fall to 26 cents per pound, or $3.38 per gallon of pure tetraethyl lead. (There are 13 pounds in a gallon of Ethyl lead).

30. Testimony, Charles Kettering US v Du Pont, p. 3624.

31. "Experiences with Iron Carbonyl in Germany," IG Farben, Government Trial Exhibit No. 722, US v du Pont, 1953. It is difficult to know which side of this technical debate to believe. In many cases research performed in preparation for contract negotiations may be defensive. It is likely that the buyer (G.M.) overstated the problem while the seller (Farben) understated it.

32. Du Pont to Sloan June 26, 1925 Government Trial Exhibit 715, US v du Pont, transcript p. 3631.

33. Ibid. Also, Nickerson, "Tetraethyl Lead." Note that I.G. Farben was a conglomerate of German chemical companies which included BASF, or Badische Analin and Soda Fabrik, and seven other firms which had merged all assets in 1924.

34. William H. Smith, Ford Motor Co., to C.E.A. Winslow, August 15, 1925, notes the manufacture of 60,000 gallons per month at the Farben plant. C.E.A. Winslow Papers, Yale University archives.Note that Winslow sent this note from Ford to others on the tetraethyl committee and to the PHS, but the PHS files on alternatives to leaded gasoline have vanished from the U.S. National Archives.

35. "Liquid Fuels of the Future," <u>Industrial & Engineering Chemistry,</u> Vol. 17, No. 6, April 1925, p.334. Also, "Synthetic Marvels Arouse Scientists," <u>New York Times,</u> May 8, 1925, p. 22.

36. C.F. Kettering, Memorandum Dealing with Research Program, Dec. 22, 1924, Box 5, File F, GMI.

37. T.A. Boyd to Kettering, "Changed English View of the Importance of Anti-knock Development of this Laboratory," Nov. 11, 1924, Midgley unprocessed, GMI. Boyd is citing W.R. Ormandy & E.C. Craven, as well as H.R. Ricardo, in 1923-24 Report of the Empire Motor Fuels Committee.

38. Testimony Irenee du Pont, p. 2169 US v Du Pont 1953.

39. Memorandum of Meeting of Board of Directors of Ethyl Gasoline Corp. Dec. 23, 1924. by

Irenee du Pont, Government Trial Exhibit 676, U.S. v Du Pont.

40. "Synthetic Marvels Arouse Scientists," New York Times, May 8, 1925.

41. Homer S. Fox, "Alcohol Motor Fuels," Supplementary Report to World Trade in Gasoline, Minerals Division, Bureau of Domestic & Foreign Commerce, Trade Promotion Series Monograph No. 20 (Washington, D.C.: Dept. of Commerce, May 15, 1925). The report provided detailed statistics on trade volume, duties, tax incentives and laws surrounding the use of alcohol blended fuels, including ethanol and methanol, in France, Germany, England, Italy and 15 other countries were it was routinely used.

42. N.P. Wescott, "Origins and Early History." Workers were: Fred.W.DeFiebre, 21; Robert Huntsinger, 35; Loring Boody, 53; and James Connell, 49. Du Pont engineers were not successful in creating the closed system they envisioned, a fault which Wescott attributed to pressure from GM to produce more quickly. The fully enclosed processing system would eventually become the basis of du Pont's future tetraethyl lead production, and millwright Connell's death on March 28, 1925 would be the last until an incident in the late 1950s, when eight more workers died.

43. "Tetraethyl Lead Fatal to Makers," New York Times, June 22, 1925.

44. Prosser to Kettering, Telegram, Jan. 5, 1925, Box 5, File 165, Kettering collection, GMI, Flint, Michigan.

45. Rex Harlow to Kettering, October 12, 1925, Box 5, GMI, Kettering Collection, Flint, Michigan.

46. "Radium Derivative $5,000,000 an ounce / Ethyl Gasoline Defended," New York Times, April 7, 1925, p. 23; Also, Thomas Midgley, Jr., "Tetraethyl Lead Poison Hazards," Industrial and Engineering Chemistry, Vol. 17, No. 8 August, 1925, p. 827.

47. See, for example, Thomas A. Midgley and T.A. Boyd, "Detonation Characteristics of Some Blended Motor Fuels," Society of Automotive Engineers Journal, June 1922, page 451. Similar statements about ethyl alcohol, benzene and other anti-knock agents are found throughout the early 1920s. In April, June, July and August of 1925, Industrial & Chemical Engineering published papers by a variety of scientists on alternative fuels, including ethanol from sugarcane

and methanol from coal. A May, 1925 article in the Society of Automotive Engineers Journal detailed the work of the Fuel Research Board on alcohol fuel blends in Britain ("Power Alcohol from Tubers and Roots," SAE Journal, May 1925, p. 546.)   Note that neither Midgley nor any of the other researchers working on studies of anti-knock agents published before 1933 raised any serious technical objection to the use of alcohol blends with gasoline. When alcohol fuel became a political issue in 1933, oil industry pamphlets claimed alcohol blends produced "serious difficulties," but even then admitted that alcohol had "a high anti-knock value.""Analysis of Technical Aspects of Alcohol Gasoline Blends," American Petroleum Institute, Special Technical Committee, April 10, 1933, J. Howard Pew papers, Series 4 Box 52, Hagley Museum and Library, Wilmington, Del.

48. Irenee du Pont to Frank Harrington, cited in Wescott, Origins and Early History, p. 9.

49. "Says Lead Mixture Doubles Gas Mileage," New York Times, March 29, 1925, p. 20. This statement by the Pennsylvania State University Dept. of Chemistry chairman is quite exaggerated, but would have been taken as highly authoritative at the time. It is another reflection of the investment of credibility by the scientific community in tetraethyl lead prior to obtaining actual experimental data which, as it turned out, was not all that impressive. Typically, the benefit was 30 percent fuel efficiency improvement in a higher compression ratio engine not yet marketed. Ethyl engineers later claimed 45 percent improvements in Graham Edgar, "The Manufacture and Use of Tetraethyl lead," Industrial and Engineering Chemistry, December, 1939, Vol. 31, Pp.. 1439-1446, esp. Figure 3. However, Edgar clams an average of 45 percent improvement but compares a 70 RON fuel in a 5.5 CR engine with a 100 RON in a 10.3 CR engine; the former is below while the latter was far above market levels.

50. "Discussion of Papers at Semi-Annual Meeting," SAE Journal, October 1921, p. 269; also see July, 1921 for papers on high compression engines.

51. Wescott, Origins and Early History, p. 4.

52. Sloan to Du Pont, March 28, 1925, Government Trial Exhibit No. 678, U.S. v. du Pont et al., US District Court, Chicago, 1953.

53. Roberts, Ethyl, p. 124.

54. "Work on New Type of Auto and Fuel," New York Times, August 7, 1925; also "New Auto, Fuel to Save Costs are Announced," United Press, August 6, 1925.

55. For example, Ludlow Clayden, Chief Engineer of Sun Oil Co., predicted 75 to 100 mile-per-gallon fuel in 20 years -- without Ethyl gasoline. "The cost of fuel shouldn't exceed present prices, as it is possible to improve the quality of natural gasoline without resorting to use of Ethyl -- a more expensive product," he said. Clayden was referring to Sunoco's development of catalytic reforming at its Marcus Hook, N.J. refinery that boosted octane by 15 to 20 points -- twice as much as Ethyl and at a much lower cost. See "Predicts Double Gasoline Mileage," New York Sun, Jan. 20, 1926.

56. "May Take Years to Find Good Gasoline Substitute," New York Times, Oct. 25, Section 9, p. 14. Also, Associated Press, "Gas Substitutes Held Uneconomical," Detroit Free Press, October 2, 1925.

57. C.S. Mott, Kettering Oral History Project, Interviewed by T.A. Boyd, October 19, 1960, GMI.

Text

CHAPTER SIX
THE CONFRONTATION CONTINUES

Alice Hamilton's eyes blazed; her voice shook with emotion. "You are nothing but a murderer," the silver-haired Harvard University scientist declared to Charles Kettering. As America's leading expert on worker safety and lead poisoning, Hamilton had reason to believe that Kettering was to blame not only for the negligence involved in the Bayway deaths and injuries, but also for the thousands more that she believed would follow if General Motors (G.M.), du Pont and Standard Oil of New Jersey allowed their joint venture, the Ethyl Gasoline Corporation, to renew sales of leaded gasoline.[1]

The confrontation between Hamilton and Kettering took place in the hallway of a Washington, D.C. federal office building a few blocks southeast of the US Capitol on the morning of May 20, 1925 during a break in a Public Health Service (P.H.S.) conference on leaded gasoline. G.M. researcher T.A. Boyd witnessed the scene and later wrote in an unpublished memoir about the fire in Hamilton's eyes and the bite in her words.

According to Boyd, Hamilton said: "Why, there are thousands of things better than lead to put in gasoline." At this, Kettering must have drawn up his gangling, crane-like frame and looked down in surprise at this frail woman. He answered her with the detached amusement that colleagues admired but Hamilton must have found grating:

"I will give you twice your salary if you will name just one such material," Boyd recalls Kettering saying. "Oh, I wouldn't work for you," was Hamilton's supposed response, which Boyd saw as "weak and unprofessional."[2]

In his own unpublished memoirs of the event, Kettering recalled the confrontation more charitably. "Dr. Alice Hamilton of the Harvard Medical School was of the opinion that under no circumstances should the product be sold; but that, if it had the high values that we claimed for it, other materials should be substituted in its place at once. She said that she felt perfectly confident that there were at least 50 compounds that would be better than lead. I asked her to give us the names of a few. She replied that it was not her business to invent antiknock materials, but that anybody who had any knowledge whatever of organic chemistry would would know what those compounds were."[3]

Hamilton apparently did not attach as much importance to the private confrontation in memoirs or letters.[4] She saw the conference as a David and Goliath confrontation, "with Standard Oil and the du Ponts on one side and, on the other, a few scientists and the New York World."[5] It may have come as something of a surprise to see Kettering wrapped in the mantle of objective science. Perhaps Hamilton was angry, but Boyd and Kettering's pictures of her seem out of character. In confrontations with industrialists whose policies endangered workers, Hamilton usually engaged in a spirited argument ending with a direct and frequently warm-hearted appeal to the kindness of the owner or factory manager, urging him to greater heights of humanitarian feeling.[6] She usually tried to turn confrontation into cooperation without compromising her principles. Although the dialogue may have occurred more or less as Kettering and Boyd recalled, the interpretation depends greatly on perspective.

<u>The Public Health Service Conference</u>

The confrontation between Hamilton and Kettering illustrates the extreme differences between scientific viewpoints at the P.H.S. conference on tetraethyl lead. Some 87 participants gathered in the Butler building at Third and B streets in May 1925 represented labor groups, oil companies, universities and government agencies. Also crowding into the Treasury department auditorium that Wednesday morning were a dozen news reporters. Absent was Treasury Secretary Andrew Mellon, who as head of the agency overseeing the P.H.S., should have given welcoming remarks. However, Mellon's own Gulf Oil Co. had exclusive contracts to distribute Ethyl gasoline in the Southeastern U.S. at the time, and he may have wished to avoid the appearance of impropriety.[7] Interior Secretary Hubert Work gave the opening address instead. The Assistant Secretary of Treasury, the Surgeon General, and Charles Kettering are listed as principal speakers; others from labor, universities and industry are listed in specific panels. Significantly, Kettering's authority was equated with that of impartial government officials. Kettering opened the conference by describing the development of antiknock fuels:

> We found out that with ordinary natural gas we could produce certain [antiknock] results and with the higher gravity gasolines, the aromatic series of compounds, alcohols, etc., we could get the high compression without the knock, but in the great volume of fuel of the paraffin series we could not do that.[8]

This apparently authoritative statement skims across several questionable premises to the conclusion Kettering obviously desired. In the first place, aromatics are made from petroleum and refining for increased aromatic content could improve a fuel's anti-knock rating. Also, alcohols do not necessarily have to be made from petroleum -- they can be made from other materials and mixed with gasoline to improve anti-knock rating. No one at the conference directly questioned the premise, although several public health scientists insisted in a general way that alternatives were available.

Subsequent discussions at the conference sharpened points of disagreement and focused on the need for more information. Midgley, Howard and others from the Ethyl side testified, as did Hamilton, Henderson, and scientists at Columbia University, concerning the immediate and long range public health risks from lead in exhaust fumes versus the general benefits of leaded gasoline. Also at issue was whether the burden of proof should be on industry or public health advocates. Industry officials, such as Frank Howard of Standard Oil, argued that with limited oil reserves, conservation through more efficient engines was needed. They said regulation over minor fears, such as the impact of lead on public health, would stifle the progress of industrial civilization. Hamilton, Henderson and other public health experts maintained that in the case of such uncertainty about public health, the burden of proof fell on the industry and not on those concerned about public health. Industry should have to prove a new chemical safe; it was not up to scientists to prove it unsafe, they said. Further, Henderson and Hamilton insisted that industry could find alternatives.

Government officials had little to say at the conference, other than to note that there were no laws that allowed the P.H.S. to regulate chemicals in the same way that the Food and Drug Administration and the USDA regulated pharmaceuticals and meat packing. However, one result of the conference, partially in response to criticism of the 1924 Bureau of Mines report., was the announcement that the Surgeon General would form its own investigating committee.[9]

Most news reports focused on the announcement of an investigating committee, but as might be expected, each newspaper had a different view of what was significant. The Times attempted to quote from many different points of view, noting an especially dramatic confrontation between Howard and Grace Burnham of the Workers Health Bureau. As the Times reported it, Howard said: "Present day civilization rests on oil and motors... We do not feel justified in giving up what has come to the industry like a gift from heaven on the possibility that a hazard may be involved in it..." A few moments later, Grace Burnham stood up said: "It was no gift of heaven for the 11 who were killed by it and the 149 who were injured." (Actually, 17 men had been killed and many more had been injured). The Times also briefly took notice of Alice Hamilton who "urged the men connected with the industry to put aside the lead compound entirely and try to find something else to get rid of the knock."[10]

The Herald Tribune carried excerpts from an Associated Press article that emphasized the industry viewpoint. The headline said: "Ethyl Gas Safe, Say Experts, If Used with Care." The Herald Tribune did not mention the appointment of a committee of experts or any of the scientists who spoke out against Ethyl; only industry representatives were quoted. The afternoon Journal carried what at first glance seems a well balanced article, quoting from both sides of the issue and attempting to achieve an overview of the conference. On careful examination, however, the Journal's article turns out to have been plagiarized without credit word-for-word from the New York Times. The Sun and the Brooklyn Daily Eagle had apparently forgotten about the controversy, and carried no articles about it.

The World, of course, had not forgotten. Its May 21 story described the decision to name a committee and discussed the "attack" on "doped fuel." The story did not include the Howard - Burnham confrontation over the "gift of heaven," and unlike the Times, the World did not attempt to provide an overview of the conference. It took the "haystack" approach, piling up facts about one aspect of the event -- the "damning" evidence from the Columbia University study that was presented at the conference. In its next story, on May 22, the World emphasized the search for a substitute to tetraethyl lead, quoting Alice Hamilton: "It would be foolish to talk of the industrial value of tetraethyl lead, when there is a health hazard involved. Men who could discover the fuel value of tetraethyl certainly could invent or discover something equally efficient and in no way dangerous. American chemists can do it if they will." The May 22 World report also did something quite unusual for journalism of the day -- it discussed something that did not occur. At the end of the article, this paragraph is found:

> Original plans had called for presentation to the Public Health conference of claims of various persons that they have discovered dopes [additives] for fuels which are as efficient as lead but lack the danger. The conference decided at the last minute, however, that such things were not in its province, since it was called to consider only the danger of lead and not the lack of danger of any other chemical or mineral. For this reason, the conference adjourned after only a one day meeting, where it had been thought at first that four or five days might be taken. Many of the delegates to it held informal conferences today, however, at which fuel dopes were discussed.[11]

No record of these “informal conferences” on safe fuel “dopes” is found in the news media or in the P.H.S. archives, and the World never followed up. That the formal conference was originally scheduled for more than one day is consistent with Secretary of the Interior Hubert Work’s welcoming address, in which he said: “The purpose of this conference is very important, and your deliberations will take, I assume, some days.”[12] On Tuesday, May 19, a New York Times correspondent noted that the conference “will be opened tomorrow and probably will consume all of that day and Thursday,” while the New York

Journal noted on May 20th that the conference "will continue through tomorrow."[13]

Instead, the conference took only one day, and P.H.S. archives offer no clue as to why the conference was cut short.[14] One possible explanation is that the Surgeon General did not wish to venture beyond the confines of his authority. This would be consistent with the general tenor of the business-government relationship of the era, but it would be inconsistent with plans already made and the aggressive and suspicious attitude toward tetraethyl lead taken by the P.H.S. in the 1922-24 period. More likely is the possibility of pressure from higher up the chain of authority in the government. With Andrew Mellon as Secretary of Treasury, the P.H.S. may have been pressured to cut the hearing short. Mellon was known for intervening in government when family oil and banking concerns were affected.[15] Also, Mellon Institute scientists had been closely following Ethyl and had worked with the Bureau of Mines on experiments on Ethyl gasoline in Pittsburgh.[16] Whether or not Mellon directly influenced the content of the conference, it is clear that business interests of Gulf Oil Co. and the Mellon Institute corresponded closely with those of the Ethyl Corp., G.M. and Standard Oil.

The Public Health Service Appoints an Expert Panel

At the end of the one-day Washington conference on leaded gasoline, Surgeon General Hugh Cumming announced that he would appoint a blue-ribbon panel of seven experts from universities to study the tetraethyl lead and report back in January, 1926. The panel was appointed a month later and was composed of independent scientists from Johns Hopkins, Harvard, Yale, Vanderbilt and the the Universities of Chicago and Minnesota.[17] Hamilton and

Henderson were not asked to join the committee, but respected senior colleagues at their institutions were. The Ethyl Corp. agreed to stop marketing Ethyl gasoline until their report had been completed.

This in itself seemed a victory to Hamilton, since the problem of regulating industry had apparently been taken out of the hands of corporate ownership and turned over to university scientists without a protracted fight in Congress. This shift in the locus of authority had taken place, Hamilton noted, under the "glare of publicity" and, as we will see, Hamilton felt indebted to the news media and particularly the World for its role in the Ethyl controversy. The combination of a muckraking news media and the scientists advocating government intervention in the affairs of the nation's largest industries was, as Hamilton knew, the powerhouse behind the progressive reform movement of 1900 - 1912 and earlier reform movements as well. She was apparently gratified that even during the 1920s nadir of the progressive movement, the public interest could be defended by the old alliance.

Much of the victory Hamilton seemed to celebrate was, however, symbolic. The Surgeon General's committee was not directly involved with the study and voiced some objections at the end of the course of the study which were not made public. The committee met June 14 and June 28 to consider the design of the study and corresponded with the P.H.S. on the plan of investigation during the summer.[18]

In July, 1925, J.P. Leake of the P.H.S. Hygiene Laboratory was assigned to conduct the study.[19] Two garages in Dayton, Ohio -- one using leaded gasoline and one not using leaded gasoline -- were to be selected and the employees tested for blood stippling and fecal lead accumulation. Two more garages in Washington, D.C. were to have been added to the list "if time and personnel permit," according to the preliminary plan.[20] Committee member

C.E.A. Winslow wrote back saying that the Washington garages should be included and that it was "most essential that the study cover three garages in which ethyl gas is used and one which it is not used." Winslow also argued for larger test samples or workers but agreed that the test plan seemed "most admirable."[21]

The actual study began early in October, 1925. Two groups of Dayton and Cincinnati, Ohio workers (one of drivers and one of mechanics) who had been exposed to leaded gasoline were compared with two similar groups that had not been exposed. A control group of men working in lead industries was also examined. Overall, 252 case histories were taken. Men were given physical exams and blood and stool specimens were analyzed. Researchers found that drivers exposed to leaded gasoline showed somewhat higher "stippling" damage to red blood cells, while garage workers exposed to leaded gasoline showed much more damage to red blood cells, and one quarter of those exposed had over one milligram of lead in fecal samples. In contrast, over 80 percent of the industrial workers showed large amounts of lead in fecal samples. Although techniques for measuring lead levels were primitive in contrast with today's standards, it is probable that workers with blood damage and high amounts of lead in fecal samples had absorbed amounts of lead that would today be considered dangerous, according to toxicologist and lead historian Jerome Niragu.[22] Even then, the lead burdens were considered high. In a Bureau of Mines final report about the study in 1927, the Surgeon General's Committee report is noted as having found blood cell stippling "to a relatively high degree" in garage mechanics whose exposure had been relatively short -- as little as two and a half days.[23]

One find that raises questions about the integrity of the study is that leaded gasoline samples from Cincinnati appear to have about half as much lead than they should have had during the time the study was taking place. In the first draft of the report presented to the committee December 22, 1925, J.P. Leake, said that "not very far from the plant where we make our studies" four gasoline samples from service stations ranged from 75 percent to 55 percent less lead than expected.[24]

As the study progressed over the first weeks of October, a General Motors Executive Committee meeting in Detroit, Michigan received this unsigned memo dated October 25, 1925:

> The committee has seen nothing that would justify its taking the position that the sale of tetraethyl lead involved a hazard any greater than any other manufacturing operation. The president (of General Motors) said that he feels quite confident that the (Public Health Service) committee report will not be unfavorable to our continued production of this compound.[25]

TABLE I
SURGEON GENERAL'S COMMITTEE
ETHYL TEST RESULTS

	Control chauffeur	Ethyl chauffeur	Control garage worker	Ethyl garage worker	Exposure to Lead Dust
No.men	36	77	21	57	61
% showing definite stippling	12	12	24	46	93
% showing over ./3 mg. lead per gram ash	6	2	6	14	81
Clinical symptoms	0	0	0	0	23

Source: Anon, (probably J.P. Leake), Draft report to Committee on Tetra Ethyl Lead, December

22, 1925, C.E.A. Winslow papers, Box 101, Folder 1801, Yale University Library, New Haven, Ct.

G.M.'s inside information was on target. The most important finding of the committee was that none of the garage workers and drivers had any of the outright symptoms of lead poisoning that killed 17 refinery workers and poisoned at least several hundred more between 1923 and 1925. As a result, the committee concluded that there were "no good grounds for prohibiting the use of Ethyl gasoline." Not all the committee members agreed with that assessment. In a meeting on December 22, 1925, committee member David L. Edsall of Harvard objected that "we would be presenting a half-baked report" unless the committee studied "the effects this is going to have on others." Reed Hunt of Harvard noted that the "big question" was whether the committee should absolutely prohibit tetraethyl lead or not. "If we say we shouldn't absolutely prohibit it, then we should say that money should be appropriated to study any further hazard."[26] C.E.A. Winslow of Yale insisted on and got the following statement inserted into the report: "A more extensive study was not possible in view of the limited time allowed to the committee."[27]

In the end, the report warned that the uncertain danger and the incomplete data did not lead it to a definite conclusion:

> Owing to the incompleteness of the data, it is not possible to say definitely whether exposure to lead dust increases in garages when tetraethyl lead is used. It is very desirable that these investigations be continued... It remains possible that if the use of leaded gasolines becomes widespread, conditions may arise very different from those studied by us which would render its use more of a hazard than would appear to be the case from this investigation. Longer exposure may show that even such slight storage of lead as was observed in these studies may lead eventually in susceptible individuals to recognizable lead poisoning or chronic degenerative disease of obvious character... The committee feels this investigation must not be allowed to lapse.[28]

Winslow also recommended that the "search for and investigation of antiknock compounds be continued intensively with the object of securing effective agents containing less poisonous metals (such as iron, nickle, tin, etc.) or no metals at all."[29] The recommendation was based on correspondence with Ford Motor Co. that Winslow forwarded to L.R. Thompson of the Public Health Service, asking that a file be established on alternatives. The letter to Winslow reads as follows:

> August 15, 1925
> ALCOHOL FOR MOTOR FUEL
> Further to my letter of June 19th:
> You may probably have observed the production of synthetic alcohol as brought out by the Badische Anilin and Soda Fabrik [BASF of I.G. Farben], now being produced in Germany at the rate of 60,000 gallons per month. Such alcohol is reported to be produced for between 10 cents and 20 cents per gallon and has much promise as a mixture with hydrocarbon fuels to eliminate knocking and carbonization.
> (signed) Wm. H. Smith, Ford Motor Co.[30]

The letter, clearly, is a fragment of more extensive correspondence which has been lost in the Public Health Service files. Winslow's recommendation about continuing the search was not incorporated in the final committee report. Although disappointed in the report, Winslow wrote Henderson, who was in England in the winter of 1925, that he "did not see how things could have gone differently."

Meanwhile, Ethyl officials announced that they had been vindicated, and after agreeing to warning labels on leaded gasoline, began to market it again in the spring of 1926. These warning labels would become familiar to three generations of motorists and would appear in virtually every service station except Sunoco: “Contains lead (tetraethyl) and is to be used as a motor fuel only. Not for cleaning or any other use.”

The news media had written sporadically about the controversy during the summer and fall, and by January 21, 1926, it was a back page item even in the New York Times. "Report No Danger in Ethyl Gasoline," the headline said. While there were "no good grounds" for prohibiting tetraethyl lead, "continued study was proposed." Prominently mentioned was fear of eventual "sterility of the race."[31]

The World's headline that day said "Poison Gasoline Declared Safe For Sale Again." The article noted that the committee of scientists strongly recommended (rather than proposed) further research. The article also pointed out, in a face-saving exaggeration, that "drastic regulations" would be required for use of leaded gasoline.[32]

Thus, the controversy that had started out with such force and vehemence ended with a whisper, and the restless spotlight of publicity moved on.

Ethyl Narrowly Avoids Further Controversy

The findings of the Surgeon General's committee closed off much of the public debate about leaded gasoline in 1926, but two events might have reopened it immediately. First, new production in Denver, Colorado was organized so poorly that additional deaths would have certainly occurred had not du Pont engineers intervened. Secondly, the product was implicated by the British Air Corps as one of several causes of the September, 1925 wreck of the U. S. Navy airship Shenandoah.

With renewed market demands, Ethyl Gasoline Corp. signed a contract for new production in the spring of 1926 with American Research Co., a small manufacturer in Denver, Colorado. On a visit to the facility in the spring of 1926, Kettering's replacement at Ethyl, Earl Webb, asked what precautions were being taken to protect workers. The president of American Research said "none whatever." Webb asked, "Do you wear rubber gloves or anything of that kind, rubber aprons or anything?" No, he said, "We handle it like any ordinary product."

"It's surprising someone hasn't died in your outfit," Webb said.[33] It is unclear what action, if any, Webb took after making this remark. It was only after du Pont engineers objected to the new contract that it was terminated by Ethyl board member Irenee du Pont because, du Pont later said, "the risk of serious catastrophe is too great to be considered."[34]

Signs began appearing across the country in Standard, Esso, Amoco and Gulf stations saying "Ethyl is back." Competing service stations sometimes put up humorous responses saying that their fuel "never had to leave."[35] However, many technical problems with Ethyl remained unsolved. In a May, 1926 memo from Alfred Sloan to Webb noted that valve corrosion with Ethyl gas was still so severe after 2,000 to 3,000 miles as to make a car "inoperative." He said he had been concerned about the valve sticking problem before the product was pulled off the market. "Now that we are back in again and are considering pushing the sale to the utmost, I think we ought to be concerned with this question."[36]

An additional cause for concern appeared in the spring of 1926 when an article in the British journal Engineering linked Ethyl with the wreck of the U.S. Navy airship Shenandoah the previous year. The airship was the first U.S-made lighter-than-air craft, or dirigible, and was called the "pride of the U.S. Navy." The Shenandoah two-year-old craft was on a public relations tour across the American Midwest on September 4, 1925 when it encountered a violent storm at dawn over a rural section of Ohio. Because two of five engines were out, and at least one more was having serious trouble, the airship did not have the power to move away from the storm's center. When the storm hit, the wind carried the ship up several thousand feet in a few seconds. As the dirigible gained altitude, the helium inside the ship's frame expanded, and safety valves that should have released some of the helium failed. When the ship reached 12,000 feet it ripped in half, and the crew clung to twisted girders and dangling gondolas in the dark storm. Out of 43 crewmen, 16 were killed.[37]

An official inquiry blamed the storm as the direct cause of the ship's loss. The inquiry reported that the original engineering decision to reduce the number of safety valves when the ship was under construction was an "error in judgement" that also led to the ship's breakup.[38] The inquiry also brought out the fact that the airship was having engine troubles. The "untimely failure" of two engines meant that the ship could not avoid the vortex of the storm, according to Col. Charles G. Hall, an Army officer aboard at the time of the accident. "I believe that, had it been possible to have had the full speed of power of all five engines continuously, it would have been more probable that we would have been successful in not being drawn into the vortex of the storm that ultimately wrecked the ship," Hall told the Naval commission of inquiry.[39]

The reason for the engine trouble was never clarified at the inquiry. However, in April, 1926, the British journal Engineering published a summary of an Air Ministry laboratory's investigation of fuel additives. After running a Napier Lion 450 hp engine for 100 hours on an Ethyl aviation gasoline blend containing 5 cc of tetraethyl lead, spark plugs "showed signs of having been severely overheated" and three of the plugs were "useless." In another test, the engine was run 100 hours, and then switched to 20 percent benzol. "The engine commenced detonating and overheating, and it was considered inadvisable to take a power curve under these conditions." Following these remarks, Air Ministry engineers noted:

> It is said that the engines of the ill-fated airship Shenandoah with a compression ratio of 6:1 used a mixture of Aviation spirit with 10cc of

> ethyl fluid per gallon, which would probably lead to similar troubles at full power.[40]

The fact that the Shenandoah used Ethyl gasoline was a point of pride for the Ethyl Gasoline Corp. In a G.M. press release dated April 24, 1925, Thomas Midgley noted that the engines used on the Shenandoah had for some time been using Ethyl gasoline "as being the fuel best suited for this type of high-efficiency motors" [sic].[41]

After the link between the disaster and Ethyl gasoline in the Shenandoah was made by the British Air Ministry, the Ethyl Gasoline Corp. began an internal inquiry. T.A. Boyd wrote Graham Edgar, an Ethyl scientist, asking for the facts about the use of Ethyl gasoline in the Shenandoah. "It was our understanding here that while their intention was to fuel with Ethyl gasoline, it was not actually used for some reason," Boyd said.[42] No response is available in the archive. Even if Ethyl gasoline was not used in the Shenandoah on that September trip, the second engine test run by the British in which severe overheating occurred after a switch from Ethyl to benzene shows that, one way or another, Ethyl could have contributed to the disaster.

It is interesting that Midgley advised against using Ethyl brand leaded gasoline in aircraft engines two years previously, as was briefly noted in Chapter Three. In a letter to Navy Lt. B.G. Leighten, who was about to attempt a record breaking flight over the Pacific Ocean, Midgley said:

> I would recommend, in view of the crucial character of a trans-Pacific flight, you use a blended fuel rather than a gasoline treated with an antiknock compound. We have made great progress in overcoming the spark plug and valve trouble caused by the presence of some of these compounds in the fuel. But we have not yet solved the problem to our entire satisfaction; and in view of the fact that it is essential that no engine trouble of any kind develop, it seems wise not to risk the use of this material, even though it would have decided advantages from the weight standpoint.[43]

Although research on solving the problems with tetraethyl lead proceeded between 1923 and 1925, valve and spark plug problems persisted, as we have seen above in the 1926 memo from Sloan to Webb.

Such problems probably contributed to the Shenandoah disaster. Although no single problem can be isolated as a direct cause of the crash, a mix of engineering failures is evident. "The exact cause of the crash is still being debated today," said historian Peter Andrews. "Poor piloting, poor ship design and inadequate helium resources were all brought forth."[44] The role of Ethyl gasoline in the engine failure that led to the accident may be yet another cause for debate.

Ethyl Concern about "Substitutes"

As we have seen, Kettering and Midgley of G.M. and Frank Howard of Standard insisted at the P.H.S. conference that no substitute could be found for Ethyl brand leaded gasoline. Howard said it had come like a "Gift of God." Four months later, Howard surveyed the substitutes in a private memo to Kettering.

"There are three types of Ethyl Gasoline substitutes now on the market, as follows: 1) vapor-phase cracked products; 2) benzol blends; 3) gasoline from napthenic-base crudes." The "cracked" gasoline and napthenic crude gasoline had low knock ratings that did not justify the 3 cent premium price, he felt. "Benzol blends are, of course, in another category," Howard said, "... equal or superior of Standard Ethyl Gasoline in knock rating." Howard also said that Standard's benzol blend was so well established in the Baltimore-Washington territory that they could not replace it. Blending ethyl into higher base octane gasoline from napthenic crude oil would help in New Jersey "where the Gulf No-Nox competition is severe, having a knock value not quite the equal of Ethyl

Gasoline on the average, although the difference is very small."[45] Although the P.H.S. may not have been aware of it, many refiners had turned their attention to premium antiknock gasolines in order to compete with the new Ethyl additive being sold by Gulf (now Chevron), Standard of Indiana (American / Amoco) and Standard of New Jersey (Esso / Exxon). In fact, worries about the competition had caused the original problem of worker deaths with reckless manufacturing schedules, as we have seen in Chapter Five.

Regular unleaded gasoline at this time had an octane rating in the high 50s to low 60s, while engine compression ratios hovered between 5 and 6 to 1. By 1940, engine compression ratios of new cars were as high as 8 to 1, while octane ratings of fuels ranged from about 80 to 85. Some of the increase in automotive compression ratios was due to the improvement of fuel with Ethyl, but improved refining operations were a much more important factor. Three cubic centimeters of Ethyl only raised base gasoline by about 9 points, whereas the catalytic reforming raised the base by 20 points. This fact has not gone unrecognized. "The major factor [in improving the engine] was the improvement in refining processes to get a better, more knock-free base gasoline," T.A. Boyd said in an oral history interview with Frank Howard. "Yes, that's right," Howard responded.[46]

During the 1920s controversy, and long after it, alternatives of equal or possibly superior technical quality were well known and widely employed. Although this fact seems rather obvious, it has been repeatedly denied. In a memoir written in 1945, Kettering asserted that "no compound other than tetraethyl lead has ever been found that can be used in practice as an antiknock agent."[47] This statement seems to indicate that even his private memoirs may have been written under some constraint or concern for corporate image.

During the summer of 1925, when the fate of the Ethyl Gasoline

Corporation hung in the balance, Kettering developed a new fuel idea called "Synthol" at the Dayton labs. The breakthrough was announced in the same way that Ethyl was announced in 1923 and selenium was announced in 1921: an unnamed G.M. spokesman at the Dayton research labs claimed it would "double gas mileage."[48] Synthol fuel was a mixture of benzene, alcohol and a metallic additive -- either tetraethyl lead or iron carbonyl. Used in combination with a new high compression engine much smaller than ordinary engines, "Synthol" would "revolutionize transportation."[49] Engines would be much smaller and get 40 or 50 miles per gallon. Speculation about "Synthol" was apparently accelerated by the rumor that Ethyl would not return to the market. One syndicated cartoonist, Will B. Johnstone, pictured "Synthol" and small engines powering lounge chairs down the street and jewellers using magnifying lenses to repair tiny motors.[50] Whatever happened to the Synthol idea is not known -- no reports on its ultimate fate are found in the archives.

Due to the broad availability of substitutes for tetraethyl lead, the Ethyl Gasoline Corporation decided in 1927 to loosen restrictions and to end the exclusive 1924 contracts with Gulf, American and Esso and sell tetraethyl lead to any refiner or marketer who qualified. By 1933 it was sold without an Ethyl brand on the pump. "Ethyl corporation realized that by limiting the sale of Ethyl fluid to only premium grades, they were stimulating the refining industry to solve the problem of engine knock in other ways," said historian Augustus Giebelhaus. "Thus the competition presented by [Sun's] Blue Sunoco, [Atlantic Refining Co.'s] White Flash ... and other non-leaded, antiknock gasolines pushed the Ethyl Corp. into a major marketing challenge."[51] Ethyl's sales pitch to the oil industry was simply its "cheaper costs and greater flexibility" in refining. Thus, the "only compound that could be used in practice," the indispensable "gift of God," was in fact one less-than-celestial additive among many.

Approaching the International Markets

Ethyl was not received with enthusiasm in Europe, where alternatives had been employed as a matter of government policy for many years. In France, the combination of defense needs and farm surplus led the government to require the use of alcohol blends in most gasoline beginning in 1923. Many other European governments supported either farm-based ethanol (ethyl alcohol) or coal-derived methyl alcohol either through tax incentives or mandatory blending programs or both. The French program had problems, "due in part to the poor results obtained when such fuels were first introduced and also to the casting of discredit upon such fuels by its adversaries who profit in the fuel business," said Charles Schweitzer, a research chemist in the Melle complex.[52] Schweitzer also noted that "the health properties of lead tetraethyl constitute an obstacle in its general use," and that the French minister of hygiene said using it on crowded streets constituted a hazard.[53]

Meanwhile in Britain, a controversy over use of Ethyl gasoline arose in 1928. The Daily Mail quoted a number of British scientists as saying that leaded gasoline posed a public health hazard. "Your courtesy in keeping us informed of such developments is helpful and I am grateful for its continuance," Surgeon General Hugh Cumming wrote Ethyl president Earl Webb that year after Webb sent information on the British controversy.[54]

Cumming was not only grateful. Within a few years he became positively helpful. In 1931, he cabled from a conference in Paris: "Have Leake and Bevan send Carriere our and British Reports. Favorable outlook." Leake and Bevan were PHS employees, while Carriere was the Swiss minister of health, according to a PHS memo attached to the cable. The memo also said: "Of course, this refers to Ethyl Gasoline."[55] The omissions in this cable are interesting. Was Ethyl such a high priority of the P.H.S. that the Surgeon General could cable home from a European meeting and simply refer to "reports" and have it be known that it refers "of course" to Ethyl? Apparently, marketing Ethyl was a high priority for the Public Health Service in the 1930s.

Cumming also provided letters of introduction for Ethyl officials to the public health directors of other countries, paving the way for Ethyl sales. "This will introduce you to Mr. E.W. Webb, President of the Ethyl Gasoline Corp.," Cumming wrote to the public health officers of most Latin American nations in 1934. Cumming assured the public health directors of these countries that Webb had fully consulted with the US Public Health Service. "The preliminary health study was made by the United States Public Health Service," which, Cumming said, was the basis of the regulations followed in the U.S.[56]

Cumming also helped Ethyl expand its sales in the U.S. In 1928 he wrote a letter to the New York City Sanitary Advisory Committee stating that the "opinion expressed by the PHS committee ... three years ago has been confirmed by subsequent experience and we still believe there are no good grounds for prohibiting the use of such gasoline under the proper regulations."[57] He also wrote letters helping Ethyl overcome minor regulatory problems with state legislatures and public health authorities.

Problems with worker exposure to Ethyl fluid in refineries and service stations continued to occur. In 1928, Julius Stieglitz of the University of Chicago, who had been a member of the 1925 Surgeon General's Committee on tetraethyl lead, wrote to complain about an "infraction of the spirit if not the letter of the regulations" on tetraethyl lead from spillage and other workplace exposures to concentrated Ethyl fluid. Ethyl Corp. responded to Cumming that Dr. Robert Kehoe "whose duty it is to visit various sections of the country and examine the most exposed cases" believed the problem was under control.[58] How many of these cases existed is not clear, but they may have been substantial and they may have continued throughout the history of the product. For example, in 1960 several U.S. Army fuel depots reported incidents in which workers were injured, and one in which eight workers died from lead poisoning after cleaning out sludge that had settled in old fuel storage tanks.[59]

Ethyl in the 1930s

The idea that anti-knock compounds that could substitute for tetraethyl lead was not openly acknowledged by industry, despite the memos exchanged between Kettering and Howard noted above. Apparently, the idea was also difficult for government to acknowledge. For example, in 1933, the USDA found that Ethyl leaded gasoline and 20 percent ethyl alcohol blends in gasoline were equivalent in terms of brake horsepower developed. These tests, conducted at the Navy's engineering experiment station in Annapolis, were never made public.[60]

In the spring of 1933, a dispute about encouraging widespread use of ethyl alcohol blended with gasoline swept through Midwestern state legislatures and Washington, D.C. Dozens of proposals to provide tax incentives for alcohol fuel were heard in statehouses and in Congress; two states passed tax incentives. The oil industry reacted with heavy negative publicity and an all-out public relations campaign designed to disparage and discredit alcohol fuel in any way possible. This period has been addressed in other histories,[61] although there are aspects of controversy that are to this day the subject of anti-trust litigation and continued historical research.[62]

In 1936, all public criticism of leaded gasoline in commercial speech was overruled by the Federal Trade Commission, which said that "disparaging remarks" about its danger would be considered an unfair trade practice. The ruling came in response to an advertisement for Cushing gasoline, which advertised it was not "doped" and said: "It stands on its own merits and needs no dangerous chemicals -- hence you can offer it to your customers without doubt or fear." In its restraint order, the FTC said Ethyl gasoline "is entirely safe to the health of [motorists] and to the public in general when used as a motor fuel, and is not a narcotic in its effect, a poisonous dope, or dangerous to the life or health of a customer, purchaser, user or the general public."[63] Ethyl was "said to be the only chemical used commercially for mixture with gasoline for the purpose of eliminating the 'knocking'..." the FTC said in a press release.[64]

Clearly, the picture about alternatives was as confusing in 1936 as it had been a decade earlier. When the Justice Department investigated the Ethyl Corp. in preparation for a 1937 anti-trust suit, it found that the catalytic cracking process was "the only available competing method of increasing the anti-knock rating of gasoline..."[65] And in a stipulation in the suit, the Ethyl Corp. said:

> High anti-knock values may be and are also obtained by the addition to gasoline of benzol and alcohol, but insufficient quantities of the former are available to permit its use in any large amount of gasoline ... while the use of alcohol is relatively new in the United States, though it has been used extensively abroad for many years.[66]

At this point, Ethyl leaded gasoline was used in 70 percent or more of American gasoline[67] and in all but one major brand -- Sunoco. Despite the market success, only 10,000 of the 12,000 wholesale fuel dealers in the US received licences to carry Ethyl products. The anti-trust suit developed when dealers complained to the Justice Department that Ethyl was enforcing its view of "business ethics" on the market. Dealers who cut prices or who used alcohol or benzene in other fuels were not allowed to wholesale Ethyl's lead additive. “It seems clear that the Ethyl Gasoline Corporation has exercised its dominant control over the use of Ethyl fluid substantially to restrain competition by regulating the ability of jobbers to buy and sell gasoline treated with ethyl fluid and by requiring jobbers and dealers to maintain certain prices and marketing policies..." a 1937 Department of Justice memo said.[68] Ethyl lost the suit at the Federal District Court level in 1938 and at the Supreme Court in 1940. The company was ordered to make the product available to any customer who met minimum technical criteria.[69]

A second major anti-trust case filed by the Justice Department in the early 1950s against du Pont Corp. involved Ethyl. It focused primarily on the competitiveness of the relationship between du Pont, General Motors and Standard Oil Co. in various sectors, including fuel development. Du Pont won the case, in part because company memos showed that in 1924 it was not aware of G.M.'s pending partnership with Standard to form the Ethyl Gasoline Corporation. In addition, cooperative research on leaded gasoline between the major parties was not found to have been in violation of anti-trust law.[70]

Updating the Ethyl Controversy: 1940 to 1986

Public health controversy about leaded gasoline was subdued if not entirely submerged in the late 1940s and '50s, in part because University of Cincinnati physician Robert Kehoe performed a great many studies that argued that some amount of lead was normally present in the body. Kehoe's studies claimed that lead was relatively harmless and most cases of lead poisoning came from improper nutrition which hampered excretion of normally occurring lead.[71] This became the predominant scientific view despite findings, some as early as 1943, that even after lead poisoned children were "cured" and blood lead levels were reduced, they still had significant mental problems.[72] Also, a study of Philadelphia tenements in 1955 showed children becoming ill and dying from eating chips of lead-based paint. The study was considered a landmark because it took lead research beyond the world of "occupational diseases" and back to the general question of its impact on public health and the environment.[73]

Historian William Graebner said of the predominant view of lead:

> Quite simply, the lead industries had engineered the development, dissemination and perception of knowledge concerning the lead hazard... The result was the suppression of genuine pluralism within the scientific community. Here and there, a dissident voice could be heard. But so complete was the industry domination of research into and knowledge of the hazards of lead that the central paradigm for understanding lead and its effects remained that pioneered by Kehoe and his associates in the 1920s and 30s.[74]

Meanwhile, concern about the environment was growing with the problem of smog in the Los Angeles basin. A group of scientists and citizens in 1953 formed the Air Pollution Control Foundation to study smog and recommend remedies for it. One citizen suggested that lead was partly responsible for smog formation. Although unsupported, the suggestion was enough to alert General Motors. Kettering kept close track of the group, which eventually led to the formation of a state committee on air pollution but which also dropped lead from its list of priorities.[75]

In 1959, Ethyl asked for an increase in permissible gasoline lead level from three to four grams per gallon. A Public Health Service committee considering this request noted:

> It is regrettable that the investigations recommended by the Surgeon General's Committee in 1926 were not carried out by the Public Health Service. Such studies should be undertaken without further delay to assure the validity of the present decision [to raise

permissible lead levels] and to guide future committees[76] ...

In Europe that same year, debate over urban air pollution began in earnest with the International Clean Air conference of 1959 sponsored by the World Health Organization. Lead was mentioned as a major concern of only the Italian research effort.[77] In the U.S., debate mushroomed in 1966 with the Senate Public Works committee's first hearings on air pollution.[78] By the time the first Clean Air Act was passed in 1970, the recommended solution was to introduce catalytic converters for unleaded fueled vehicles, which became standard after 1975. The converters would not function after being exposed to leaded gasoline, which was one primary reason for the introduction of unleaded gasoline. Ethyl attempted to assert in federal court that it was being deprived of its property without due process. But the courts upheld the right of the E.P.A. to mandate unleaded gasoline.[79] The courts also heard the mounting evidence of brain damage to children exposed to leaded gasoline.[80] The Reagan administration flirted with deregulation of environmental rules for gasoline in 1982,[81] but the E.P.A. quickly backed off that position when leaded gasoline was clearly linked by medical authorities to high blood lead levels and physical abnormalities in children.[82] The E.P.A. proposed a 90 percent mandatory cut in lead content for gasoline in 1984.[83] By 1986, the lead phaseout had been accelerated, and lead had almost vanished from gasoline in the US. The issue had come full circle, from the discovery of tetraethyl lead in December, 1921 to a government-ordered phase-out 65 years later.

In most of the Third World, however, the brain damage, hypertension and other effects of leaded gasoline, especially on urban children or people living close to highways, have yet to be dealt with. U.S. factories still export tetraethyl lead to other countries for their gasoline, although most tetraethyl lead is today made in other countries under license agreements with Ethyl and du Pont.[84]

Historian Samuel P. Hays noted that almost all of the events in the series of controversies over Ethyl leaded gasoline reflect intense differences of opinion between industry affiliated scientists and public health scientists. These differences clearly were related to institutional affiliation. Scientists working at hospitals or with the Centers for Disease Control, the E.P.A. or public health organizations held a far different view of scientific facts than those who were affiliated with the Lead Industries Association or the International Lead-Zinc Research Organization. Another important factor in the debate was the role of professional specialization, Hays argued. Although the conventional wisdom is that science is a unifying force, "increasingly specialized knowledge fractures science and fosters intense dispute." The lead issue involved, in its later years, differences between scientists who specialized in nutrition or inhalation, occupational health or biogeochemical cycles, clinical pediatrics and laboratory research.[85]

Not surprisingly, the specialization and fractured approaches to science that marked the end of the debate over leaded gasoline in the 1970s and 1980s were evident in the beginning of the debate in the 1920s. When Alice Hamilton called Charles Kettering "nothing but a murderer" at the Public Health Service conference in May, 1925, the two scientists were glaring across a gulf that would characterize the lead debate, and many other similar debates, for the rest of the century.

1. Du Pont owned a 27 percent share of G.M. at this time, while G.M. and Standard became equal partners in the Ethyl Gasoline Corp. on Aug. 18, 1924. Standard's entry as a partner against du Pont's wishes is explained mainly by its independent development of the ethyl chloride process, the cheapest way to produce tetraethyl lead, according to N.P. Wescott's Origins and Early History of the Tetraethyl Lead Business, unpublished du Pont Corp. report,1936, Longwood MS group 10, Series A 418-26, General Motors Anti-Trust Suit documents, Hagley Library, Wilmington, Del. (Hereafter cited as Wescott, Origins and Early History.)

2. T. A. Boyd, The Early History of Ethyl Gasoline, Report OC-83, Project # 11-3, Research Laboratory Division, GM Corp., Detroit Michigan, (unpublished) June 8, 1943, GMI, Flint, Michigan, p. 2. (Hereafter cited as Boyd, Early History).

3. Charles F. Kettering, "The Story of Ethyl Gasoline: Growth History of a New Product," Experimental Draft, Dec. 1946, p. 132, GMI, Flint, Michigan (Hereafter cited as GMI). .

4. A search of the Hamilton papers at Harvard's Schlesinger library did not turn up any information on her perspective on this confrontation.

5. Alice Hamilton to Katy Hamilton, May 17, 1925, cited in Angela Young, "Exploring the Dangerous Trades" Ph.D. Dissertation, Brown University, 1982.

6. Barbara Sicherman, Alice Hamilton: A Life in Letters (Cambridge, Mass: Harvard University Press, 1984), p. 168.

7. Gulf had discontinued sales on Nov. 1, 1924, "in deference to public opinion" according to Wescott, Origins and Early History, p. 25.

8. U.S. Public Health Service, Proceedings of a Conference to Determine Whether or Not There is a Public Health Question in the Manufacture, Distribution or use of Tetraethyl Lead Gasoline, PHS Bulletin No. 158,

(Washington, D.C.: U.S. Treasury Dept., August 1925), p. 6. (Hereafter cited as PHS Conference).

9. For instance, Alice Hamilton wrote to Surgeon General Cumming Feb. 12, 1925 that the General Motors funding of the Bureau of Mines study "will in the eyes of Labor always serve to cast doubt on any negative results obtained by the investigators..." Hamilton to Cumming, Feb. 12, 1925, PHS File 1340, U.S. National Archives, Washington, D.C.

10. "Shift Ethyl Inquiry to Surgeon General," New York Times, May 21, 1925. It is interesting that the New York Times account does not correspond with the Public Health Service stenographic record. Howard and Burnham referred to a "Gift of God" according to the PHS, instead of (as the Times reported) a "gift from heaven."

11. "U.S. Board Asks Scientists to Find New 'Doped Gas,'" New York World, May 22, 1925, p. 1.

12. PHS Conference, p. 1.

13. "Scientists to Pass on Tetraethyl Gas," New York Times, May 20, 1925, p. 1. "Lead gasoline peril taken up today," New York Journal, May 20, 1925, p. 1.

14. Joseph A. Pratt, "Letting the Grandchildren Do It: Environmental Planning During the Ascent of Oil as the Major Energy Source," The Public Historian 2, No. 4 (Fall, 1980), p. 40, notes that Henderson wanted to return to classes and could not stay at the conference (PHS Conference, p. 60). However, Henderson's need to get back to classes would not have been a compelling reason to cut short the conference. No other discussion about the agenda of the conference is found in the conference minutes themselves.

15. Daniel Yergin, The Prize: The Epic Quest for Oil, Money & Power (NY: Simon & Schuster, 1991), p. 295.

16. For example, Donald K. Tressler of the Mellon Institute wrote the article

"New Quest for Riches of the Sea," about the steamship Ethyl attempting to find new sources of bromine for the New York Times, Sunday, April 5, 1925. It may be of some passing interest that the original list of representatives to the conference, as printed in the New York Times on May 20, has R.R. Sayers, a joint appointee of the Bureau of Mines and the Public Health Service, listed as representing the Mellon Institute. ("Scientists to Pass on Tetraethyl Gas," New York Times, May 20, 1925).

17. These were David L. Edsall, Dean of the Harvard Medical School; W.H. Howell, Johns Hopkins; ; A.J. Chesley, State of Minnesota; W.S. Leathers, Vanderbilt; Julius Stieglitz, University of Chicago; and C.E.A. Winslow, Yale Medical School.

18. Cumming to C.E. A. Winslow, June 12 and Aug. 24, Box 101, Folder 1800, Winslow papers, Yale University.

19. Memorandum for the Files, Ethyl Gasoline Corp., April 17, 1937, U.S. Dept. of Justice records division 60-57-107, National Archives, Washington D.C.

20. "Preliminary Plan for Ethyl Gas Investigation," Aug. 24, 1925, Box 101 Folder 1800, Winslow papers, Yale University.

21. Winslow to Cumming, Sept. 9, 1925, Box 101 Folder 1800, Winslow papers, Yale University.

22. Personal communication, Jerome Niragu, Sept. 1991. An international expert in toxicological studies of heavy metals, Niragu reviewed the original PHS report at this writers request and roughly estimated that blood lead levels would have exceeded 50 to 100 micrograms per milliliter in the group of highly affected garage workers. The currently acknowledged safe blood lead level is 10 micrograms per milliliter.

23. R.R. Sayers, A.C. Fieldner, et al., "Experimental Studies on the Effect of Ethyl Gasoline and its Combustion Products," U.S. Bureau of Mines

(Washington, D.C. U.S.GPO, 1927), p. 12.

24. Minutes of the Surgeon General's Committee of Experts on Tetraethyl Lead, Dec. 22, 1925, p. 21, File 1340, Record Group 90, Public Health Service, U.S. National Archives, Washington, D.C.

25. Executive Committee memo, October 25, 1925, General Motors Exhibit 92, United States v. E.I. du Pont de Nemours et al., US District Court, Chicago Ill., 126 F. Supp. 235 (1953). (Hereafter cited as US v. du Pont).

26. Minutes of the Surgeon General's Committee of Experts on Tetraethyl Lead, Dec. 22, 1925, p. 21, File 1340, Record Group 90, Public Health Service, U.S. National Archives, Washington, D.C.

27. Winslow ms, Box 101, Folder 1805, cited in Rosner & Markowitz, Dying for Work.

28. "The Use of Tetraethyl Lead Gasoline in its Relation to Public Health," Public Health Bulletin No. 163, U.S. Public Health Service, Treasury Dept. (Washington: GPO, 1926).

29. C.E.A. Winslow, "Recommendations for the Drawing Up of a Report on the Use of Lead Tetra-Ethyl Gasoline by the Public," memo to P.H.S. committee members, Dec. 31, 1925, Box 101, Folder 1801, C.E.A. Winslow papers, Yale University Library, New Haven, Ct. It is interesting to note that Winslow must have been well briefed on available alternatives, because the three metals he mentions -- iron, nickle and tin -- had undergone extensive testing along with lead.

30. W.H. Smith to C.E.A. Winslow, Box 101 Folder 1800, C.E.A. Winslow papers, Yale University. Forwarded to Surgeon General in Sept. 1925. Note that such correspondence is not found in the National Archives files. Winslow also attempted to have alternatives to tetraethyl lead mentioned in the final report but was voted down by others on the committee.

31. "Report No Danger in Ethyl Gasoline," New York Times, Jan. 21, 1926.

32. "Poison Gasoline Declared Safe for Sale Again," New York World, Jan. 21, 1926.

33. Statement of Earl Webb, US v du Pont, p. 3646.

34. Statement of Irenee du Pont, US v du Pont, p. 2177. Du Pont's key role here in preventing disaster is, of course, stated from du Pont's own perspective.

35. Transcript of a memoir by Charles Kettering for "The Story of Ethyl Gasoline," early 1945, GMI.

36. Sloan to Webb, May 4, 1926, Midgley unprocessed, GMI.

37. Peter Andrews, "Lighter than Air" American Heritage Invention & Technology, 9, No. 1, (Summer 1993), p. 9.

38. "Shenandoah Court Condemns Changes Made in Airship," New York Times, Jan. 2, 1926.

39. "Shenandoah Victim of Engine Trouble, Says Army Witness," New York Times, Sept. 25, 1925, p. 1.

40. H.L. Calendar, Capt. R.O. King, Lt. C.J. Sims, "Dopes and Detonation," Engineering, April 9, 1926, p. 475.

41. Statement by Thomas Midgley, Jr., April 24, 1925, Midgley unprocessed files, GMI. Note: This press release was Midgley's attack on Henderson following the controversy over Henderson's April 22 speech.

42. T.A. Boyd to Graham Edgar, April 28, 1926, Unprocessed Midgley files, GMI.

43. Midgley to Leighten, Bureau of Naval Aeronautics, March 16, 1923, Unprocessed Midgley files, GMI, Flint, Michigan. The blended fuel Midgley recommended was alcohol, benzene and gasoline.

44. Andrews, "Lighter than Air," p. 22.

45. Howard to Kettering, Sept. 25, 1925, Unprocessed Kettering files, "Cyclo-

Gas" file, GMI. Alternatives were an ongoing concern. At one point in 1928, Sloan requested a report on alternatives to Ethyl. At another point in 1931, Boyd identified alternatives in the field. (TA Boyd, "Remarks on Ethyl Gas as Made to the G.M. Technical Committee," March 19, 1931, Box 18, GMI).

46. Kettering Archives oral history project, interview with Frank A. Howard, recorded Sept. 14, 1960, GMI

47. Charles F. Kettering, "The Story of Ethyl Gasoline, Experimental Draft," Dec. 1946, unpublished manuscript, GMI.

48. "New Auto, Fuel to Save Costs Are Announced," United Press Service, Aug. 6, 1925, Kettering collection press clipbook No. 2, GMI.

49. "Work on New Type of Auto and Fuel," New York Times, Aug. 7, 1925; also "New Auto, Fuel to Save Costs are Announced," United Press, Aug. 6, 1925.

50. The cartoon is entitled "Patent 1201850," and was printed in Aug., 1925. That particular patent was issued in 1916 for a catalyst to make fuel from coal to A. Mittasch and C. Schneider. Kettering or someone at G.M. kept the cartoon as part of a scrapbook in a section of clips from August, 1925. The cartoonist may have simply picked a number out of the air or perhaps there was actually some connection between the Mittasch patent and the G.M. Synthol announcement. Possibly the Mittasch patent was considered as an alternative to the more famous Fischer-Tropsch "Synthol" fuel from coal patent also issued in 1916. See Chemical Abstracts 18, p. 3705 and p. 3143, and Vol. 19, p. 1487.

51. August W. Giebelhaus, Business and Government in the Oil Industry: A Case Study of Sun Oil, 1876-1945 (Greenwich, Ct.: JAI Press, 1980), p. 171.

52. Charles Schweitzer, "L'Etat Actuel De La Question De L'Alcool Carburant," Chimie & Industrie 28, No. 1 (1932); Translated and abstracted by E.I. Fulmer, R.M. Hixon, L.M. Christensen, W.F. Coover in "The Use of

Alcohol in Motor Fuels: Progress Report Number I, A Survey of the Use of Alcohol as Motor Fuel in Various Foreign Countries," May 1, 1933, unpublished manuscript, Iowa State University archives.

53. "Anti-detonants: leur emploi dans les carburants et leur danger," Ind. Chimique, No. 208, p. 332 (1931), cited in Fulmer, "The Use of Alcohol in Motor Fuels."

54. Cumming to Webb, March 20, 1928, U.S. Public Health Service RG 90 Box 98, National Archives, Washington, D.C.

55. F.D. Patterson to J.P. Leake, May 18, 1931, Public Health Service RG 90 Box 98, National Archives, Washington, D.C.

56. Cumming to Webb, Webb to Cumming, and Cumming to various public health authorities, August - November, 1934, Public Health Service RG90 Box 98, National Archives, Washington, D.C.

57. Cumming to Sanitary Adviser, Nov. 21, 1928, Public Health Service RG90 Box 98, National Archives, Washington, D.C.

58. Cumming to Prof. Julius Stieglitz, Sept. 13, 1928, Public Health Service RG90 Box 98, National Archives, Washington, D.C. Note that P.N. Leech, a director of the American Medical Association, also signed the original letter of complaint to Cumming.

59. E. Elbridge Morrill, Jr., "Tetraethyl Lead Poisoning Incident with Eight Deaths," American Industrial Hygiene Journal 21, No. 6, (Dec. 1960), p. 515-17.

60. R.B. Gray, "On the Use of Alcohol-Gasoline Mixtures as Motor Fuels," unpublished, USDA, April 1933, National Agricultural Library, Beltsville, Md.

61. Hal Bernton, Bill Kovarik, Scott Sklar, The Forbidden Fuel: Power Alcohol in the Twentieth Century (New York: Griffin, 1982); also see Christy Borth, Modern Chemists and their Work (New York: Bobbs-Merill, 1939); Pratt,

"Letting the Grandchildren do it"; and Augustus W. Giebelhaus, "Resistance to Long-Term Energy Transition: The Case of Power Alcohol in the 1930s," Proceedings of the American Association for the Advancement of Science, Jan. 4, 1979.

62. Greater Rockford Energy & Technology, et. al., and the State of Illinois, et. al. v. Shell Oil Co., Marathon Petroleum Co., Amoco Oil Co., Chevron U.S.A. Inc., Exxon U.S.A. Inc., BP of America, ARCO, and Mobil Oil, Civil Docket 90 - 3119, U.S. District Court for the Central District of Illinois, Springfield Division, filed 1990.

63. Federal Trade Commission Docket No. 2825, Cushing Refining & Gasoline Co., June 19, 1936, Dept. of Justice files, 60-57-107, National Archives, Washington, D.C.

64. "For Release in Morning Newspapers of Friday, June 5, 1936," Federal Trade Commission, Dept. of Justice files, 60-57-107, National Archives, Washington, D.C.

65. "Memorandum for the Attorney General RE: Proposed Suit in Equity against Ethyl Gasoline Corp. et al.," Feb. 4, 1937, U.S. Dept. of Justice files, 60-57-107, National Archives, Washington, D.C.

66. Stipulation, US v. Ethyl Gasoline Corp. et al., Southern District of New York, U.S. District Court, Dept. of Justice files, 60-57-107, National Archives, Washington, D.C.

67. According to the Justice Department. Ethyl advertisements said 90 percent.

68. John Henry Lewin to Lamar Hardy, "Proposed Suit in Equity Against Ethyl Gasoline Corp.," Feb. 4, 1937, Department of Justice file 60-57-107, National Archives, Washington, D.C.

69. Ethyl Gasoline Corp. et al., v. United States, 1940, 309 U.S. 436.

70. US v du Pont, 126 F. Supp. 235.

71. Testimony of Robert Kehoe, Committee on Public Works, U.S. Senate, Subcommittee on Air and Water Pollution, 89th Congress, 2nd Session, Washington D.C., 1966, pp. 203 - 228.

72. R.K. Byers and E.E. Lord, "Lead Poisoning," Pediatrics, 23, (1959), pp. 583-603.

73. Theodore H. Ingalls, Emil A. Tiboni and Milton Werrin, "Lead Poisoning in Philadelphia, 1955-19609, Archives of Environmental Health, 3 (Nov. 1961), 577.

74. William Graebner, "Hegemony through Science: Information Engineering and Lead Toxicology, 1925 - 1965," in David Rosner and Gerald Markowitz, eds., Dying For Work: Workers Safety and Health in 20th Century America, (Bloomington, Indiana: Indiana University Press, 1989), p.140.

75. Press Releases, Air Pollution Foundation, Los Angeles, Calif., May 8, May 19, July 3, Oct 23, 1955; Correspondence of the Air Pollution Control District, Los Angeles, Calif.; Box 46 - 16, GMI, Flint, Michigan.

76. "Public Health Aspects of Increasing Tetraethyl Lead Content in Motor Fuel," Report of the Advisory Committee on Tetraethyl Lead to the Surgeon General, PHS publication No. 712 (Washington, D.C. Public Health Service, March 30, 1959), p. 2.

77. Arthur Stern, "Survey of Air Pollution Research in Europe," American Industrial Hygiene Journal 21, No. 6 (Dec. 1960), pp. 459-465.

78. U.S. Congress, Senate Committee on Public Works, "Air Pollution - 1966," Hearings before a Subcommittee on Air and Water Pollution of the Committee on Public Works, June 7, 8, 9, 14, and 15, 1966 (Washington, D.C.: GPO, 1966).

79. Ethyl Corp. v. EPA, 1979, Environment Reporter Cases 8, p. 1785, and Lead Industries Association v. EPA, 1980, Environment Reporter Cases 14, p. 1906, cited in Herbert L. Needleman, Human Lead Exposure (Baton Rouge,

La.: CRC Press, 1992), p. 282.

80. Samuel P. Hays, "The Role of Values in Science and Policy: The Case of Lead," in Herbert L. Needleman, Human Lead Exposure (Baton Rouge, La.: CRC Press, 1992), p. 267.

81. “EPA may allow more lead in gasoline” Science March 12, 1982, 1375-78.

82. New York Times, June 9, 1983, p. 17.

83. New York Times, July 31, August 5, Sept. 7, 1984.

84. Nicholas Regush, "MMT," Mother Jones, May/June 1992, p. 24.

85. Hays, "The Role of Values in Science and Policy," p. 280.

Text

CHAPTER SEVEN
ETHYL AND THE NEWS MEDIA :
HISTORICAL TREATMENT AND CONTENT ANALYSIS

Histories of Ethyl leaded gasoline tend to describe the discovery as an enormously successful invention worthy of Thomas Edison and the controversy surrounding it as, at best, a misunderstanding on the part of the news media. This chapter focuses on the question of the performance of the news media, especially the seven major New York City newspapers that covered the controversy closely.

According to many accounts, journalists did not understand the scientific problem and misinterpreted the problems inherent in manufacturing a difficult chemical as a danger to public health. Industry historians have also seen the press promoting "sensational publicity," "wild stories," "panic," "lurid details," and "shocking cartoons depicting Ethyl ... squeezing blood from an innocent public." They repeated the speculation of industry leaders who believed the press "invented" the phrase "loony gas." They blamed the N.Y. World for inflaming public opinion and fabricating out of wholecloth visions of sudden, rampant insanity on the streets of Manhattan. These views are unsubstantiated by any actual research on the part of the industry historians or the general historians whom they have influenced. The views tend to follow a stereotype of a rare and pugnacious form of yellow journalism. What is most objectionable about them (or any stereotype) is that the misperception obscures an important truth. Stereotypes of the press in this case obscure the deep concern over public understanding of science and technology of two leading editors who set the agenda for the Ethyl controversy: Carr Van Anda at the New York Times and Walter Lippmann at the New York World. As shown in Chapter Eight, both men were champions of science and believed that the scientific method had enormous importance for civilization.

This chapter first examines the historical record concerning the news media's performance in the Ethyl controversy and then examines the facts about seven daily newspapers from New York City that covered the controversy.

The Historical Record of the News Media in the Ethyl Controversy

Aside from a few self-congratulatory articles in the New York World and a comment that "journalistic vigilance" has done what government has not in the New York Daily News, no contemporary newspaper commented on the general performance of the news media in the controversy.

In 1927, as the controversy faded and the last of the critical articles disappeared from popular magazines, the Ethyl Gasoline Corp. printed a sales pamphlet called "A Brief Story of Ethyl Gasoline." The story of its discovery followed the Motor magazine "trial and error" saga in which the solution to the anti-knock problem appeared only after a thorough scientific search. This story would become the often-repeated description of how leaded gasoline was discovered.[1]

Ethyl advertised leaded gasoline extensively in the 1930s, but little of substance was written for public consumption until 1939, when Ethyl employee Graham Edgar wrote a dry account of the precautions taken in making leaded gasoline for an industry journal.[2] Sometime in the mid-1940s, a short memorial article recalling Midgley and his contributions to science appeared in an unknown magazine, entitled "It all Began When..."[3]

Two unpublished legal histories of the Ethyl controversy were written and later influenced historians to some extent. In 1927, Frank A. Howard of Standard Oil Co. of New Jersey wrote a private history of Ethyl Gasoline at the request of the U.S. Department of Justice. Howard focused on the contacts between Standard and General Motors between 1919 and 1924, when collaboration on research and marketing led to the 50-50 partnership between the two companies in creating the Ethyl Gasoline Corp. Howard also discussed the Bayway incident, and his attitude is indicative of corporate views:

> This catastrophe received widespread notoriety, much of which was of a misleading nature, indicating that the poisoning had come from the gasoline itself rather than from the process of manufacturing the [Ethyl fluid]. Certain newspapers undertook campaigns against the product and were supported by persons claiming to have particular scientific knowledge of the dangers attendant on its use... As a result of this agitation ... the Surgeon General of the U.S. called a conference of health officials and other interested persons in Washington[4] ...

A second internal history was written in 1936 by N.P. Wescott at the du Pont Corp., partly because of the pending expiration of patents and partly because of another Justice Department inquiry, this time involving a full-fledged anti-trust suit against Ethyl. The du Pont Corp. emphasized the importance of the du Pont role in developing a safer manufacturing process for tetraethyl lead. As noted in previous chapters, the du Pont history was sharply critical of the role of Standard Oil Co. in manufacturing tetraethyl lead at Bayway; and it indicated that tetraethyl lead was seen strategically as a transitional fuel to renewable ethyl alcohol fuels from cellulose. The history also noted the "storm" of publicity over the sudden insanity of Standard refinery workers:

> The violent and spectacular nature of this strange malady had at once attracted newspaper attention; and the dramatic sequence of deaths from the small [Standard] operation was naturally played up, with various lurid implications. 'There was front line publicity in every paper in the country,' according to a review of the occurrence in the 1924 annual report of the Ethyl Gasoline Corp., 'and mention was made of the accident abroad.' A widespread state of panic and public hysteria followed... A sensational 'crusade' was carried on by the New York World.[5]

World War II interrupted retrospection in the chemical and automotive industries, but in the mid- and post-war years, memoirs about Ethyl gasoline started to be written. In 1943, Thomas A. Boyd, a lab assistant to Midgley, began sorting several thousand pages of original documents called the "Lead Diary," which included lab notebooks, correspondence, reports and factory orders surrounding the 1919 to 1933 development of Ethyl leaded gasoline. This "diary" has apparently been withheld by General Motors from the GMI archives and is still not available to researchers. From the diary, Boyd, Charles Kettering and the G.M. public relations staff distilled a series of memoirs that were never published. What prompted this organization of materials and memoirs is unclear, although the death of Thomas Midgley in 1943 may have been a factor. Another may have been the 1938 anti-trust suit against Ethyl, and yet another may have been the 1942 investigations by Sen. Harry S. Truman's committee into how Ethyl gave leaded gasoline technology to German industries in 1938. In any event, it may have seemed that an explanation for the discovery of Ethyl gasoline might be needed. Boyd's first unpublished memoir, "The Early History of Ethyl Gasoline," was completed in June, 1943.[6] It was an extensive overview of the research and development efforts beginning in 1916 and continuing through the 1920s. It is highly defensive about the question of safety precautions for workers, claiming that all efforts were made to warn and guard against poisoning.[7] Boyd also dealt extensively with the public side of the controversy:

> There was front page publicity in the New York papers and in almost every newspaper in the country. A story in the New York Times was headlined: 'Odd Gas Kills One, Makes Four Insane' ... Some more expressive writer in another paper dubbed the stuff 'looney gas...' In contrast to the criticism and adverse propaganda in the popular press, the technical journals almost universally took an impartial or unprejudiced position. Dr. H.E. Howe, editor of Industrial and Chemical Engineering, for instance, published in the Dec. 1924 issue of that journal a fine editorial on the subject. Also, Dr. H.C. Parmelee, editor of Chemical and Metallurgical Engineering, tried to help calm the hysteria of the moment about Ethyl Gasoline. But nevertheless, the propaganda continued, fostered chiefly in the press by the New York World, but also by some labor union publications... So great was the effect of the events and of the flood of propaganda upon the public and upon the boards of health that in May, 1925, Surgeon General Cumming felt compelled to call a conference ...

Note that Boyd said that the conference was a result of both the "effect of events" and the "flood of propaganda." Later industry-oriented accounts would omit the former and emphasize the latter. Also, note that Boyd said a newspaper writer invented the term "loony gas." (Whether or not this is true is discussed below).

In 1945, Charles Kettering began drafting his own memoirs about the invention of Ethyl gasoline.[8] Kettering had planned to write a book on Ethyl "as a typical case of the means by which new things get started," according to one note,[9] viewing the many problems surrounding Ethyl as the "price of progress." However, Kettering was not completely in touch with the facts when the memoir was transcribed. Kettering asserted that the 1924 - 26 Ethyl controversy was basically a misunderstanding that occurred after a flawed experiment on leaded gasoline was run at Yale university:

> One of the [Yale] professors got in touch with one of the writers of the New York World. It seems that this particular writer had had a brother who suffered ill effects from lead poisoning which he had contracted from the handling of type metal and, therefore, he felt that the public should not be exposed to any other form of lead. The publicity which was brought about by the publications of these articles in the New York World resulted in our going to Dr. Cumming, who was then Surgeon General, and asking him to start an investigation, because it was foolish for us to try to continue unless we had this point completely determined.[10]

This story about a writer who knew about lead poisoning appears no where else and could not be checked, but clearly there was more going on than one writer's concerns. From the drafts and papers assembled for the memoirs, Ethyl and General Motors public relations staff began assembling a compilation called the "Green Book" and entitled "Historical Summary: Ethyl Corporation, 1923 -48." It was never printed, but the assertion that GM and Ethyl were under attack by the press shows up several times. "Many outsiders freely predicted that the tragedy meant the end of the company," said one version. "The New York World conducted a campaign of publicity against the public sale of gasoline containing the company's antiknock compound and labelled it 'loony gas.'"[11]

Meanwhile, several small public relations articles entitled "The Tetraethyl Lead Saga" and "The Product that Nobody Wanted" were printed in Du Pont Magazine in 1947 and in 1951 respectively. The former did not mention any controversy other than "difficulties" that had to be overcome. The latter was a short article based on the premise that a chemical discovered in 1852 had no use until, in 1921, scientists discovered one.[12]

The controversy was also downplayed in scientific circles. Edgar noted in a 1951 American Chemical Society paper: "At one time, many doubts existed over the safety even of gasoline containing [lead], but 25 years of extensive study and experience have proven [it]... safe as normally used.[13]

The first short public account of the discovery of Ethyl in the years following the controversy was written by Midgley's former laboratory assistant T.A. Boyd and appeared in 1950 in a Society of Automotive Engineers paper entitled "Pathfinding in Fuels and Engines."[14] Soon afterward, a pamphlet entitled "The Trail of the Arbutus,"[15] highlighted the heroic view of the discovery, beginning with the first discussions about engine knock in 1916 between Kettering and Midgley and culminating with the discovery itself.

A second and somewhat more detailed account of the discovery of Ethyl was written by G.M. public relations staff writer Stanton P. Nickerson in 1954. The history brought to light many of the positive details that had not been known about Ethyl, including the collaboration of university chemists at MIT, Harvard, Yale, Cornell, Johns Hopkins, the University of Cincinatti and others, and the investigation of alternatives such as an unnamed "synthetic knock-free fuel from cellulose." Like many others in Ethyl, Standard and GM who had been caught up in the controversy, Nickerson took a dim view of the news media. Nickerson claimed that publicity was in and of itself the cause of intervention by the government:

> Newspaper publicity in May of 1925 focused public attention on several deaths caused by lead poisoning among those exposed to tetraethyl lead during its manufacture and handling... [Quoting Dr. Robert A. Kehoe, a physician consulting for Ethyl] 'the major significance of the events of May, 1925 lay in the fact that they created in the public mind an apprehension concerning hazards associated with the distribution and use of leaded gasoline which, while wholly unjustified, was so great and so widespread as to require official action on the part of the health authorities of the U.S. government.'[16]

Another public relations effort was a Kehoe article for Ethyl News in 1962 claiming that "intensive medial studies show that lead ... compounds in auto exhaust create no hazards." The historical aspect of the controversy was not mentioned, but the controversy over air pollution building in the 1960s was acknowledged as "increasing interest in the cleanliness and purity of the air..."[17]

Many company officials sincerely believed that they were under attack by the news media. At one point, for example, Irenee du Pont told a federal court in 1952: "The newspaper accounts got a lot of people stirred up and confused over the danger."[18] Earl W. Webb, president of Ethyl Corp., had the following exchange with an attorney at the same anti-trust suit on April 9, 1953:[19]

> Q: Mr. Webb, on assuming presidency of Ethyl Gasoline Corp. [in 1925] you realized the most important problem was the health situation.
> A: There had been unfavorable publicity about it.
> Q: They called it "loony gas," did they not?
> A: The New York World did.

Clearly, corporate executives felt that the press in general and the World in particular had treated them unfairly, and that their "health situation" was the creation of the unfavorable publicity.

The first biography of Charles F. Kettering was written in 1957 by T.A. Boyd and called Professional Amateur. Boyd based the work on the series of unpublished memoirs (discussed above) and his own memories, capturing some of Kettering's jocularity and the sense of adventure he brought to his scientific research. Boyd did not give even a partial account of the controversy, which he reduced to the "concerns of doctors" that were met by "a long and thorough investigation."[20]

In a 1961, a biography of Charles F. Kettering, Boss Ket was written by his niece, Rosamond Young. The biography included a lengthy account of the discovery of Ethyl gasoline, building on the memoirs and public relations accounts at General Motors and Ethyl Corp. The biography echoed the romantic and heroic view of the discovery along with a disdain for the role of the press:

> News of the deaths spread through the country like lightning. Everywhere people who had used Ethyl gasoline in their automobiles became frightened. Further hysteria was created when the fact was published that deaths from lead poisoning had occurred earlier at Dayton and at the du Pont Deepwater plant. Sensational stories in the press had everyone believing that gasoline containing Ethyl accidentally dropped on the hands lowered blood pressure, causing unconsciousness and death before the victim could wash his hands. Dr. Yandell Henderson, a Yale University expert, declared that breathing exhaust fumes from Ethyl gasoline attacked the brain and nerves, causing delirium, paralysis and death. 'Loony gas' as the papers labeled it, became notorious overnight... Midge [Thomas Midgley] made a trip to New York during the investigations. Although he demonstrated that Henderson's statements were false by washing his hands in tetraethyl lead in the presence of reporters, the wild stories continued. It was useless for him to point out that the fatalities had been caused by heedlessness of the workers and that ethyl was harmless when properly handled.[21]

Young provides no evidence of frightened people or of hysteria, and does not say exactly which "wild stories" continued or even why she considered them to be wild. It is also interesting that she blames workers for "heedlessness" to workplace hazards.

Boss Ket was published the same year as the definitive and ostensibly scholarly industry history of oil, Williamson and Daum's The American Petroleum Industry. The work is exhaustive in many details; but dealing with the Ethyl controversy, it merely notes that tetraethyl lead sales had been halted in 1925:

> The immediate cause [of the halt in sales] was a report of 45 cases of lead poisoning, with four fatalities, at Jersey Standard's pilot plant for the ethyl chloride process at its Bayway refinery. The subsequent publication of findings by the Bureau of Mines from extensive tests that no health hazard existed from the exhaust of leaded gasoline did not curb the panic. Investigations by a committee appointed by Surgeon General Hugh S. Cumming finally cleared the way to resumption of sales a year later..." (after

handling precautions were developed).[22]

Again, no description of "panic" is given, and the history is flatly inaccurate regarding the number of workers who died.[23]

Another corporate history written in 1983 by Joseph C. Robert focused in part on the discovery of Ethyl gasoline by Charles Kettering and researchers T.A. Boyd and Thomas Midgley. Robert discussed the technical problem behind finding and developing anti-knock gasolines, adding very little not already available in Boyd and Young's biographies. Like them, Robert also blamed journalists for fanning the flames of controversy:

> The tragedies [of the dead workers] provided the journalists covering the event with an excuse for coining the phrase 'looney gas' which for a long time clung to gasoline containing the new additive. Newspapers in the U.S. and abroad gave sensational publicity to the Bayway story, picturing in lurid detail the agonies of the ill and dying.[24]

Here Robert passes along as a positive fact T.A. Boyd's speculation that the press created the term "loony gas." It is embellished with the further speculation that journalists were seeking to discredit Ethyl Gasoline Corp. Like Boyd and Young, Robert does not provide any supporting evidence.

Two important interpretations of the Ethyl controversy are found in the literature in history of technology. The first is Thomas P. Hughes' 1979 discussion about the discovery of tetraethyl lead as exemplary of a "reverse salient," that is, a key technical problem that must be improved if the broad front of technological advance is to continue. Hughes was interested not so much in the Ethyl story itself but in the question of how inventors choose their problems and how they arrive at solutions. The tetraethyl lead story provides details closer to the heart of these questions than most other stories of invention that are often "simplistic and adulatory," Hughes said.

To some historians, Hughes notes, Midgley was an excellent researcher and his discoveries of tetraethyl lead and chlorofluorocarbons were "beautiful pieces of pure, or at least deliberately planned, research." Midgley recognized knocking as the reverse salient in engine development and "tried out all elements possible in a so-called Edisonian style."[25] Hughes did not deal with the public controversy.

David Hounshell and John Smith's 1988 book about the du Pont Corp., Science and Corporate Strategy, briefly mentioned the public controversy:

> Newspapers across the country, but particularly the New York World, detailed the horrible effects of loony gas. Public health authorities in several states considered banning the use of tetraethyl lead. Deaths had occurred earlier, but none had received the publicity of the Standard (Bayway) incident...[26]

Hounshell and Smith's almost perfunctory criticism seems plausible but is unsupported by facts. It is likely that they did not read the newspapers of the era, since they would have also found that health authorities in several cities and states did not just "consider" banning tetraethyl lead. Between 1924 and 1928, many cities and states did, in fact, ban it, as was noted in Gerald Zilg's earlier history of the du Pont Corp.,which claimed that workers died from a lead compound that "newspapers promptly condemned as 'loony gas.'" The history also said "the country was in a furor" and that "federal intervention was necessary to avoid a national panic."[27]

Four general histories and a magazine article that re-examined the Ethyl controversy from a broader perspective have been published in recent years. Joseph Pratt noted in a 1980 paper that environmental discussions of the 1970s about water pollution, leaded gasoline and refinery safety were taking place without reference to their long history. He described the events leading up to the leaded gasoline controversy:

> A series of accidents involving tetraethyl lead catapulted debate over the new product from the internal correspondence of government agencies onto the front pages of newspapers throughout the nation... As the incident at Three Mile Island altered the context of debates on nuclear safety in 1979, so the highly publicized accident at Bayway pushed the discussion of the possible health effects of tetraethyl lead into a broader, more public forum, giving the opponents of the product added ammunition for renewed attack. The publicity created by newspaper headlines such as "Tetraethyl lead in victim's brain:" and by magazine articles such as the Nation's "Standard Oil's Death Factories" and the Literary Digest's "Insanity Gas" helped create a national concern over leaded gasoline.[28]

Althought Pratt's history is generally insightful, the New York Times November 13, 1924 story about lead found in the brain at an autopsy is hardly representative of Times coverage; nor are the other headlines representative of general trends. Pratt also takes a politically utilitarian and relatively shallow view of the news media in that it "gave" opponents ammunition. Didn't the news media also "give" proponents ammunition? Which side "got" the most "ammunition?"

Another important history of technology, Stuart Leslie's 1983 biography Boss Kettering, devoted a chapter to Kettering's study of anti-knock fuels. Leslie focused primarily on the discovery of leaded gasoline and its context in the general fear of an oil shortage and associated long-range automotive engineering decisions. The story of the discovery followed the "trail of the arbutus" saga in greater detail than had been available before and mentioned alternatives to Ethyl leaded gasoline for the first time in any history. Also, Leslie used publicity as a signifier of the controversy's depth and vigor. "Headlines dubbed leaded gasoline as 'Looney Gas' and shocking cartoons depicted Ethyl as a greedy giant squeezing blood from an innocent public."[29] Although Leslie's biography is exemplary in many respects, the description of the public controversy is impressionistic, not factual. Moreover, the cartoons in question have not been located.[30]

One labor history that paid more attention to the public controversy was

David Rosner and Gerald Markowitz' 1989 book Dying for Work, that contained two chapters on the Ethyl imbroglio. Although generally accurate and relatively well informed about the performance of the news media, Dying for Work did repeat the canard that the poisonings were "due to what the newspapers called 'loony gas.'" The authors also accepted the premise that the elimination of engine knock with tetraethyl lead "allowed for the development of the automobile essentially as we know it today."[31] As we have seen in Chapters Three and Five, a good many alternatives were available and were used to boost octane. The question as to whether the automobile would have been significantly different had tetraethyl lead been banned in 1925 is wide open, as this dissertation has argued elsewhere.

Another important historical interpretation of the Ethyl controversy is found in a dissertation concerning Alice Hamilton, a professor of public health at Harvard University during the time in question and an outspoken opponent of Ethyl gasoline. In the absence of federal regulations, scientist - advocates like Hamilton welcomed a role for the news media in bringing the issues out into "a blaze of publicity" in conferences between health advocates and industrialists.[32] This "conference system," a transitional phase in public health regulation in the conservative 1920s, depended on a role for the press, according to a dissertation on Hamilton by Angela Nugent Young. "The novelty of the acute symptoms caused by tetraethyl lead, scientists' ignorance of the chemical's physiological effects, and the possibility of risk to drivers using leaded gasoline sparked popular interest in the hazards of the new technology," Young said. "The press devoted unusual attention to the tetraethyl lead victims..." Novelty, uncertainty and the possibility of public risk, said Young, were factors that sparked interest.

Also, in a 1992 Mother Jones article on the modern impacts of the Ethyl Corp., journalist Nicholas Regush recalled the 1924 controversy as leaving "at least five dead and 35 others suffering from tremors, palsies and hallucinations ... The press soon dubbed the substance 'loony gas.'"[33]

Thus, even the Ethyl Corp.'s worst critics have been deeply affected by the industry view of its history. It is also important to look at what has not been said. Until 1980, only the company viewpoint about the Ethyl controversy was available in print unless one somehow knew to return to the newspapers and magazines that originally wrote about the public controversy. A spate of critical histories about the oil industry written in the 1970s and 80s completely missed the Ethyl controversy. At a time when interest in the oil industry was resurgent and when the public health problems of leaded gasoline were again being debated, an historical vacuum prevailed. Carl Solberg's Oil Power, a highly critical history of oil industry manipulation of politics, economics and foreign policy, described Ethyl as "Kettering's magic antiknock fluid" and followed Young's account of the controversy to the letter[34] . The Ethyl controversy is not even mentioned in The Control of Oil by U.S. Senate staff attorney John M. Blair, nor does it appear in Anthony Sampson's The Seven Sisters, James Ridgeway's Powering Civilization or Daniel Yergin's The Prize.[35]

Content Analysis of News about the Ethyl Controversy

Previous chapters showed that news coverage of the Ethyl controversy in the leading newspapers of New York city -- the Times, the World, the Herald Tribune, the Journal and the the Brooklyn Daily Eagle, -- presented both the industry and the public health side of the story. Yale professor Yandell Henderson, recognized as an expert by industry scientists and public health scientists, had seen a potential danger to the public. For the news media to ignore his views and print nothing in the "public interest" (as a Standard Oil spokesman requested) would have been unthinkable and irresponsible. Even the du Pont Corporation's 1936 internal history conceded that the "violent and spectacular nature of this strange malady had at once attracted newspaper attention," and that the dramatic sequence of deaths at Bayway "was naturally played up."[36] Certainly, all industry spokesmen had a chance to present their side of the story, and in all but the World newspaper, they successfully obtained the largest portion of the copy (as will be quantified below).

Journalists showed some enterprise in their use of sources. They interviewed political and industry authorities, as would be expected, but also tracked down workers and concerned scientists. They questioned authorities not only about the Bayway, New Jersey refinery, but also Deepwater, New Jersey and Dayton, Ohio, where other workers had died in the months before the Bayway disaster. On the critical side, the news coverage tended to follow the action rather than broaden public debate. Reporters wrote about workers who died, about public officials who investigated, about doctors who attempted a cure and about scientists and industrialists who issued press releases. In only one case, that of the Herald Tribune's note about Thomas Midgley's 1923 American Chemical Society paper, did readers learn anything about the scientific record, and in that case a lack of follow-up ensured that Midgley was not held accountable for the difference between his public relations posture and his other professional papers. (The professional and personal links between James T. Grady and Thomas A. Midgley may have been a factor. Grady, a former Tribune editor and journalism professor at Columbia University, became a paid public relations advisor to Midgley around this time.) Although reporters and editors were clearly alarmed at the extraordinary events at Bayway, coverage was not "lurid" except in Hearst's Journal, in which every event was painted in the most lurid colors. And since most of the Journal's coverage of the Ethyl controversy was plagiarized word-for-word from other newspapers, the lurid sensationalism was in fact far less than might have been expected.

Industrialists, historians and editors at the World itself have all concluded that the World played a leading role in "crusading" against Ethyl gasoline. Yet its news accounts were accurate, factually oriented and "objective," in that they did not reflect outright personal biases of the writer or the editor. Certainly differences in tone, style, source selection and basic political orientation were visible between the World and the Times, although both approached the issue with a basic commitment to the public interest.

The factual orientation of the articles calls into question the interpretation of the term "crusade" by various interests. On May 5, 1925 the World indulged itself in a pontifical set of self-congratulatory front page articles on its “crusade” against Ethyl gasoline. “Dangerous Leaded Gasoline Sale Stopped After Fight by the World,” a three-column headline said. The article below described “the story of the World’s successful fight to stop the sale of tetraethyl gasoline pending a thorough inquiry into its danger.” Another story also noted that “Dr. Yandell Henderson of Yale took a large part in the crusade.” In a sidebar, Henderson was quoted as writing: “I congratulate the World heartily for the high service it has rendered, for without the intelligent support given this undertaking no such victory could have been achieved.” Yet the World’s self-declared crusade appears on the surface to be little more than a few congratulatory articles linked to routine coverage of an important issue. Aside from its reliance on public health authorities, the World did not engage in the kind of crusade that was common a generation before. It did not assault Standard Oil or General Motors on the front pages. No one was reviled in editorials. Instead, coverage was thoughtful and even handed, and if university sources were higher on the agenda than they were at the Times, the question of editorial prerogative looms larger than outright bias. The use of the term"crusade" seems to have been something of a mutually accepted anachronism. If it was convenient for the World to believe its mild-mannered "crusade" was effective, it was equally convenient for industry to believe what appeared to be the same thing. In the end, the fact that no libel suits resulted from the extensive coverage demonstrate, at least, that the facts reported in the World could not be challenged in court.

Perhaps most irritating to industry, the World's articles lent more credibility to public health scientists than industry scientists, as is noted below in a quantitative content analysis. Where the Times and other newspapers tended to minimize or downplay public health scientists, the World printed twice as much from them as the Times. The World also initiated negative articles. For instance, the public would not have known about the Harvard criticism of the Bureau of Mines study or poisoning of Columbia University researchers had not the World made the issues public. The Times, in contrast, merely reacted to negative articles and initiated only positive articles, such as the April 6 story on Midgely's statements to the ACS conference, the April 5 story on the SS Ethyl and the May 8 story about a trade editor defending leaded gasoline. The Times printed rebuttals to negative news, but often did not print the negative news itself. The Times was accurate, factually oriented and "objective," although it had a markedly different orientation toward the protagonists in the controversy.

The differences between the two newspapers represent variations in the news and political judgements of editors and the orientation of each institution toward scientific authority. Simply put, the World gave dissident scientific voices far more credibility and viewed industry scientists more skeptically than the Times. The difference can be graphically demonstrated through a simple exercise in content analysis of source reliance in the Ethyl controversy.

Granted, considerable debate surrounds the use of quantitative methods in historical research. One frequent objection is that quantitative analysis has been used in a reductionistic fashion, as if thorny and multi-faceted historical questions were easily answered by compiling statistics. Another view is that historians should resist the tendency to mimic social sciences.[37] Even so, this content analysis is intended to address an historical question within the context of other historical research.

Analysis of News Source Orientation in the Ethyl Controversy

One important question that emerges in the history of the Ethyl controversy is the extent to which the New York World stood out from other newspapers in its approach to news coverage. The question involves the justification for the praise for the World from university scientists Yandell Henderson of Yale and Alice Hamilton of Harvard and the condemnation of the World by Charles Kettering, Thomas Midgley, T.A. Boyd, Alfred P. Sloan, Irenee Du Pont -- all members of the industry -- and by many industry-oriented historians such as Joseph C. Robert.

No qualitative impression of the World's coverage quite clarifies the picture as well as a simple exercise in content analysis. In this case, the unit of analysis most appropriate is source reliance, which has been used to analyze controversial trends in news coverage in recent years. The selection of sources is one way that the news media "wield enormous gatekeeping responsibility," said D. Lasorsa in a review of sources quoted about the 1987 financial crash.[38] Source selectivity has also been used to evaluate news coverage about illegal drugs in the 1970s.[39] Despite its potential usefulness, it has not been widely employed for historical content analysis.

The seven newspapers considered in this analysis represent the broad spectrum of the New York city press in the 1920s era. The New York Times, stolid and ostensibly dispassionate; the World, a liberal intellectual newspaper without much depth in science; the New York Journal, which along with the American was William Randolph Hearst's sensational subway tabloid newspaper; the Herald-

Tribune, the recently merged and still-shaky partnership of Horace Greeley's Tribune and James Gordon Bennett's Herald; the Sun, an aging relic of the 19th century; the Daily News, more concerned with beauty pageants and murders than scientific controversies; and the small Brooklyn Daily Eagle. Specialized daily newspapers like the Wall Street Journal and the Daily Worker were omitted from the content analysis. The New York Daily Graphic and the American were the only major daily newspapers of general circulation from the period to be omitted since no archives of the papers exist for the time period in question.[40]

The content analysis included 124 articles printed about the Ethyl controversy during the 15-month period of October 27, 1924 through Jan 20, 1926. The Times alone printed 51 articles, by far the largest number of articles; the World printed 24 articles, the Journal 15 articles, and the others covered only highlights of the news, printing six to 12 articles each. Although the World printed fewer articles than the New York Times, they tended to be twice as long, resulting in about the same amount of coverage between the two papers.

Methodology

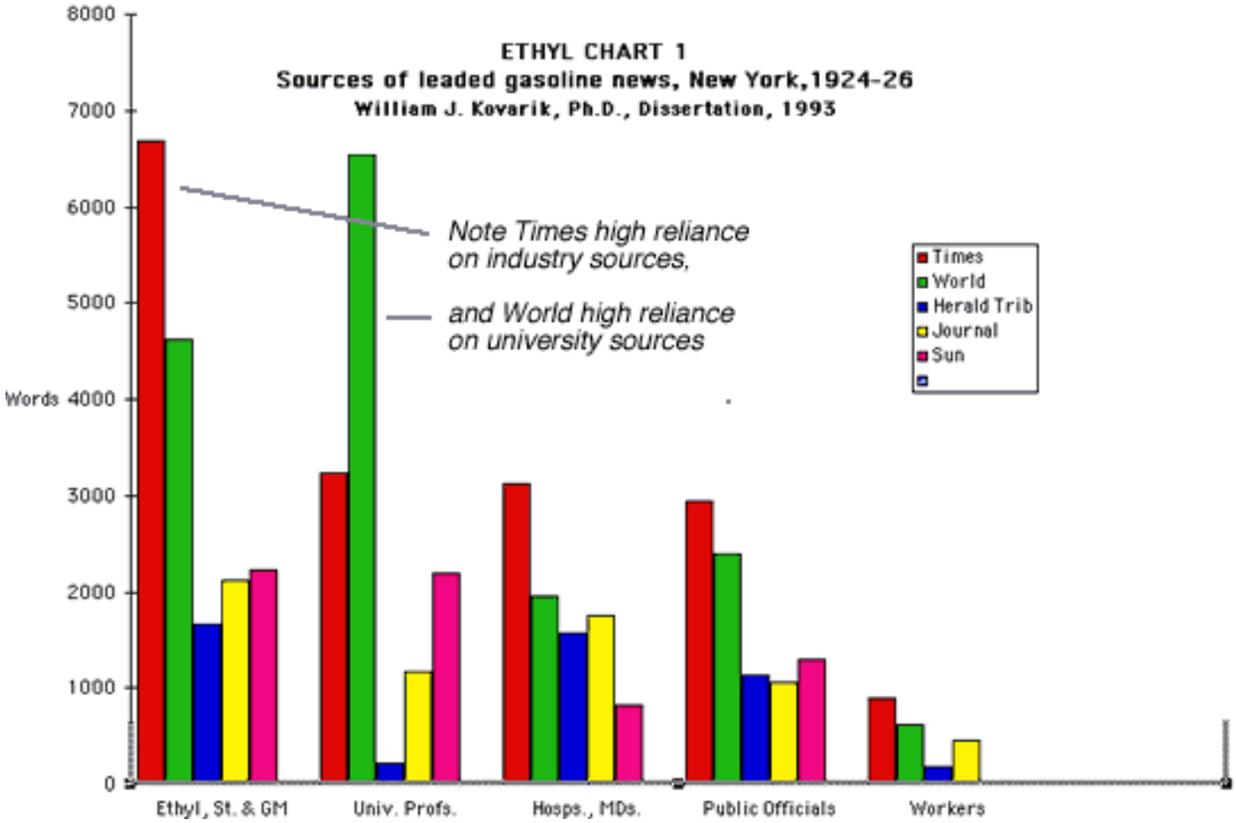
Three independent coders measured the text of the articles and noted the apparent source of the information in inches or halves of inches. For example, if the article quoted an official of the New Jersey health department, it was assumed that the official was the source, and the source was noted as such. In only one case was this problematic: the Journal plagiarized large volumes of its material verbatim from the New York Times and the Herald Tribune. For the purposes of a content analysis it is best to conclude that the Journal editor's source reliance is reflected in the copy as it is, notwithstanding wholesale plagiarism.

Coders were instructed to measure the text of the article with a ruler and to note the column inches of copy provided to categories of sources. For example, industry affiliated sources included General Motors, du Pont, Standard Oil and Ethyl Corp., while university sources included Yandell Henderson of Yale; Alice Hamilton, Cecil Drinker and David Edsall of Harvard; Frederick Flynn and others from Columbia. If no source was apparent, the information was attributed to background / unknown. The measurement for column inches was converted into a figure for total number of words by adjusting for the number of words found in a representative column inch. This adjustment allowed an equal comparison despite differences between the typesetting styles of the seven newspapers. It was also necessary in order to adjust for the various magnifications with which copies of microfilmed articles were made in various archives.

The measurement for inter-coder reliability followed standard procedures. Each coder measured at least 20 articles that had been measured by other coders, for a total overlap of over 30 percent. The sums of the differences between coders in assigning adjusted column inches to categories were divided by the number of inches measured by both coders. The inter-coder reliability factor of 84.4 percent and 85.9 percent was derived among the three individuals, which is within an acceptable range.

Findings of the Content Analysis

The most striking result of the content analysis involves the difference between the investment of credibility in scientific sources between the Times and the World. The volume of coverage by the two newspapers is similar, but the frequency of publication and distribution of source reliance is remarkable different. While the Times printed 51 articles during the crisis period, the articles averaged 6.3 inches in length, while the World printed 24 articles with average lengths of over 15 inches.



The charts (seen here) show the contrast between the source reliance of the newspapers. Charts No. 1 and No. 2 show that the Times relied heavily on industry sources, devoting almost 7,000 words to information from General Motors, du Pont, Standard Oil Co. and Ethyl Corp, for a total of 36 percent of all coverage. The Times also relied heavily on state and local government sources, giving them over 5000 words, for a total of 26 percent of coverage. University scientists were given a smaller amount of space, amounting to about 3,000 words or about 17 percent of the total. In contrast, the World relied quite heavily on university scientists, citing them in over 9,000 words of coverage, or 42 percent, giving industry only 5000 words (26 percent) and government only 3,000 words (19 percent). Thus, the Times provided readers with more industry-sourced information than the World, but the World included much more university-derived information than the Times.

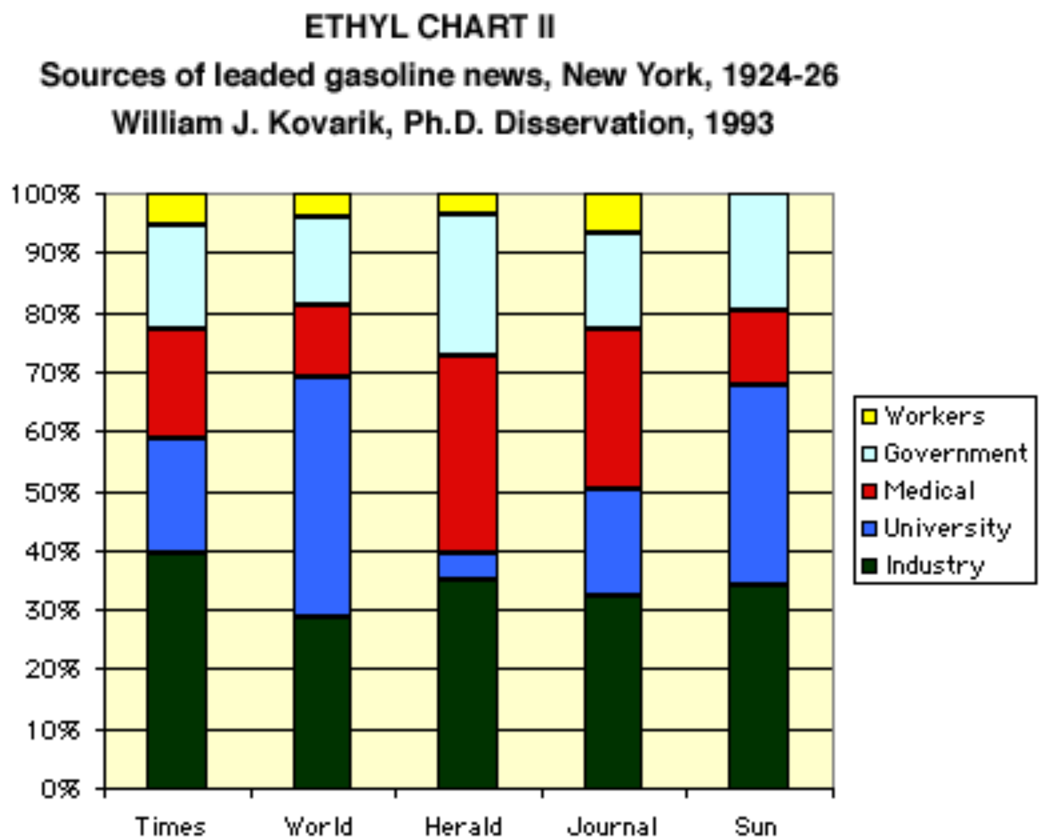


Chart No. 2 shows the percentage of each paper's coverage and compares it to an overall average. Clearly, the highest industry source reliance was found at the Times, with the lowest reliance on university sources at the Herald Tribune.

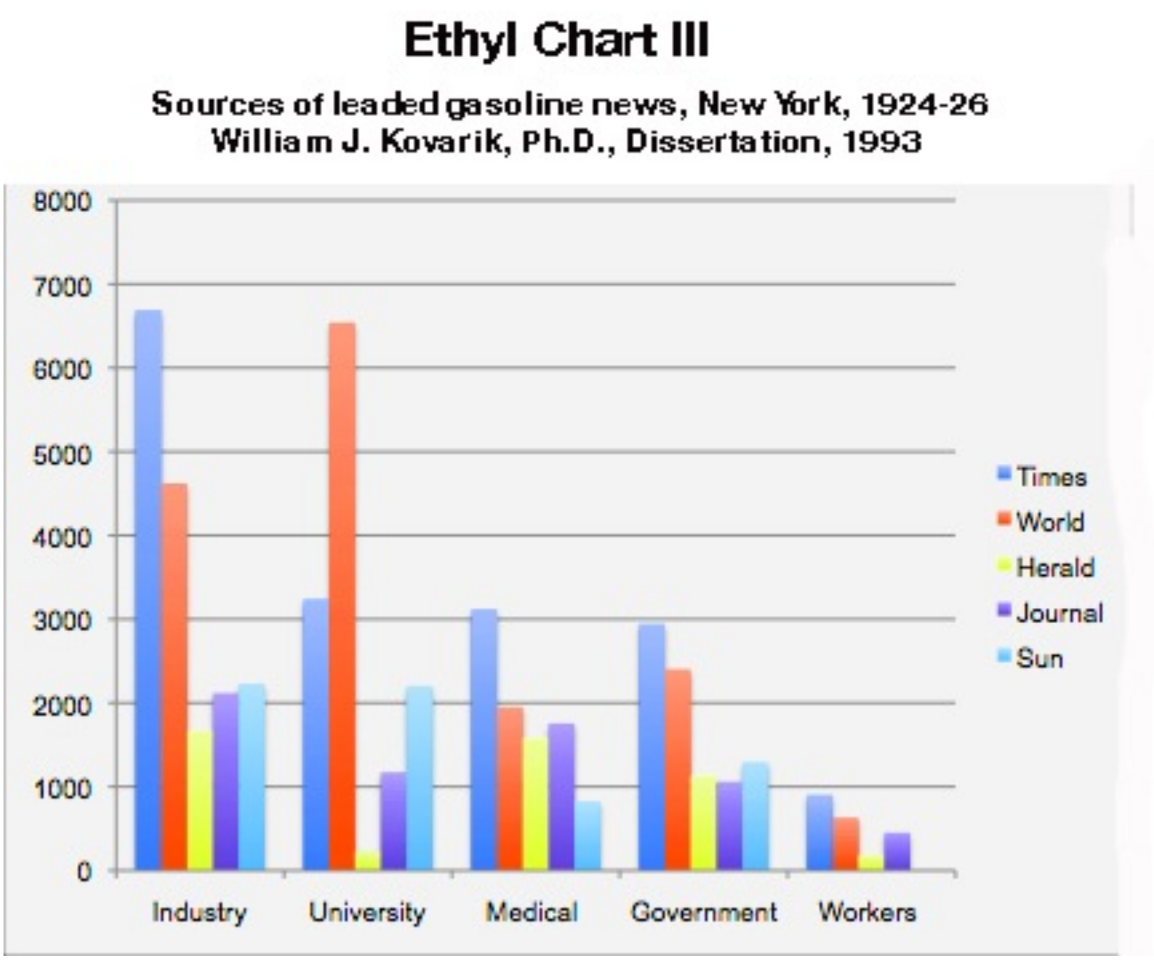


Chart No. 3 is simply another cut at the information in Chart No. 1, taking the categories of sources in comparison. Again, there is a striking contrast between the coverage of the New York Times and the New York World in terms of source reliance.

In summary, the World gave university scientists three times more space than did the New York Times and far more than the other newspapers. The World's articles were longer and much more likely to provide detailed information on the university public health experts' views of leaded gasoline. Other newspapers, such as the Sun and the Daily Eagle, attempted to balance industry and university sources, but the Herald Tribune virtually ignored the university sources and relied heavily on industry and medical officials.

Who Called it Loony Gas?

As noted above, industry historians have claimed that the press invented the term "loony gas" and used it frequently in coverage of the controversy. T.A. Boyd, Rosamond Young and General Motors' public relations history said the World labelled Ethyl as "loony gas." Ethyl president Earl Webb testified in federal court that the World called the product "loony gas." Historian Joseph C. Robert said the term loony gas "clung" to Ethyl, while historians Hounshell and Smith said "newspapers detailed the horrible effects of loony gas," and historians Rosner and Markowitz said the deaths were "due to what the newspapers called 'loony gas.'" A 1992 Mother Jones article asserted that "the press soon dubbed the substance 'loony gas.'"

It is interesting to contrast these interpretations with the first news article about the Ethyl controversy. It was printed on the front page of the New York Times on October 27, 1924, under the subhead: "Called It "Loony Gas Building":

> Employees at the plant revealed that the experiment building was known as the 'loony gas building.' Men who took up work in this building came in for 'undertaker jokes' and serio-comic handshakes and farewell greetings when their comrades learned of their action. So far as could be learned, no special warnings were given employees working with 'loony gas' nor apparently did they sign documents relieving the company of responsibility.[41]

This account corresponds with a June 1925 Times report concerning the Deepwater, New Jersey, du Pont plant:

> One of the early symptoms [of strickened workers] is a hallucination of winged insects. The victim pauses, perhaps while at work or in a rational

> conversation, gazes intently at space, and snatches at something not there. The employees at Deepwater have ironically dubbed the plant "'the House of Butterflies..'" C.K. Weston, who is head of the du Pont Publicity Bureau said ... [he] had heard of the workers name for the plant. 'Some of them drew pictures of butterflies on the walls of the plant,' he said. 'This disease is somewhat like delirium tremens. Instead of seeing snakes, the men see butterflies.'[42]

Clearly, the term "loony gas" was invented by workers and not by the news media. It might never have been used at all if Standard Oil had followed the philosophy of Ivy Lee, its public relations counselor, and had made public the facts about Ethyl leaded gasoline right awayt. As it was, the term "loony gas" was used far less than might be imagined from the histories mentioned above. It was used in 12 headlines out of 126 New York daily newspaper articles on Ethyl gasoline; the World used the term twice in a headline. The vast majority of terms used in headlines were neutral and described the company or the product: Ethyl gas, leaded gas, tetraethyl gasoline, or Ethyl gasoline. Descriptive and colorful terms were used in the first five days of the controversy in October, 1924, but other terms were used far more often than "loony gas." The terms tended to indicate either uncertainty ("odd gas," "mystery gas," "new gas,") or danger ("insanity gas," "mad gas.") It is important to recall that Ethyl, Standard and General Motors officials repeatedly refused to talk with New Jersey health and labor officials or the press during the time of uncertainty and danger and that the actual name of the product was unknown.

The World's use of the term "loony gas" was innocuous. It is found in an inside (not front page) headline in the first stage of the controversy in October, 1924. Later, in May, 1925, the term was used once again in quotes showing it was meant in a joking tone. The World did use terms such as "mystery gas" and "mad gas" in the period when Standard refused comment, but after the mystery was settled, the World relied on neutral terms such as Ethyl, tetraethyl or leaded gasoline. None of the World's headlines tended any more toward the sensational than the Times.

The New York Times, the Sun, the Herald Tribune and the Daily News never used the term "loony gas" in a headline, although the Times used the term in a subhead the first day (October 27, 1924) and used terms like "odd gas," "insanity gas" and "poison gas" in headlines during the first week. The sensationalistic Journal used the term "loony gas" five times in 15 articles, but these, too, were primarily in the initial stage of the controversy, and neutral terms such as Ethyl Gas were usually used in headlines after October, 1924. The Brooklyn Daily Eagle, also a somewhat sensationalistic newspaper, used the "loony gas" term five times in the first week of the controversy, but like the others, used "Ethyl gas" afterwards.

Why the term "loony gas" stuck in the minds of the Ethyl corporation officials as an invention of the press and in particular of the World is unclear from this data. The term was not a prominent feature of the contemporary news reporting of the controversy. What is interesting is that the perceptions of Ethyl officials greatly affected historians even though they had easy recourse to non-corroborating documents. What this suggests is the degree to which such perceptions may have colored other areas that were far more difficult to corroborate.

Conclusion

Although the Ethyl controversy occurs during at an important juncture of public policy and the philosophy of science and technology, the public controversy has not been considered in any great detail by existing histories, and the role of the news media in the public controversy has been perceived in an extremely negative light. This perception is surprisingly strong, considering that is has been formed without even minimum reference to primary documents that are immediately available.

The significance of the disdain for the news media is not simply that American industry and labor historians may have uncharitable views of of the media that journalists might reflexively call a "kill the messenger" syndrome. Nor is it deeply troubling that historians with a broader agenda did not check the newspapers to ensure that they were not passing along a small but undeserved canard.

The unfortunate aspect of the historical misinformation is that a more accurate view of a news media struggling to cover science and apply scientific principles to journalism has been obscured. (That topic is taken up in the next chapter). What is also troubling is that history has left Americans without a record of public controversy in scientific and technological areas. The consequences of this lack of a record may be far greater than can be explained here. One may have been that the emotionally colored and deeply entrenched positions in the environmental controversies of the 1960s and 70s might have emerged in a different way had there been a tradition of public debate in the area. Another consequence may be that the public interest perspective has remained dependent on authorities with their own hidden interests.

The omission of the Ethyl controversy from historical accounts of automotive and petroleum histories of the 1960s through the 1990s is highly significant given the intent of many of these histories to deal with public policy and environmental problems. The omissions demonstrate the influence of the ideology of industry and the myth of heroic invention on historians, even upon those who are apparently trying to be critical of the oil and automotive industries. In addition, the omissions point toward a broader horizon that needs to be explored.

---

1. "A Brief Story of Ethyl Gasoline," (New York: Ethyl Corp., 1927), American Petroleum Institute library, Washington, D.C.

2. Graham Edgar, "The Manufacture and Use of Tetraethyl Lead" Industrial and Engineering Chemistry 31, (Dec. 1939), pp. 1439-1446.

3. Anonymous, "It all Began When..." undated and unlabeled clipping of a magazine article, probably from an American Chemical Society or Ethyl Corp. pamphlet, found in the American Petroleum Institute library, Washington D.C.

4. Frank A. Howard, "History of the Ethyl Gasoline Corp.," memo to Mr. William Benhem, US Dept. of Justice, April 21, 1927; Defendants Trial Exhibit No. 274, U.S. v. E.I. Du Pont de Nemours and Co., 126 F. Supp. 235, p. 9. (Hereafter cited as U.S. v du Pont). It is interesting that this line of reasoning was taken up by others in defense of Ethyl, including du Pont attorney Ferris Hurd at the 1953 anti-trust trial.

5. N.P. Wescott, Origins and Early History of the Tetraethyl Lead Business, June 9, 1936, Longwood MS Group 10, Series A, Hagley library and Museum, Wilmington, Delaware, p. 22. (Note that Ethyl's 1924 annual report is not available in the GMI archive).

6. T. A. Boyd, The Early History of Ethyl Gasoline, Report OC-83, Project # 11-3, Research Laboratory Division, GM Corp., Detroit Michigan, (unpublished) June 8, 1943, GMI, Flint, Mich., p. 2. (Hereafter cited as Boyd, Early History).

7. Ibid, p. 164.

8. Charles Kettering, "Transcript of Matter on the Story of Ethyl Gasoline," dictated in Florida, 1945, GMI, Flint, Michigan. (Hereafter cited as GMI).

9. Typewritten note on the cover of "Transcript of Matter on the Story of Ethyl Gasoline," GMI.

10. Ibid, p. 93. Note also that the experiment in question was conducted at Columbia University and that Kettering's interpretation is shallow at best.

11. Historical Summary Ethyl Corp. 1923 - 1948, Ralph C. Champlin, Ethyl Corp. Public Relations Dept., 1951, Third Draft. p. 47; GMI.

12. N.W. Kent and A.L. Delin, "The Product Nobody Wanted," du Pont Magazine, Feb.-March, 1951, p.14, Hagley Museum & Library, Wilmington, Del.

13. Graham Edgar, "Tetraethyl Lead," paper to the American Chemical Society, New York, Sept. 3-7, 1951, Reprinted by the Ethyl Corp.

14. T.A. Boyd, "Pathfinding in Fuels and Engines," Society of Automotive Engineers Transactions, (April 1950), pp. 182-183.

15. "The Trail of the Arbutus," probably published either by Ethyl Corp. or General Motors, Aug. 29, 1951, unprocessed Midgley files, GMI.

16. Stanton P. Nickerson, "Tetraethyl Lead: A Product of American Research," Journal of Chemical Education 31, (Nov. 1954), p. 567.

17. Robert A. Kehoe, "Antiknock Compounds and Public Health," Ethyl News, May-June, 1962, p. 7.

18. Testimony of Irenee Du Pont, p. 2169, US v. du Pont .

19. Testimony of Earl Webb, p. 3646, US v E.I. du Pont .

20. T.A. Boyd, Professional Amateur (New York: E.P. Dutton, 1957).

21. Rosamond Young, Boss Ket: A Life of Charles Kettering, (New York: Longmans Green & Co., 1961), p. 162.

22. Harold Williamson, et al., The American Petroleum Industry, The Age of Energy, 1899-1959 (Evanston, Ill.: Northwestern University, 1963), p. 414.

23. du Pont put the official toll at 16 in its corporate history, with one suicide probably linked, for a total of 17.

24. Joseph C. Robert, Ethyl, A History of the Corporation and the People Who Made It (Charlottesville, Va.: University Press of Virginia, 1983), p. 122.

25. Thomas P. Hughes, "Inventors: The Problems They Choose, The Ideas They Have and the Inventions They Make," in eds., Patrick Kelly, et al., Technological Innovation: A Critical Review

of Current Knowledge (San Francisco, San Francisco Press, Inc., 1979). Of course, having tried out all elements possible, and having found several that worked quite well, Midgley insisted that only one was known to science.

26. David Hounshell and John Smith, Science and Corporate Strategy: du Pont R&D, 1902-1980 (New York: Cambridge University Press, 1988), p. 154. Note the major source cited was the du Pont 1936 history and other papers in the anti-trust suit for which the history was prepared.

27. Gerard Colby Zilg, DuPont: Behind the Nylon Curtain (Englewood Cliffs., N.J.: Prentice Hall, 1974), pp. 214, 217.

28. Pratt, "Letting the Grandchildren do it," p. 46. Note also that the politically utilitarian view (the press gave opponents ammunition) could be contrasted with a more factual view that the press reported the incident and concerned citizens and scientists created a media opposition.

29. Leslie, Boss Kettering, p. 166.

30. Personal conversation with Bill Leslie, Jan. 14, 1992; a search of files at the GMI collection July 7 - July 11, 1992 did not turn up any greedy giants squeezing blood; it is likely that this is hyperbole. No editorial cartoons about the incident are available except for the Journal's Hal Coffman series depicting insane people in straitjackets and a May 4, 1925 New York World cartoon depicting a "Manufacturer" at the gas pump "Not Waiting for an Investigation." Both are reproduced in the appendix. It is interesting to note that the Daily Worker often used the "greedy giant squeezing blood" motif to protest capitalism's various insults to workers; however, not even the Daily Worker used such a cartoon in the Ethyl case.

31. David Rosner and Gerald Markowitz, "A Gift of God? The Public Health Controversy Over Leaded Gasoline during the 1920s," Dying for Work: Workers Safety and Health in Twentieth Century America, (Bloomington, Ind.: Indiana University Press, 1989), p. 125. The contention assumes that no alternatives were available or were employed in automotive history, which is not the case.

32. Angela Nugent Young, "Interpreting the Dangerous Trades: Workers' Health in America and

the Career of Alice Hamilton, 1910 - 1935," Ph.D. Dissertation, Brown University, June, 1982, p. 160.

33. Nicholas Regush, "MMT," Mother Jones, May/June 1992, p. 24.

34. Carl Solberg, Oil Power (NY: New American Library, 1976).

35. John M. Blair, The Control of Oil (NY: Vintage Books, 1978); Anthony Sampson, The Seven Sisters: The Great Oil Companies and the World They Shaped (NY: Viking, 1975); James Ridgeway: Powering Civilization; the Complete Energy Reader (NY: Pantheon, 1982); Daniel Yergin, The Prize: The Epic Quest for Oil, Money & Power (NY: Simon & Schuster, 1991).

36. Wescott, Origins and Early History.

37. J. Morgan Kousser, "Quantitative Social-Scientific History," in Michael Kammen, ed., The Past Before Us: Contemporary Historical Writing in the United States (Ithaca: Cornell University Press, 1980), p. 433-456.

38. Dominic L. Lasorsa and Stephen D. Reese, "News Source Use in the Crash of 1987: A Study of Four National Media," Journalism Quarterly, 67, No. 1, (Spring 1990), pp. 60 -71.

39. R. Gordon Shepherd, "Selectivity of Sources: Reporting the Marijuana Controversy," Journal of Communication 31, No. 2, (Spring, 1981), p. 135.

40. Also, the extensive clipping files of the Public Health Service and the GMI library do not contain any Graphic or American clips. In the case of the American we can assume that virtually everything in the Journal was also carried there. The Graphic, like the Daily News, was probably disinterested in all but the surface of the controversy. Thus, the content analysis can be said to cover all general circulation daily newspapers in the city for which archives are available, and those for which archives are not available are incidental.

41. "Odd Gas Kills One," New York Times, Oct. 27, 1924, p. 1.

42. "Tetraethyl Lead Fatal to Makers," New York Times, June 22, 1925.

Text

CHAPTER EIGHT

SCIENCE NEWS IN THE 1920s

The differences in the two news agendas that are depicted in Chapter Seven reflect the philosophies of two leading New York editors at the time of the Ethyl controversy: Carr Van Anda at the New York Times and Walter Lippmann at the New York World. Historians who have attempted to portray the news media of the 1920s era as ignorant or unconcerned about science and technology, some of whom have been discussed in Chapter Seven, are widely off the mark.

This chapter begins with a general overview of the history of science journalism and continues with the contrast between the Times and the World coverage of the Ethyl controversy as influenced by the different philosophies of journalism and science held by Van Anda and Lippmann. It concludes with a discussion of the models of science news coverage that have been used in history and proposed by communications researchers.

A Brief History of Science Journalism to 1925

The early origins of popular news about discovery and science might be traced back to Christopher Columbus' printed newsletter of 1493, announcing the results of his first expedition to the Indies. Or perhaps "science journalism" could be traced to the occasional report in newsletters from the houses of Taxi and Fugger that circulated around Europe in the early 16th century and discussed such topics as witch burnings and the effect of weather on crops.[1] The expansion of printing and publishing, and the availability of books such as De Re Metallica (1556) and De Re Navali (1536), broke down the "secrecy and mystery" of many crafts traditions in the 16th century that would lead to an expansion of technology and, in turn, an expansion of scientific knowledge.[2] However, the tradition of truly popular science writing can be said to have emerged by the late 17th century, when Bernier le Bovier de Fontenelle (1657 - 1757) lectured and wrote for the Paris magazine Mercure Galant about astronomy and physics "in the least philosophical manner possible." Science writing should be, he said, "neither too dry for the gentry nor too superficial for the scientist." Fontenelle's idea of public involvement in science was to encourage people to spend evenings peering through telescopes trying to see the people living on the moon.[3]

Publik Occurences, America's first newspaper, contained reports of smallpox "raging in Boston" and other "epidemical fevers." It was suppressed in 1690 by the governor of Massachusetts.[4] Another early media controversy involved an argument around 1720 between New England Courant publishers James and Benjamin Franklin and the Rev. Cotton Mather over smallpox inoculation in Boston. The Franklins opposed it in the Courant, while Mather printed pamphlets, gave sermons, provided physicians with information and demonstrations and conducted a study to prove his point.[5]

Social reform was a concern of the British press in the late 17th and early 18th centuries, and reform efforts were linked to medical and scientific arguments. In 1699, the London Spy, provided an "alehouse view of English society" with articles such as "Hell in an Uproar," (about the Bedlam lunatic asylum) that set the stage for more scientifically-oriented reform movements in years to come.[6] Campaigns for sanitation, prison improvement, child welfare, worker safety and temperance were a reaction to the steaming slums of 18th and 19th century London. One of the first public health campaigns was directed against cheap gin and was sparked by William Hogarth's 1750 book Gin Lane, which described shocking depravity and brutality caused by alcoholism. The campaign used newspaper editorials, petition drives, public events and organized lobbying of magistrates and other officials. In response, Parliament quickly regulated gin sales. The campaign "was a prototype of public health agitation that was to assume crucial significance in the 19th century," said historian George Rosen in his classic History of Public Health.[7] John Howard, High Sheriff of Bedfordshire, published State of the Prisons in 1777 that described the evils of prison in terms of their impact on the health of the surrounding community. "He thus showed that people are galvanized into action when the facts about social disease are forced upon them and that an aroused public opinion could be employed as a lever to compel reform," said Rosen.[8]

An unprecedented increase in popular education about science and medicine emerged in the 18th century through books, magazines and newspapers.[9] Physicians such as Benjamin Rush published regular articles on medicine in a variety of American and British magazines, varying vastly in tone, accuracy and content. They contained advice about hygiene and herbal remedies, epidemics, medical curiosities, and theories of disease.[10] Reform and the spread of scientific knowledge was occasionally suppressed. For example, the discovery of the origins of the Devonshire Colic (lead sheets in the presses of cider mills) was hotly controversial, as we have seen in Chapter Two.[11] Also, a school for mechanics at Royal Institution was dismantled in

1802. "I was asked rudely what I meant by instructing the lower classes in science," wrote Thomas Webster of the school. "It was thought to have a dangerous tendency."[12]

Yet popularization of science continued with lectures by notable scientists, through articles by scientific and medical professionals and, increasingly, in articles by laymen attempting to understand science. A prominent early American journalist concerned with science was Baltimore editor Hezekiah Niles, whose Niles Weekly Register (published 1811 - 1849) was concerned with a broad spectrum of human activity beyond politics and foreign affairs. He regularly wrote about developments in medicine, technology, exploration, economics, chemistry, physics and astronomy. In an 1816 article about sunspots, Niles neatly summed up the old and new views of the world: "One class of philosophy calls every extraordinary appearance a judgment or a sign; another class views everything as the working of matter and motion. These two sets are at war with each other. The one denounces the other as superstitious or aesthetical..."[13]

Niles Weekly Register belonged to an elite group of publications that by the 1830s found itself competing with cheaper publications supported in part by advertising. In 1835, the New York Sun, one of the new "penny press" newspapers, managed to embarrass many of the more expensive publications by printing an extraordinary story that the Sun claimed had come from the Edinburgh Journal of Science. The story involved Sir Percival Lowell's supposed discovery of winged inhabitants on the moon and contained elaborate descriptions of their cities. The expensive papers published the story as if they, too, had picked it up from the Journal of Science, and when the hoax was uncovered and no such Journal of Science was shown to exist, they "were reduced in stature" and the penny press got a boost.[14]

By the 1840s, the Sun, the Herald, the Tribune and other daily newspapers routinely sent reporters to courthouses, police stations and battlefields in search of news. Science, meanwhile, was beginning to find a voice in a new group of science magazines, including Scientific American, Science, and Popular Science Monthly. By the end of the 19th century, newspapers contained enough science material that they tended to introduce readers to areas better covered by specialized magazines. The specialized lay publications, in turn, served as introductions to medical journals and books, according to Terra Ziporyn, in Disease in the Popular American Press.[15] "American interest in scientific matters burgeoned in the 1860s and 70s" with the new publications and with regular science and medical columns in general interest magazines, Ziporyn said.

As the 19th century ended, muckraking magazines, such as McClure's and Munsey's, showered a generation with scandals about tainted meat and milk, patent medicines, worker safety and a host of other abuses of corporate and scientific power. Muckraking fervor accomplished some of the intended reforms by the first decade of the 20th century, but the public grew tired of it. There continued to be a preference for the sensational "yellow journalism" approach in among some levels of the culture.

The two largest newspapers practicing "yellow journalism" at the turn of the 20th century were William Randolph Hearst's New York Journal and Joseph Pulitzer's New York World. Both played up the sensational and emotional aspects of science, usually with disregard for facts but sometimes on behalf of the public interest. Journal editors, for example, paid a new bacteriology laboratory in 1904 to run fecal coliform tests on oysters, ice and milk sold throughout New York City; not surprisingly, the lab found extensive contamination.[16] Pulitzer's World ran a column called "Wonders of Science" that presented science news as "exciting" and "miraculous."[17] The formula for a good science story was often to play up the exciting aspects as much as possible. The news about the 1910 return of Halley's Comet, for example, might involve a picture of a pretty girl, a "good nightmare idea like the inhabitants of Mars watching (the comet) pass," pictures of scientists and "a two-column boxed 'freak' containing a scientific opinion that nobody will understand, just to give it class."[18]

Yellow journalism was never the style of the New York Times, but when Van Anda became managing editor in 1901, he attempted to refocus the profession's attitude toward the news in general and science in particular. He believed that journalists, like scientists, had to be disinterested observers ready to accept the facts as they were rather than see them through pre-existing prejudices. He is sometimes described as a "scientist as well as a journalist." He lionized scientific expeditions and research with as much enthusiasm as his meticulous and cold-blooded personality would allow. While Pulitzer and his executive editor Frank Cobb were still dressing up news about Halley's Comet with pretty girls and Martians, Van Anda was directing serious science coverage of polar expeditions, archaeological excavations, medical and astronomical discoveries and new technologies. These signalled a new era of science, and Van Anda believed it was important to understand science and not see it as merely a source of entertainment.

Taking science seriously paid off more than once. With his interest in the new wireless radio-telegraph, Van Anda had a reporter listening when the Titanic sent out a distress call. The Times scored a major coup with a wireless interview of the Titanic radio operator who had been rescued by another ship. Van Anda was himself famous for his scientific acumen. He once corrected an interpretation of Egyptian hieroglyphics from King Tut's tomb shown in a news photo. On another occasion, he noticed something amiss in a photo of a blackboard behind Albert Einstein, who was visiting Princeton University for a lecture. The equation on the blackboard was wrong, he claimed. When Einstein was shown a photo of the blackboard, he studied it a few moments, confirmed the error and said the equation must have been mistakenly transcribed by an assistant.[19]

Because of Van Anda, the New York Times employed an exacting standard that excluded all but the most scientific and respected points of view. Cures for cancer and other sensational stories with little authoritative backing were rare in the Times. Other newspapers, notably the Herald, the Tribune and Sun, frequently followed the Times' lead, while Hearst's Journal (and its twin, the morning American) preferred sensationalism.

TABLE TWO

NEW YORK CITY DAILY NEWSPAPER CIRCULATIONS 1924

	Morning	Afternoon	Sunday
World	361,000	271,000	575,000
Journal (Hearst)	300,000	--	--
American (Hearst)	--	641,000	1,090,000
Times	333.000	---	535,000
Sun	--	258,000	---
Tribune	131,000*	--	--
Herald	166,000*	--	--
Daily News	--	633,000*	--

Sources: New York World, Sept. 19, 1924, p. 3.
* Richard Kluger, The Paper (New York: Random House, 1986), p. 210.
Note: The Herald and Tribune merged in March, 1924.

Pulitzer's World was both a "yellow" journal and a champion of progressive causes at the turn of the century, but as the years went by, Pulitzer became determined to make his newspaper respectable without losing its soul. Unlike the Journal, the World by 1910 began to be influenced by the widespread movement toward scientific positivism that had been taken up a decade earlier by Van Anda at the Times. This movement, which coincided with the Progressive reform movement, promoted professionalism and objectivity, not only in the field of journalism but also in art, history, social science and engineering.[20]

From the gold-domed 14-story office building on Park Avenue in lower Manhattan, Pulitzer and his successors at the World labored over a "drastically independent" newspaper that championed "progress and reform" and that would never tolerate "injustice or corruption" and "never be afraid to attack wrong, whether by predatory plutocracy or predatory poverty."[21] With a dedicated following, the World was the second largest circulation news operation in New York, somewhat behind Hearsts' evening Journal and morning American and ahead of the Times, the Sun, the newly merged Herald Tribune and others, as seen in Table Two, above. Yet the empire under the World's gold dome was not as secure as it might have seemed from the outside. Just before his death in 1911, Pulitzer had chosen Frank Cobb, a brilliant editor, to lead his paper. Cobb was remembered as a great editor, but his death in 1923 left a vacuum at the top. The new executive editor Herbert Bayard Swope, and the relatively young editorial page director, Walter Lippmann, were both newcomers in their positions in 1924. They sensed that the World's progressive constituency was changing in the "Jazz Age," and worked to improve the paper's news and editorial content. According to historian Edwin Emery, the World "failed to keep pace with its orthodox rivals in complete coverage of the news, even though it sometimes performed brilliantly." On the other hand, many of the World's "subway-riding readers" began succumbing to the "lure of the tabloids."[22] Thus, at the time of the Ethyl controversy, the World was losing subscribers from both the high and low ends of the spectrum of readers.

Science coverage in the World also failed to keep pace or to entertain. The trend in coverage was an improvement over the days of pretty girls and Martians, but its science writers and editors were inexperienced and undiscriminating. In the era of the Ethyl controversy, the World's science news offerings included "cheap gold" from sea water, oranges "curing" baldness, and healing by cosmic forces.[23] Stories about cancer cures abounded. Yet there were also stories about the ethical problems of genetic control, Thomas Edison's ideas about education through film, and even a highly speculative story about a scientist named Robert Goddard who thought he could send a rocket around the moon.[24] The approach, then, was somewhat democratic -- the sensational, the speculative and the scientific received more or less equal treatment, if for no other reason than it was impossible to determine which was which.

Standards for science writing were not a major preoccupation for the World's 1920s editor Herbert Bayard Swope, a man described as a "flamboyant, self-publicizing, high living promoter." Swope said that "the giants" in his era of journalism were focused on the problem of bringing facts to light:

> We had men who made journalistic history. No poll parrots they -- no mere echoes of the songs sung by hired hands. They always insisted on seeing the central figure... They refused to take 'no' for an answer... That was the best method of obtaining accuracy -- the prize element good journalism...[25]

Clearly, Swope's reliance on authority to produce "accuracy" represents the older "objective" model of reporting. Swope's formula for setting the news agenda, on the other hand, was simply to "take one story each day and bang the hell out of it."[26] This was the apparent strategy behind the World coverage of the Ethyl controversy. While the story was developing, the World wrote about it frequently, quoting authorities freely and occasionally "banging" it in a self-promoting manner reminiscent of Pulitzer and Cobb's era. However, once the pace of developments slackened the story was forgotten.

Swope's counterpart on the editorial page could not have been more opposite. Walter Lippmann was cool-tempered, intellectual and inclined to write editorials that closely weighed many sides of political arguments. A graduate of Harvard who had first served as editor with Herbert Croley's New Republic and had worked with Woodrow Wilson's post-World War I diplomatic efforts, Lippmann's Progressive and Socialist views had evolved, in the crucible of the war's disappointments, into a liberal democratic theory that was to have profound influence on the thinking of New Deal politicians in the 1930s. From the 1930s to the 1960s, Lippmann's name became a household word as one of the nation's most pre-eminent columnists and pundits, and his views on objectivity and the role of the press have been well characterized elsewhere.[27] Around the time of the Ethyl controversy, Lippmann was skeptical that the press could help inform public opinion to the extent that it supported the "original dogma of democracy," which was the ideal of an informed electorate making wise choices in the public interest.

Science, for Lippmann, exemplified the difficulties of an informed electorate, but it also represented a powerful institution that could stem the tide of totalitarianism and an approach to life that could potentially replace religion.

Although most Americans were not ready to accept science as a religion, they did see science as a mysterious and highly competent new force in their lives. After World War I, people "were ready to believe that science could accomplish almost anything, and they were being deluged with scientific information and theory," wrote historian Frederick Lewis Allen.[28] Images of scientists in the news media were "omniscient, powerful, well-meaning and heroic," according to a survey of popular magazines between 1910 and 1955. The survey also found that public interest in scientific topics peaked in 1926.[29]

The effects of World War I and the commercialization of new technologies had much to do with the new appreciation for science. In a single generation, a handful of inventors had completely transformed American life. Edison, Ford, Bell and the Wright Brothers had become the American equivalent of a pantheon of saints. Although none of these inventors began as scientists *per se*, the prestige of their accomplishments spilled over onto all scientific and technological enterprises of the age. Historian Marcelle La Follette provides dozens of examples of the supremacy of scientific authority and of the public perception of a close link between science and technology in this period. "Automobiles, radios, pocket cameras, electric appliances, synthetic materials ... each new product improved or changed American life and all carried at least the aura of being based on scientific achievement," La Follette said.[30]

The controversy over Einstein's theory of relativity, settled by the Michaelson-Morley experiment demonstrating that gravity could bend light, had been heavily covered by the New York <u>Times</u> in 1919. It showed that scientists were not always in accord and that the public could be interested in even the most arcane topics if they were controversial.[31] Other more down to earth controversies were highlighted in the press in the 1920s, and no one could look at the state of science and technology and imagine that they had delivered unalloyed blessings. Somber accounts about scientists dying from a modern "leprosy" known as radiation poisoning were featured on front pages.[32] Oil pollution had become serious enough to alarm beach resort owners, the Corps of Engineers and harbor insurance companies in the early 1920s.[33] There were also thousands of routine traffic fatalities, carbon monoxide poisonings, electrical fires, train and subway wrecks, steamship sinkings, and other disasters every year -- the entire host of side effects of science and technology.

The Ethyl controversy contributed to the contradictions in the public perception of science and technology. The many blessings of science had clearly come at a cost, and the sobering truth was beginning to dawn that the cost had not been fully counted. Yet at the same time, the philosophy of science that had produced such extravagant results in technology was just beginning to catch hold in various professions, including journalism. The leading journalists of the era were not about to abandon science and technology, or even look at it too skeptically, while at the same time asking science and technology to carry so much of the momentum of their own philosophical approach to life and their own profession.

Van Anda, Lippmann and the Ethyl Controversy

The spirit of disinterested inquiry that motivated science was taken up in many professions around the turn of the 20th century,[34] and it had profound importance on developments in journalism. Carr Van Anda, managing editor of the Times between 1901 and 1925, was one of the early proponents of scientific journalism . Walter Lippmann, editorial page editor of the World in the 1920s, was also vitally concerned with science.

The difference between their two approaches represents an important distinction in discussions about public understanding of science and technology and the influence of the scientific method on journalism. Van Anda understood science and technology like no other journalist before or, possibly, since. His approach to science journalism involved constant study and personal development of expertise in (or "knowledge of") science and technology.

Lippmann did not understand the facts of science and technology so much as he attempted to understand their importance in the cauldron of social change. He was more concerned with "knowledge about" science and technology and its impact on society and public policy.[35]

They had a great deal in common, in that both men believed that the scientific spirit had enormous importance for civilization and had immediate implications for their own profession. Not only were both Van Anda and Lippmann very much in favor of scientific and technological progress, but they wanted the profession of journalism to internalize the methods that made this progress possible. Journalism was "particularly amenable" to the scientific approach, they believed.[36]

However, they also had different political philosophies. Van Anda, like the Times itself, tended to be politically conservative, pro-business, and suspicious of government regulation. Lippmann championed the liberal interventionist theory of government. These approaches and philosophies reflected the institutions in which the men served and also influenced the way issues were handled in their institutions. We do not have a great deal of information about Van Anda's personal philosophy,[37] but as an expert in science, steeped in the ideology of scientific progress in the heroic era of invention, he might be expected to agree with the views of Charles F. Kettering and Thomas Midgley. As the acknowledged science expert on the Times staff, Van Anda may very likely have influenced (or written) an unsigned Times editorial that held that the "sentimental view" of the tragedy at Bayway must not be allowed to stand in the way of progress. Although the Times provided a generous amount of space for critics of GM, Standard and Ethyl -- even more space for Henderson's abrasive speech of April 24, 1925 than the World -- Times editors clearly deferred to industry, which they saw as having the greater scientific authority. They did not invest a great deal of credibility in the public health concerns of university scientists.

Public health authority was seen in a different light at the World. The scientific spirit that animated Van Anda was also prized at the World, but it might be described as having more of the liberal scientific spirit that tends to resist authority and question dogma. Lippmann had noted in 1914 that journalism was "particularly amenable" to the scientific approach:

> It does not matter that the news is not susceptible of mathematical statement. In fact, just because news is complex and slippery, good reporting requires the exercise of the highest of scientific virtues. They are the habits of ascribing no more credibility to a statement than it warrants, a nice sense of the probabilities, and a keen understanding of the quantitative importance of particular facts.[38]

In a speech twenty years later, in 1931, Lippmann said that the scientific method was the heart of the liberal concern of "remaining free in mind and action before changing circumstances." That is why, Lippmann said:

> Liberalism has always been associated with a passionate interest in freedom of thought and freedom of speech, with scientific research, with experiment, with the liberty of teaching, with the ideal of an independent and unbiased press, with the right of men to differ in their opinions and be different in their conduct. That is why it is associated with resistance to tyranny, with criticism of dogma and authority, with hatred of intolerance.[39]

Thus, Lippmann's idea of the scientific approach to journalism has little in common with the idea of stilted objectivity as a guarded and neutral approach to facts, or to naive empiricism and the piling up of fact after fact. It was, rather, the spirit of the unfettered search for the truth. "Of necessity, the interpretation [of events] must be an exploration, tentative, sympathetic and without dogmatic preconception. And whoever attempts it, whether as a working newspaperman, as a scholar or as a statesman must find that he is sailing an uncharted ocean."[40]

Science itself had become a destroyer of the moral old order and the source of a new social order, Lippmann said. Civilization depends on science and technology, which depends on people who refuse to put their own desires, tastes and interests first. This scientific code in turn rests on "an elaborate method for detecting and discounting prejudices" through peer review and controlled experiments. "This method provides a body in which the spirit of disinterestedness can live and it might be said that modern science -- not in its crude consequences but in its inward principle, not, that is to say, as manifested in automobiles, electric refrigerators and rayon silk, but in the behavior of the men who invent and perfect these things -- is the actual realization in a practicable mode of conduct which can be learned and practiced, of the insight of high religion."

Lippmann believed, then, that scientists were (or should be) completely disinterested, and automotive inventors (even after the Ethyl controversy) were his premier exemplars of the scientific spirit. Lippmann railed against those who would “distort the basis of public discussion by the shrewd manipulation of evidence” as having succumbed to the anti-democratic temptations of the era. The scientific spirit he promoted was so powerful, he believed, that it could (in a sense) replace religion. “It is no exaggeration to say that pure science is high religion incarnate,” he said in A Preface to Morals.

Lippmann believed that scientists were more powerful than politicians, but that they must be protected from politics. He wrote to a friend: "Science is power if you can fence off the area in which it operates long enough... but the rate at which science expands is much slower than the pace of politics.."[41] He believed that regulation of technological industry was unquestionably needed, but unlike the previous generation of Progressives, he thought regulation was only a makeshift solution. In Public Opinion, he said the “Great Society” was, at its core, made by engineers and could be “brought under human control only by the technic which created it.”[42] This is an echo of the idea of professional responsibility that swept through the engineering profession between the turn of the 20th century and the 1930s.[43] A few years later, in A Preface to Morals, Lippmann said the “social history of last 75 years has in large measure been concerned with the birth pains of an industrial philosophy that will really suit the machine technology and the nature of man.” This new philosophy would be a departure from “naive” capitalism, that produced a “shocking” waste of natural resources and “a whole chain of social evils.” Among these were not only obvious evils, like child labor, but also the extreme reaction to the social evils, such as communism, and the moderate necessity of government “policing” of science and technology. The trouble with government policing was that there was “no way to make sure that the policemen will themselves be civilized. .. The fundamental problem is not solved. It is merely deposited on the doorsteps of the politician." Lippmann may have been thinking of the complexities of the Ethyl controversy when he said: "Every year as the machine technology becomes more elaborated, the legislative control for which the prewar progressives fought becomes less effective...[44] "   In a 1931 speech he said the old progressive antagonism toward industry had been outpaced by events:

> The Progressives of the last generation were attempting to police what seemed to them an alien intruder upon their normal existence. For us the problem is to civilize and rationalize these corporate organizations ... The simple opposition between people and big business has disappeared because the people themselves have become so deeply involved in big business... This does not mean the economic problem is solved. It means rather that the problem has become subtler and greater... [The economic system] must somehow be made stable and yet it must expand so that the standards of life may rise; it must invite the shocks which inventions and technical improvements produce, and yet it must also learn to insure security and continuity.[45]

Historian Edward L. Schapsmeier notes that Lippmann's ideas about government intervention had their origins in the Federalist doctrine championed by Alexander Hamilton and carried on in the "American System" supported by Henry Clay, Matthew Carey and Baltimore editor Hezekiah Niles. This was not, Schapsmeier notes, the individualistic, laissez faire, small-government democratic theory of Jefferson and Jackson. It was, rather, the thread of Republican / Progressive "active government" picked up from Clay by Abraham Lincoln and expanded by Theodore Roosevelt, which had taken a turn toward the left of the political spectrum in the era of big business reform and Woodrow Wilson and which, with the help of Lippmann and others, would evolve into the New Deal.[46]

The pure food and drug laws of the early 1900s were one turning point in this evolution. Republicans originally backed the laws, but Democrat Woodrow Wilson promised greater enforcement as part of his 1912 campaign platform. The laws did not cover public health threats from sources other than foods and drugs. In fact, there existed no mechanism for federal involvement in the Ethyl lead controversy, nor, in pro-business Republican climate of the 1920s of Warren Harding, Calvin Coolidge and Herbert Hoover, were such mechanisms likely to be set up.

Lippmann's insistence that a disinterested spirit ruled science and technology must have seemed almost as tenuous as the hope for disinterested capitalism. Could the shock of the introduction of Ethyl be seen as something that inventions naturally produce? Could he have seen a disinterested spirit among industrial authorities who claimed Ethyl leaded gasoline had no substitute and was vital to civilization? If he did not, as might be suspected, perhaps Ethyl was seen as an exception to the general rule; perhaps these anomalies were not crucial problems to Lippmann.

Although Lippmann refers to the Ethyl controversy in some correspondence, he does not mention it in his books, nor is it addressed by his biographers. In accounting for this, it is important to recall that the broader scope of Lippmann's philosophy was concerned at the time with the very urgent fight against the rising tide of both fascism and communism. Science and industry did not need more control, he continued to insist in 1937. "The naive interpreters of the modern world who have justified the increase of authority in order to realize the promise of science find themselves facing the awkward fact that science is being crushed in order to increase the authority of the state." He also promoted a synergistic marriage of science and government in extraordinarily utopian terms: "Out of the union of science with government there is to issue a providential state, possessed of all knowledge and of the power to enforce it. Thus at last, the vision of Plato is to be realized: reason will be crowned and .. the philosophers are to be kings."[47]

Given the luxury of historical hindsight, it would seem that the grand alliance between science and government saved civilization from Nazi Germany and Communist Russia, and that Lippmann's very prominent advocacy played an inspirational role. To some extent, we might say that the price of salvation involved the continuation of "naive" capitalism and the continued uncushioned shocks from science and technology in the emerging "Great Society."

Lippmann, in summary, believed that industry needed guidance but resisted widespread regulation because he was convinced that the interests of democracy and of science and technology were closely linked. He understood that the news media was often expected to play a symbolic role in helping address imbalances in governmental power. The imbalance, in the Ethyl case, had been created through the arguably premature application of a new technology with dangers unacknowledged by industry. Although Lippmann did not think that newspapers could "take up the slack" for public institutions,[48] he believed that government regulation was an important interim step toward addressing "a whole chain of social evils" brought on by unrestrained "naive" capitalism.[49] Here Lippmann and colleagues from the Times differed; the liberal philosophy of government intervention was not shared by the politically conservative Van Anda or his newspaper, which abhorred government interference in private business.

Advocacy, science and the news: Walter Lippmann and Alice Hamilton

By the end of the 19th century, the news media had increasingly become the focus of the nation's political life and, with it, attempts at reform.

James W. Carey suggests that the increasing influence of the mass media led reform movements to tailor their messages to satisfy the demands of professional communicators, which led to the conscious staging of speeches, demonstrations and marches -- in short, to the creation of pseudo-events.[50] Social movements increasingly depended on the press to relay their concerns to the general public and attract new members, according to Richard Kielbowicz. Citing modern sociological research, Kielbowicz notes that the news media prefers to report dramatic, visible events; relies on authoritative, centralized sources; and has limited newsgathering resources and routines.[51] With these insights, both Carey and Kielbowicz see reform organizations molding themselves to an increasingly rationalized and ubiquitous information system of the late 19th century.

Yet there is another form of advocacy to which the press is susceptible, the kind of advocacy that offers solid expertise in exchange for the opportunity to inform from a clearly stated viewpoint. It is a symmetrical, friendly and mutually supportive exchange, which is exemplified in the relationship between Walter Lippmann and Alice Hamilton. Lippmann was not an expert in science, as we have seen, but he did have knowledge "about" science, and when affairs became complex he turned to experts who could guide him. One of his advisors Alice Hamilton, who, as we have seen, was a medical doctor, Harvard University professor and public health expert.

Hamilton and Lippmann had met through their friendship with New Republic publisher Herbert Croley and his wife.[52] The young Lippmann, then in his mid-20s and working at the New Republic, was a dashing Harvard graduate with a presence so impressive that he might have been on his way, as John Reed once said, to the presidency. Lippmann was obviously charmed by Hamilton, who was then in her mid-40s. He described her with these glowing remarks: "In a platonic world she will represent the idea of feminism, no amenities required. She has the most satisfying taste of all personalities I've ever met -- wine and silver and homespun."[53] Hamilton lamented Lippmann's support of the war effort in 1916, but through mutual friends like Felix Frankfurter, Kitty Luddington and the Croleys, the two stayed in touch over the years.

As a Harvard professor and the national expert on lead poisoning, Hamilton was appointed to be a fellow U.S. delegate with Surgeon General Cumming to the League of Nations health conferences. She was keenly aware of the controversy brewing over tetraethyl lead at the Public Health Service in the 1922-24 period, probably because Cumming consulted with her about it. She was also very concerned with a coming need for publicity. A letter from National Consumer League president Florence Kelly to a foundation member on April 18, 1924, six months before the Bayway disaster, noted that Alice Hamilton would meet with them on the 28th in New York to "present them the necessity for immeasurably more publicity than is possible to get through all the agencies working in this field."[54] The exact topic and results of this meeting are not known, but clearly Hamilton was intent on a direct approach to some news media without using "agencies." A few months later Kelly suggested a meeting with Lippmann to a Consumers League colleague working on a labor compensation issue. "Walter Lippmann as a former socialist might still have some bowels of compassion about it," Kelly said with an insight that had probably come from Hamilton.[55] In April, 1925, Hamilton wrote Kelly, saying: "It seems to me that what we need is more publicity on the subject of occupational poisoning. Look at this situation in NJ which Miss (Katharine) Wiley (of the state Consumer's League) has been uncovering (working women's exposure to radium) and tetraethyl deaths which took place in New Jersey..."[56] And in the days before the May 20, 1925 Public Health Service conference, Hamilton wrote a friend that it was a David and Goliath story, with "a few scientists and the World" standing against giants like du Pont, General Motors and Standard Oil.[57]

Some of the correspondence between Hamilton and Lippmann during the 1924-25 Ethyl controversy may have been lost, but later correspondence refers frequently to their work together in the Ethyl case as well as in the 1927 - 28 case of the New Jersey dial painters -- the "radium girls" -- who were dying from occupational exposure to radioactive radium. The Ethyl issue evolved somewhat differently than the radium issue, since the Workers Health Bureau and Yandell Henderson had taken the lead while Hamilton was in Europe in the fall of 1924. However, it is likely that major elements of the Ethyl story, such as the Harvard critique of the Bureau of Mines study and the poisoning at Columbia University -- both of which were first carried by the World -- came to Lippmann's attention through Hamilton. The depth of their professional and personal friendship is evident, for example, in a letter that insisted that Lippmann and his wife visit for a weekend sometime in the summer at Hamilton's Hadlyme, Connecticut home. The letter also noted: "There is a situation at present which seems to me in need of the sort of help which the World gave in the tetra-ethyl affair."[58]

In 1928, Hamilton wrote Lippmann:

> When I thought of the plan to ask the Surgeon General to call a conference on radium I felt that it would be of no use unless publicity added its pressure, not because he is personally unwilling, but because Washington is so cautious and niggardly in its attitude toward the Public Health Service. We should never have got the one on tetra-ethyl lead without your help.[59]

Lippmann responded: "We should be very glad to help on the radium investigation, but we would be able to do something effective only if we were supplied with the necessary technical information of which we have none, of course, ourselves."[60]

The May 20, 1925 Public Health Service conference on leaded gasoline described in Chapter Six was the first of its kind, created in both the vacuum of political authority and the spirit of government - industry cooperation. Alice Hamilton called it the "conference system," but it was actually not a "system." Instead, as we have seen, the conference was a symbolic device to deal with unprecedented public health controversy and provide the appearance of action. Hamilton called it an "informal, extra-legal method" that was effective "given a new and striking danger which lends itself to newspaper publicity."[61]

Publicity was the key to the system, and sympathetic editors like Lippmann were the key to publicity. "Under the scrutiny of the press, conference participants discussed occupational hazards in a responsible fashion," according to a 1982 dissertation by Angela Young. "As Hamilton described them, parties to the conferences debated ideas; they did not contest for power. She described each meeting as a reasoned discussion of occupational hazards, and ignored the politics which intervened to channel debate, engender conflicts and restrict the conferences' resolutions." The conferences "tested the limits of academic debate and American politics in resolving such problems."[62] However, they exemplified an attempt at a model of public relations described by James Grunig as the "two-way symmetrical" model, in which compromise, negotiation and mutual understanding from equal power positions occurs.[63]

Hamilton believed that publicity was "a wonderful thing," as she wrote a friend a few days before the Public Health Service conference. "It may be the pebble with which David will kill Goliath."[64] This optimistic faith was shared by a generation of reformers, according to Hamilton biographer Barbara Sichermann, "and it made her somewhat complacent about the long-range impact of passing episodes such as the [PHS] conference which, while briefly focusing public attention on a new industrial poison, did nothing to regulate these substances."[65]

On the other hand, Lippmann's affinity for social advocacy and a symbolic conference animated by publicity was far less optimistic. His view was that the press could not be expected to "take up the slack" for public institutions:

> The press has often mistakenly pretended that it could do just that [take up the slack]. It has at great moral cost to itself encouraged a democracy still bound to its original premises to expect newspapers to supply spontaneously for every organ of government, for every social problem, the machinery of information which these do not normally supply themselves.[66]

Yet clearly, Lippmann felt that the responsibility to "signalize" an event that had public importance could not be shirked, and the World did cover the Ethyl controversy in as much depth as it could.

When Hamilton wrote to Lippmann on July 5, 1928, asking how to proceed with the publicity for the radium conference, her letter reflected some of the strategy behind the Ethyl conference. The plan, Hamilton said, is:

> to send a letter with many signatures from interested physicians to the Surgeon General and on the day following before he has time to answer, to send it to you for publication. Now I am ignorant as to the proper etiquette in such a matter and must trust to you for guidance. If the interval allowed is too short or if there is some proper procedure which we have not observed, I hope you will either let us know or proceed according to your judgement if you do not need anything further from us."[67]

A letter from Hamilton to Florence Kelly, following the 1928 radium conference, demonstrates the influence of publicity in both the radium and tetraethyl cases:

> The (radium) conference struck me as very successful and the manufacturers far meeker and readier to be good than the tetraethyl lead men were. It is often the weapon of publicity which we hold up our sleeves that impresses them and makes them ready to do what we (scientists) tell them to. If the Surgeon General appoints as well chosen a committee as he did for the study of tetraethyl lead you need not be afraid that the matter will not be well and thoroughly handled.[68]

In light of this correspondence, it seems clear that Alice Hamilton and Walter Lippmann worked together in publicizing what both felt was a just cause, although Hamilton was more optimistic about the chances for success than Lippmann. For Hamilton, the problem was one of restraining those who created new public health dangers. In both the tetraethyl lead and radium cases, mutual political interests and personal friendship worked to bridge an "extra-legal" gap that the news media could approach symbolically if it had the authority of science behind it. Lippmann's fellow editorial writer on the World, Alan Nevins, later said: "The journalistic world is hungry ... for the solidity, exactness and special expertness of the best scholars."[69] He might well have been talking about Alice Hamilton, who was able to provide that exactness, that "necessary technical information," that "knowledge of" science that the World "of course" did not itself possess.

Hamilton did not approach the confrontation with the Ethyl Gasoline Corp. and its partners with the idea of defeating corporate interests, but clearly she was disappointed in the committee's findings in 1926. Still, she counted the conference a victory of sorts because it brought industrial questions of public health into a negotiating process with government as advised by disinterested university experts:

> If she expressed satisfaction with half measures, it was also because she was realistic about the difficulty of gaining absolute control over industrial diseases... For the most part, she believed that an agent would be eliminated only when a substitute was discovered or when it was so dangerous that even the best plants could not offer adequate protection to their workers. Under such circumstances, she readily accepted piecemeal change and small victories.[70]

Hamilton's advocacy was motivated by something more than informing the public or using public opinion to pressure industry. Hamilton envisioned a continued "conference system" that would lead to negotiation and compromise, and this was in fact the more satisfactory result of the 1928 radium conference. Thus, the Ethyl controversy set the stage for environmental regulation through a cooperative system that provides a clear early example of the Grunig model of two way symmetrical communication.[71]

Liberal Regulation and other Paradoxes

This chapter has explored some of the history of science news writing and attempted to explain some of the philosophy of news media's leading editors in their approach to science and technology. These approaches were not uniformly applied nor were they always consistent with the apparent lessons of the Ethyl controversy. One small inconsistency has to do with Walter Lippmann's split from the Progressive movement over regulation of big business and tight regulations over monopolies and trusts. More and more people depended on big business as part of their lives; it could not be regulated from afar any more, he believed. Yet the Ethyl controversy was settled by the appointment of a special panel of university based experts which Lippmann backed and which implied that industry was more or less negotiating over future regulations.

A larger inconsistency involves Lippmann's continued belief that a disinterested and objective scientific spirit was at the heart of American science and technology, specifically in terms of inventions such as the automobile and the refrigerator. This view was expressed after the Ethyl controversy in his 1929 book, A Preface to Morals. How did Lippmann reconcile this belief with the concern that GM, Standard and du Pont had chosen a dangerous technology that merely suited their interests? How could industry say there were no alternatives when public health scientists said they were readily available? One group of the scientists surely had non-objective interests in the outcome -- either that, or there was no scientifically objective approach to the controversy. Yet Lippmann's faith in the "disinterested and mature" spirit of science and technology was apparently unshaken by the Ethyl controversy or similar technological disfunctionalities. Historian Charles Rosenberg has noted that the more tenuous an area of scientific knowledge and the smaller its verifiable content, the more easily its data may be bent to the purposes of the scientists in the domain,[72] and that provides part of the explanation of the ease with which industry scientists were able to get their way. Perhaps Lippmann simply regarded the Ethyl controversy as anomalous rather than symptomatic of science and technology.

Another inconsistency has to do with why Lippmann and the World attempted a more or less objective reporting approach and yet paid so much attention to public health authorities when Van Anda of the Times paid more attention to industry scientists. This is the kind of question that might easily be distorted from the present perspective: one might say that Lippmann got it "right" because he had more "knowledge about" science and had friends like Alice Hamilton supplying him with "knowledge of" science. With 20-20 hindsight, we now know that lead is a threat to public health.[73] However, in the 1920s, it was difficult to be certain that this was a fact. Given the general uncertainty, other explanations for the differences in news coverage appear to be more appropriate.

One other explanation for differences might be that the World's support of dissident authorities was accidental. Perhaps Lippmann and his editors at the World simply didn't know enough to discriminate. The Times' Van Anda, with his acumen in scientific matters, was skeptical about authorities outside the mainstream of science, while the World labored under no such restriction. Cancer cures, trips to the moon -- who could know what marvel of science was right around the corner?

Another possible explanation is the "story / information" dichotomy noted by Michael Schudson in Discovering the News. Schudson described what he saw as a fundamental difference in the Times and the World models of news -- the former using an "information" model, emphasizing orderly facts and abstractions, and the latter the "story" model, emphasizing feelings. "We cannot infer fairness or accuracy from the fact that the Times held to an informational model of journalism," Schudson said. "Information journalism is not necessarily more accurate than story journalism... The Times ... trusted to information, that body of knowledge understandable in itself without context (or within a context taken for granted)."[74] The Ethyl controversy tends to support this idea to some extent. For example, the Times provided more concrete facts about the controversy than any other newspaper but did not initiate any critical stories about Ethyl. If public criticism was aired by an authority, the Times would cover the criticism and the rebuttal faithfully and at great length. However, the Times did not go out of its way to get to the bottom of the controversy. It "followed" the news and presented information that had already become public. The World, on the other hand, did not present a detailed account of each minor development. Instead, it attempted to provide insight into the controversy by quoting the incisive information from critics. It did not reprint lengthy public relations statements by industry sources but it went out of its way to print as much critical information as was available. The World's stories, although not as frequent, also tended to be more than twice as long.

In other respects, the information / story dichotomy does not hold up. Aside from the basic source agenda, the tone and style of both Times and World articles (and others) are heavily information-oriented and remarkably similar. Most of the 126 articles studied in this dissertation began with some concrete development, quoted several authorities, avoided direct injection of the writer's personal opinion and had no narrative theme or story-like conclusion. There was very little story telling despite the potential for a strong emotional link to public fears about poison gas. Also, if any "story" emerged from the controversy, it was found in the Times in a semi-fictional and heroic narrative written by the Mellon Institute about the S.S. Ethyl's search for "the riches of the sea."

Most compelling is the simple political explanation. "In the emphasis and choice of news, the Times and World were guided by their political biases," Schudson said.[75] This "scarcely dazzling" conclusion was one that Lippmann had noted in 1920 in a New Republic article on the Times bias in its coverage of the Russian revolution. "The news as a whole is dominated by the hopes of the men who composed the news organization ... The chief censor and the chief propagandist were hope and fear in the minds of reporters and editors."[76] Lippmann came to work for the World precisely because of his already well-known politics. His liberal post-Progressive belief that government had to tame corporations if they were to be accepted by the populace was close to the World's existing liberal political agenda.

The World, then, was the one newspaper that had the political independence to comfortably challenge the authority of Standard Oil Co. and General Motors over its choice of technology. In the process, the World helped address an early environmental problem as part of the "conference system," which as noted in Chapter Six, was a largely symbolic attempt to reconcile conflicting scientific authorities. Although the World could signalize the importance of events, it used the objective and interpretive models of reporting, which had their limits. The World did not penetrate the technological smoke screens around tetraethyl lead and it could not "take up the slack," as Lippmann said, for government oversight.

Models of News Reporting

If service to the public interest is the basic yardstick by which we measure the performance of the news media, the shortcomings of the New York City newspapers in the Ethyl controversy had little to do with the alleged offense of sensationalism. To industry, perhaps any coverage would have been objectionable because the issue itself was "unprecedented," as a New York Times editorial said. Where the news media had only within the past century become a novel and unpredictable factor in general politics in the U.S. and Europe, now the news media was stepping into a new role and becoming a novel and unpredictable factor in technological and scientific developments. When W.G. Thompson of Standard Oil and Ethyl's medical committee told reporters that "nothing ought to be said" about the Bayway disaster in the public interest,[77] what he probably meant was that interference from people who didn't understand the issues would be a new element in the politics of science and technology, and that might, in the long run, work against the public interest. This argument, like that of military dictators who promise a "greater freedom," smacks of paternalistic arrogance, but it does contain more than a grain of truth. Reporters were indeed on new territory in the 1920s, having dropped (to some extent) the partisan reporting models of the 19th century. (For the sake of clarity, an overview of news reporting models is provided in Table Two at the end of this chapter).

Like most other professions, journalism was heavily influenced by the quest for scientific objectivity at the turn of the 20th century; and, like the others, it retreated in the face of confusion and complexity in the 1920s and 1930s. For example, noted muckraker Ray Stannard Baker said around 1906: "Facts, facts, piled up to the point of dry certitude, was what the American people really wanted."[78] By the mid-30s, Baker had not found certitude in mountains of fact, and admitted he could not understand (much less solve) many of the tremendous problems in the world: "The factors are too complex," he said.[79] This may sound like nothing less than a modern realistic outlook, but it is probably best interpreted as a lament about the demise of the scientific method not only in journalism but also in history, social sciences and other fields. That “objectivity” became a watchword in journalism around the same era, the mid-30s, has been seen by historians Michael Schudson and Peter Novick more as a longing for the ideal, a reflection of what had been lost, rather than the introduction of a new professional code of conduct.

If certitude could not be found in piles of dry objective facts (or what one historian called the “haystack” technique of reporting)[80] perhaps authorities could at least provide interpretations of facts that could be compared. This approach, advocated by Lippmann and embodied in the title of Curtis McDougall’s 1930s vintage journalism textbook Interpretive Reporting, is still the most significant model for reporting controversy.[81] The problem with this approach, as noted by Edward Jay Epstein, is that "journalists are rarely if ever in a position to establish the truth about an issue for themselves, and they are therefore almost entirely dependent on self-interested sources for the version of reality that they report."[82]

Therefore, according to Leon Sigal:

> In the absence of any foolproof criteria for choosing sources who are likely to provide valid information, journalists are uncertain about whom to believe. They cope with uncertainty by continuing to rely on authoritative sources. The presumption of hierarchy, that those at the top of any organization are the people in charge and that those in subordinate positions do what their superiors tell them to, underlies the journalists criterion for selected sources even though the journalists themselves recognize that this presumption is often of doubtful validity.[83]

Typically, if authorities differ in their interpretations, the reporter emphasizes two extremes for clarity and brevity. This reductionism is derisively known in the journalism profession as the "he said - she said" approach. Its lack of nuance, especially with regard to complex scientific and technological issues, has been frequently noted. In the 1950s debate over the link between cancer and cigarette smoking, the Tobacco Industry Research Committee was established as "an authoritative front organization." Whenever a researcher or doctor was quoted in the media as saying that smoking caused cancer, the committee and its public relations consultants made certain that someone with an authoritative voice was quoted as saying it did not or that there were problems with the research.[84]

Similarly, in a 1993 controversy over the role of natural volcanic processes in creating atmospheric chlorine responsible for ozone depletion, Alan S. Miller, director of the Center for Global Change, wrote: "When it comes to questions of scientific fact, printing 'both sides' of an issue can be seriously misleading. Unless the reader is an expert in the field being discussed, he or she has no basis to judge the qualifications or validity of the facts presented."[85] Similar dilemmas are typical in the greenhouse / global warming issue and most others.

As we saw in the Ethyl controversy coverage, the news media in the 1920s was inclined to print both industry and public health claims and let it go at that. Some newspapers emphasized the industry agenda, and some emphasized the public health agenda, but both sides were represented in most articles because the news media did not have the expertise to view authorities and facts from an independent perspective.

Acquiring that expertise has long been a fundamental practical problem for journalists. In 1967, Irving Kristol lamented the lack of expertise at the New York Times and said that most of the news reports did not read as if they had been written by people who had read journal articles or even basic texts in their particular field of reporting.[86] The antidote is an approach to reporting that might called the Van Anda model because, as noted above, New York Times editor Carr Van Anda was known between 1900 and the 1920s for his specialized scientific expertise. By the 1990s, news media institutions such as the American Press Institute, the Center for Foreign Journalists, the Knight Center for Specialized Journalism and others have attempted to educate journalists in specialized fields like nuclear physics, international finance, biotechnology and medical ethics.

If specialization helps rationalize news coverage, calming the “restless spotlight” and overcoming the "he said - she said" problem, the fundamental problem of distinguishing authority remains. Science writer Joanne Rodgers, for example, believes journalists who themselves become authorities do not remain disinterested. In Europe, where the majority of science writers are Ph.D.s or M.D.s, the press is "highly uncritical and heavily defensive of the scientific and medical establishment."[87]

Each of these approaches to public understanding of complex issues has its drawbacks. The haystack approach suffers from positivistic naivete, the interpretive approach suffers in surrendering discretion to hierarchical authority, and the expert reporter approach, although useful, suffers from a potential toward bias as a reporter becomes an authority. The lack of institutional resources is problematic as well in all three cases. As Walter Lippmann noted, public opinion informed by the news media cannot by an organ of direct democracy. "It is not workable. And when you consider the nature of news , it is not even thinkable... At its best the press is a servant and guardian of institutions ... In the degree to which institutions fail to function, the unscrupulous journalist can fish in troubled waters and the conscientious one must gamble with uncertainties."[88]

Another approach suggested by Melvin Mencher in his textbook News Reporting is a multi-layered reporting approach resembling triage in an emergency room. In the Mencher approach, important stories receive detailed research treatment described as "level three," while run of the mill news articles get relatively superficial "level one" treatment.

A major departure from the reporting routine is suggested in Tom Koch's Journalism for the 21st Century. Koch notes that the primary sources for what is usually called "news" are interviews with authorities. He suggests that infinitely replicable and connectable electronic databases and other media may create a "radically new relationship" between journalists and reader / audiences by making in-depth information available to readers on demand. This new technology overcomes what Koch sees as journalism's greatest handicap: the “oral tradition of news” that turns declarative statements into facts and, by virtue of personal relationships with sources and other institutional constraints, impedes the accreditation of substantive materials. Where Walter Lippmann once insisted that journalists must trust authorities because the “the books and papers are in their offices,” now, with electronic publishing techniques, it is theoretically easier for reporters to examine those books and papers and place them directly into public circulation. By doing so, Koch argues, journalists of the 21st century may provide an “objectifying context” to the news where their counterparts a few decades before could not.[89]

Electronic access to government documents will make some information easier to obtain but may also be a shield behind which portions of the government hide. A federal and state-by-state debate over public access to computerized government records in the 1990s is evolving into a series of pitched battles and has certainly not yielded a bonanza of new information. Even if it does, the news media will remain a restless spotlight and the problem of public understanding of technological and scientific problems seems unlikely to be resolved simply by the use of a new information dissemination technique.

On the other hand, there is the possibility that journalism itself could evolve into a system of gateways through which in-depth information and educational programs could be readily obtained. From this standpoint, news itself would be redefined as the most visible and immediate portion of a larger body of data, that is, a "presentizing" context for information and education rather than a mainstream of important data in need of an "objectifying" context. In such a case, the contribution of the journalist would be to provide an independent public interest perspective.

It is interesting that the handicap of the oral tradition Koch points out in modern environmental controversies was also problematic in the Ethyl controversy. Statements made by Kettering, Midgley and Standard Oil officials to the news media were treated as “facts” even though "objectifying" research would have showed that the oral statements contradicted published scientific papers. It should be noted that reporters for the New York World were apparently aware of the contradiction. In any event, there is probably little they could have done about the contradiction because a direct challenge to a news source was something that, by tradition, took place only in the question and answer format of an interview, a news conference or on the editorial page. If the source did not rise to the bait and make a statement, if a source refused to answer questions, there was no basis for directly contrasting contradictory information in a news “story,” although a news analysis, feature or editorial might include such items. The World’s May 3, 1925 Sunday feature comparing Henderson and Midgley did probe some of the questions in a thoughtful way, as did the Times' June 22, 1925 background article on the du Pont Corp.'s tetraethyl lead plant, but they were alone among many other simple news articles that reflected an information disfunction due to the limitations of the oral tradition.

This problem of structural limitation was compounded by the apparent complexity of the scientific and technological aspects of the Ethyl controversy. Ironically, an independent interpretation would have been less problematic than reporters probably have imagined. A few hours of research, beginning with a glance at the Readers Guide to Periodical Literature, would have turned up hundreds of articles on other anti-knock fuels and on lead-related occupational disease published in the years before the Ethyl controversy. A search of Chemical Abstracts, also available in New York libraries, would have shown that Thomas Midgley held several patents on alternative anti-knock fuels and that other scientists had also patented alternatives. The question as to why authorities who insisted that they were employing the scientific method and yet were not considering the range of alternatives might, at least, have opened a broader debate.

The problem of how the news media informs public opinion about scientific and technological controversy does not appear to be amenable to a simple change in reporting technique. Although "objectifying context" may be an improvement over "interpretive" models, which are themselves improvements over "objective" models, science news coverage and public understanding of the issues over the 20th century seems to have improved only gradually.

Using any model, the best that journalists can hope to achieve in a given situation is to balance their built-in reliance (or over-reliance) on authority with a sense of social responsibility. Journalists may use contrasting interpretations, in-depth knowledge or electronic access as tools. However, good reporting still requires, as Lippmann said, the exercise of intellectual virtues: ascribing the warranted credibility to a statement; retaining a sense of the probabilities; and balancing an understanding of the quantitative importance of particular facts.

In the final analysis, Lippmann may be right in saying that much of the problem lies outside the domain of journalism. It is the responsibility of government and the scientific community to provide oversight and to ensure that scientific authority, technological development and the public interest are at least relatively close. However, in many cases neither government nor the scientific community performs adequately; that is when the news media becomes the court of last resort for ideas, technologies and scientific theories that should have been better accredited within their own domains. The problem has to do, in part, with the sclorosis and calcification of a bureaucratized system of science and technology put in place in World War II and not changed substantially in 50 years.

The accelerating pace of technological change and the increasing complexity of related issues has caught democracy with its guard down. There is very little in reporting technique that can go beyond a simple striving for independence of perspective, and less opportunity for the news media as a whole to take up the slack for government institutions in helping public opinion guide policy than might be hoped at this juncture of history. The ray of hope we find in a study of the Ethyl controversy is that the use of any methods more vigorous than the purely "objective" oral tradition would have at least cleared away the basic issue of the importance of Ethyl brand leaded gasoline to the survival of industrial civilization. Two hours in the library would have shown a reporter that plenty of alternatives were available and that the claims by industry scientists were nothing more than attempts to deflect more controversy by issuing pronouncements that had the appearance -- the ring -- of scientific authority.

---

1. Louis L. Snyder and Richard B. Morris, eds., A Treasury of Great Reporting (New York: Simon & Schuster, 1962), p.2.

2. W.H.G. Armytage, A Social History of Engineering (Cambridge, Mass.: MIT Press, 1961), p. 67. One frequently cited example of the precedence of technology over science is the invention of steam engines before the understanding of thermodynamics.

3. Maurice Goldsmith, "The Popularization of Science," Nature 250 (August

1974), p. 751-53.

4. Edwin and Michael Emery, The Press and America, 6th edition, (Englewood Cliffs, N.J.: Prentice Hall, 1988), p. 16.

5. William J. Paisley, "Public Communication Campaigns: The American Experience," Ronald E. Rice and William J. Paisley eds., Public Communication Campaigns (Beverly Hills, Calif.: Sage, 1981), p. 17.

6. Snyder, A Treasury of Great Reporting, p. 6.

7. George Rosen, History of Public Health (New York: M.D. Publications, 1958), p. 139.

8. Ibid, p. 143.

9. Volkmer, Richard M., "Edward Livingston Youmans and the Popular Science Monthly: A Study in 19th Century American Science-Technology Journalism," Master's thesis, Iowa State University, 1969.; Gail R. Meadows, "Scientific American: A Mirror of Scientific Progress, 1845-1968," Master's thesis, University of Missouri, 1969.

10. Nola Kay Gibson, "A History of Medical Journals in the United States," Master's thesis, University of Missouri, 1983.

11. Marjorie Smith, "Lead in History," Richard Lansdown and William Yule, eds., Lead Toxicity: History and Environmental Impact, (Baltimore, Md.: Johns Hopkins University Press, 1986), p. 20.

12. Goldsmith, "The Popularization of Science," p. 752.

13. Niles Register, Sept. 14, 1816, p. 42.

14. Dan Schiller, Objectivity and the News: The Public and the Rise of Commercial Journalism (Philadelphia: University of Pennsylvania Press, 1981).

15. Terra Ziporyn, Disease in the Popular American Press (Westport, Connecticut, Greenwood Press, 1988), p.20.

16. Bill Kovarik, "Dr. North and the Kansas City Newspaper War" paper presented to the Association for Journalism and Mass Communications, Washington DC, 1989.

17. Ziporyn, Disease in the Popular American Press, p. 36.

18. Edwin Emery, The Press and America, 2nd edition (Englewood Cliffs, N.J.: Prentice Hall, 1972), p. 29.

19. Barrett Fine, A Giant of the Press: Carr Van Anda (Oakland, Calif.: Acme Books, 1968), pp. 44, 89, 100.

20. Michael Schudson Discovering the News: A Social History of American Newspapers (New York: Basic Books, 1978), p. 160.

21. Joseph Pulitzer, first editorial in the World, May 10, 1883, reprinted by the World Sept. 19, 1924, p. 1.

22. Michael Emery and Edwin Emery, The Press and America, 6th edition (New York: Prentice Hall, 1988), p. 339.

23. "Cheap Gold Soon," World, Nov. 12, 1924; "Eat an Orange a Day, Keep Baldness Away," World, Sept. 21, 1924; "Miracle Man of Paris heals by Elementary Forces, He Says," World, June 14, 1925.

24. "Chemist Control of Sex Predicted," World Nov. 18, 1924; 'Movies as Textbooks Forecast by Edison," World, Feb. 17, 1925; "Science has Actual Plan for Rocket to Sail around the Moon," World Feb. 8, 1925.

25. Snyder, A Treasury of Great Reporting, p. xxii.

26. Ronald Steele, Walter Lippmann and the American Century (New York: Little, Brown & Co., 1980), p. 198.

27. Ibid. Also, see Schudson, Discovering the News; also, Charles Forcey, The Crossroads of Liberalism (London: Oxford University Press, 1961); also Edward L. Schapsmeier, Frederick H. Schapsmeier, Walter Lippmann Philosopher-Journalist (Washington, D.C.: Public Affairs Press, 1969).

28. Frederick Lewis Allen, Only Yesterday: An Informal History of the 1920s, (New York: Harper & Row, 1931), p. 3.

29. Marcel LaFollette, "Authority, Promise and Expectation: The Images of Science and Scientists in American Popular Magazines," 1910-1955, Ph.D. Dissertation, Indiana University, 1979, p. xvii.

30. Ibid, p. xvii.

31. Ibid, p. xvii.

32. "Martyrs to Science," New York World, Feb. 9, 1925, p. 1. Also see Spencer Weart, Nuclear Fear: A History of Images (Cambridge, Mass.: Harvard University Press, 1988), p. 17

33. Joseph Pratt, "Letting the Grandchildren do it: Environmental Planning During the Ascent of Oil as a Major Energy Source," The Public Historian, 2, No. 4, (Summer, 1980), p. 29. .

34. Peter Novick, That Noble Dream: The "Objectivity Question and the Historical Profession (New York: Cambridge University Press, 1988), p. 42.

35. The distinction between "knowledge of" and "knowledge about" is attributed to John Dewey, Logic: The Theory of Inquiry (New York: Holt, Rinehart and Winston, 1938).

36. John Palen, "Science and Walter Lippmann," M.A., University of Michigan, 1984.

37. Fine, A Giant of the Press, p. 100.

38. Walter Lippmann, Drift and Mastery (New York: Mitchell Kennerly, 1914).

39. Idem., "The Press and Public Opinion," Political Science Quarterly 46 (June 1931) p. 161.

40. Ibid., p. 162

41. Steele, Walter Lippmann and the American Century, p. 184.

42. Walter Lippmann, Public Opinion, (New York: MacMillan, 1949) p. 370.

43. Edward Layton, Revolt of Engineers: Social Responsibility and the American Engineering Profession (Baltimore, Md.: Johns Hopkins University Press, 1986); also David F. Noble, America By Design: Science Technology and the Rise of Corporate Capitalism (New York: Oxford University Press, 1977), p. 33.

44. Walter Lippmann, A Preface to Morals, (New York: MacMillan, 1929), p. 254.

45. Steele, Walter Lippmann, p. 276, from a speech Mar. 25, 1931: "Journalism and the Liberal Spirit."

46. Edward L. and Frederick H. Schapsmeier, Walter Lippmann Philosopher-Journalist (Washington, D.C.: Public Affairs Press, 1969), p. 18.

47. Walter Lippmann, The Good Society (Boston: Little, Brown & Co., 1937) p. 22.

48. Walter Lippmann, Public Opinion (New York: MacMillan, 1949), p. 362.

49. Idem, A Preface to Morals (New York: MacMillan, 1929), p. 242.

50. James W. Carey, "The Communications Revolution and the Professional Communicator," Sociological Review, Monograph 13, (January, 1969), p. 23-38.

51. Richard B. Kielbowicz and Clifford Scherer, "The Role of the Press in the Dynamics of Social Movements," in Research in Social Movements, Conflicts and Change, Vol. 9 (Greenwich, Ct.: JAI Press Inc., 1986), pp. 71-96.

52. Barbara Sicherman, Alice Hamilton: A Life in Letters (Cambridge, Mass.: Harvard University Press, 1984), p. 95.

53. Ibid, p. 2.

54. Alice Hamilton to Florence Kelly, April 25, 1924, National Consumers League B-13, Microfilm Reel # 26, Manuscript Division, Library of

Congress, Washington, D.C.

55. Letter to Nelle Swartz from Florence Kelly, National Consumers League, Box C1, Microfilm Reel #48, Manuscript Division, Library of Congress, Washington, D.C.

56. Alice Hamilton to Florence Kelly, April 6, 1925, National Consumers League B-13, Microfilm Reel # 26, Manuscript Division, Library of Congress, Washington, D.C.

57. Alice Hamilton to Katy Hamilton, 17 May, 1925, File 655, HFC, cited in Angela Young, "Exploring the Dangerous Trades" Ph.D. Dissertation, Brown University, 1982.

58. Hamilton to Lippmann, July 12, 1927, Box 12 Folder 496 Lippmann collection, Yale University Library, New Haven, Ct.

59. Hamilton to Lippmann, June 21, 1928, Box 12 Folder 496 Lippmann collection, Yale University Library, New Haven, Ct.

60. Lippmann to Hamilton, June 25, 1928, Box 12 Folder 496, Lippmann collection, Yale University Library, New Haven, Ct

61. Alice Hamilton, "Nineteen Years in the Dangerous Trades," Harper's Magazine, 159, Oct. 1929, p. 587.

62. Angela Nugent Young, "Exploring the Dangerous Trades: Workers Health in America and the Career of Alice Hamilton, 1910-1935," Ph.D. dissertation, Brown University, 1982, p. 158.

63. James E. Grunig and Todd Hunt, Managing Public Relations (New York: Holt, Rinehart & Winston, 1984), p. 41.

64. Hamilton to Katharine Bowditch Codman, May 17, 1925, cited in Sicherman, Alice Hamilton, A Life in Letters, p. 242.

65. Ibid., p. 242.

66. Lippmann, Public Opinion, p. 362.

67. Hamilton to Lippmann, July 5, 1928, Box 12, Folder 496, Lippmann collection, Yale University Library, New Haven, Ct

68. Hamilton to Florence Kelly, probably Jan. 1929, Raymond Berry Papers, National Consumers League, Manuscript Division, Library of Congress, Washington, D.C.

69. Allen Nevins, Allen Nevins on History, ed. A.R. Billington, (NY: Scribners 1975) p. 39.

70. Sicherman, Alice Hamilton: A Life in Letters, p. 242 - 243.

71. James E. Grunig, "World View, Ethics and the Two Way Symmetrical Model of Public Relations," Paper presented to the Herbert Quandt Communication Circle, Munich, March 1993.

72. Charles Rosenberg, No Other Gods: On Science and Social Thought (Baltimore, Md.: Johns Hopkins University Press, 1976).

73. New York Times, July 31, 1984.

74. Schudson Discovering the News, p. 88.

75. Ibid, p. 109.

76. Walter Lippmann and Charles Merz, “A Test of the News,” New Republic, August 4, 1920.

77. "Odd Gas Kills One," New York Times, Oct. 27, 1924, p. 1.

78. Schudson, Discovering the News, p. 80

79. Ibid, p. 126

80. Ziporyn, Disease in the Popular American Press, p. 20.

81. Curtis D. MacDougall, Interpretative Reporting (New York: MacMillan Co., 1970), p. 9.

82. Edward Jay Epstien, News from Nowhere (New York: Random House, 1973).

83. Leon V. Sigal, “Sources Make the News,” in Robert Manhoff and Michael

Schudson, eds., Reading the News (New York: Pantheon, 1986) p. 15, cited in Koch, p. 47.

84. Karen Miller, "Smoking Up a Storm: Public Relations and Advertising in the Construction of the Cigarette Problem, 1953 - 54," Journalism Monographs No. 136, December 1992.

85. Allan S. Miller, "Volcanic Hyperbole," Washington Post, July 29, 1993 p. A24.

86. Clifford Daniel and Irving Kristol, "The Times: An Exchange," Public Interest, Vol. 7,1967, pp. 119 - 123, cited in Tom Koch, Journalism for the 21st century : Online Information, Electronic Databases, and the News, (New York : Greenwood Press, 1991), p. 49.

87. Scott De Garmo, "An Editor Takes a Survey: Are Scientists Better Writers than Non-Scientists?" NASW Newsletter, Oct. 1981, p. 16.

88. Lippmann, Public Opinion, p. 364.

89. Tom Koch, Journalism for the 21st century : Online Information, Electronic Databases, and the News, (New York : Greenwood Press, 1991), p. 30.

TABLE THREE

MODELS OF SCIENCE NEWS REPORTING

Model	Technique	Comment
Partisan	Heroic narration, persuasive rhetoric or other non-factual approach	Emotional appeal disguises motives of writer; Typical in 19th century
Objective	"Haystack" all data (pile up dry facts)	Limited by space constraints Doesn't aid public understanding Prone to easy manipulation
Interpretive	Quote both sides "He said - she said"	Helps public understand Tends to be fair in politics Prone to manipulation in science Discretion surrendered to authority
Specialist (Van Anda)	Know everything Print all accredited facts	Difficult and time consuming Increases reporter-editor friction Less source manipulation Easier to recognize authorities Reporter becomes authority
Layered reporting (Mencher)	Three layer research Focus 3rd layer on important news	Generalist focuses on select areas Less prone to manipulation Serious research encouraged, departure from "oral tradition"
Objectifying Context (Koch)	Use computer research Report original documents electronically	Instant specialist / news in depth Avoids "oral tradition" problems Less prone to source manipulation Much easier to recognize authorities Reliant on incomplete computer data Depends on wide use of new systems
Independent Perspective	Recognize origins of info Search for other sources "Presentizing" context for education	Less prone to source manipulation Broadens reporter research burden Maintains public interest tradition in novel situations Better, but not a solution to the

dilemma of public understanding of
science and technology

Text

CHAPTER NINE

THE RING OF AUTHORITY AND THE PROBLEM OF PERSPECTIVE

This dissertation has described a little known but important controversy in the history of technology and journalism. Chapter One introduced the specific purpose of the dissertation in understanding the role of the news media in the Ethyl controversy. It noted that the role has been misunderstood by historians and that this has led to an over-reliance on archives which tend to be selective in favor of industry perspectives. Chapter One also suggested that new approaches to the technical issues are opened by taking the public controversy seriously.

Chapter Two reviewed some of the literature about the Ethyl controversy, noting that the role of the news media has received almost uniformly negative historical treatment despite a lack of research. Chapter Two also located the context of the Ethyl controversy in the deepening rift between positivistic science linked with the ideology of industry on the one hand and a humanistic science linked with labor, consumers and progressive political movements on the other. In addition, chapter Two also described the conservation and public health movements and the trend toward technological regulation as components of world views in conflict during the Ethyl controversy.

Chapter Three provided a new interpretation of the technological context of the discovery of leaded gasoline based on information recently made available at the G.M.I. (General Motors Institute) Alumni Collection archives in Flint, Mich. In the face of expected oil shortages by the 1940s, the main thrust and "special motive" of General Motor's fuel research in the 1919 - 1923 period appears to have been to raise compression ratios in engines to facilitate the anticipated shift to non-petroleum sources of liquid fuel. Of particular interest to Kettering and researchers was ethyl alcohol (which Midgley called "of course, the fuel of the future") manufactured from farm products, from petroleum and eventually from cellulose residue from farming and forestry. Metallic anti-knock additives such as lead were originally considered transitional devices to ethyl alcohol and not final and perfected products in and of themselves.

Chapter Four examined the news media's approach to the lead poisoning deaths of five workers at the Standard Oil refinery in Bayway, New Jersey in late October of 1924. When G.M. and Standard Oil officials maintained silence about the origin and nature of tetraethyl lead during the first week of news coverage, the news media used workers' ideas ("loony gas") and descriptive terms ("mystery gas") for the unknown product. Chapter Four also shows that the news media generally deserved credit for the routine public service of bringing out the facts of the Ethyl controversy and providing some space for all points of view, which is consistent with its professional responsibilities. The news media were not able to understand the controversy deeply enough to compensate for the government in the area of public health oversight and technological regulation. Yet the news media apparently assumed it was more limited than it was, and public understanding of the context of the controversy was hampered by the lack of research which would have been considered routine in areas more familiar to the press.

Chapter Five explored the private controversy between the various interests, and showed that the haste with which the Standard and du Pont manufacturing plants were assembled in the 1923 - 1924 period was a result of the fear of competition from alternative anti-knock additives. The hurried approach led to the deaths of 17 workers and the poisonings of hundreds more. To keep their options open, G.M. , Standard, du Pont and Ethyl officials patented a number of alternatives and debated them among themselves; yet their public posture was to absolutely deny that alternatives existed and to vilify their critics.

Another important point made in Chapters Five of this dissertation is that the hazards of tetraethyl lead were well understood by industry as early as 1922. Industry historians have claimed that only after the October 1924 deaths at Bayway, New Jersey were G.M. and Standard Oil appraised of the danger of tetraethyl lead. This is clearly inaccurate given the internal warnings from independent scientists two years beforehand, the secret formation of the inter-corporate "medical committee" in the spring of 1924, the unpublicized deaths in Deepwater, New Jersey, and Dayton, Ohio in the spring of 1924, and the private arguments between du Pont and Standard engineers in the summer of 1924.

Chapter Six discussed the May 20, 1925 conference sponsored by the Public Health Service in Washington, D.C. that heard from most viewpoints in the Ethyl controversy. The conference was cut short from its original longer schedule and avoided discussion about alternatives to tetraethyl lead. The conference also led to the appointment of a blue ribbon investigating committee that by January, 1926, issued a preliminary finding that "no good reason" could be found for prohibiting the sale of leaded gasoline. The committee was given a short lead time and no money to supervise Public Health Service researchers. Moreover, some components of the original plan, such as surveys of garage employees outside of Ohio, were dropped for economic reasons. Despite the strong recommendations of the blue ribbon committee, no subsequent studies were performed on the public health aspects of leaded gasoline until the 1960s. Experts from Ford Motor Co. had been in touch with committee member C.E.A. Winslow of Yale about alternatives to tetraethyl lead, but despite Winslow's request, mention of alternatives was not included in the final report.

Chapter Six also shows that, at a crucial moment in the controversy, the attitude of the federal government moved from skeptical oversight to commercial support of Ethyl. In the 1922 - 1924 period, the Surgeon General expressed serious concern about leaded gasoline. However, in May, 1925, the Surgeon General cut short the conference, avoiding discussion of alternatives. By the late 1920s and early 1930s the Surgeon General wrote letters of introduction for Ethyl officials to health ministers of foreign nations and actively promoted Ethyl brand leaded gasoline at European scientific conferences. Also, the Commerce Department kept quiet a May, 1925, report that contained detailed information on the use of alternatives to Ethyl leaded gasoline in foreign countries. The Interior Department performed a supportive study of tetraethyl lead with the Mellon Institute (funded by interests that owned Gulf Oil Co., a marketer of Ethyl), which did not take real-world conditions into account. Meanwhile, studies which directly compared Ethyl leaded gasoline with alternatives, such as one by U.S.D.A. and U.S. Naval Academy researchers on ethyl alcohol blends, were never published.

The failure of government oversight was matched by the failure of the peer review system. No automotive or chemical engineering peers of Kettering or Midgley directly challenged sweeping claims that alternatives to Ethyl brand leaded gasoline did not exist.[1] Challenges by non-peer scientists across disciplines tended to refrain from direct statements about the technical efficacy of tetraethyl lead or specifics about alternatives, although it was clear that advocating use of known substitutes was one of the best strategies of public health advocates in other controversies.

In Chapter Seven, a review of the historiography of the Ethyl controversy found that at best historians have ignored the news media and at worst they have cast it in the role of purveying sensationalistic yellow journalism and ignoring the industry perspective. A content analysis of sources quoted by leading New York newspapers in the controversy showed, on the contrary, that industry sources heavily dominated the news coverage.

Another interesting finding was that while the New York World and the New York Times used similar models of objective reporting, the editorial agenda was strikingly different when it came to coverage of the two opposed factions of scientists. While the World cited university public health scientists in over 9,000 words of copy between 1924 and 1926, the Times cited university sources in only 3,000 words. On the other hand, while the World cited industry scientists (and other industry sources) in 5,000 words of copy, the Times cited industry sources in 6,500 words. These differences in source reliance reflect a basic political difference that is evident despite the journalistically "objective" and scientifically positivistic world views of editors at both newspapers.

In addition, an analysis of the use of the term “loony gas” also showed that the supposed sensationalism of the news media had been greatly exaggerated and that the term had been coined not by an "imaginative" news media (as has been frequently claimed by industry historians) but rather by the refinery workers who were quite familiar with the effects of tetraethyl lead. It might be noted that this relatively small point reflects the contemporary distance between company executives and their workers as well as the influence of the industry perspective on mainstream historians.

Chapter Eight continued the discussion about the news media with a look at the history of science news and the philosophies of two of the leading editors of the era, Carr Van Anda of the <u>Times</u> and Walter Lippmann of the <u>World</u>. The struggle of these two men to understand the changes that science had brought about in their world, along with their overwhelmingly supportive attitude toward the doctrine (or ideology) of scientific progress, shows that there is no contextual basis for industry historians to portray the news media as waging an anti-scientific campaign against Ethyl. A better historical interpretation of the problem is that the news media recognized the uniqueness of the controversy but did not check patents, chemical abstracts or scientific journals to ensure the accuracy or depth of its reporting. Thus, the contribution of the news media in understanding the Ethyl controversy was to keep score but not broaden the debate, and in that respect, the media failed as much as the government or the peer review system. The media did not inform the public about possible alternatives or the extent to which worker deaths occurred through the negligence of Standard Oil Co. of New Jersey, E.I. du Pont de Nemours, or General Motors Corp. Why these ideas were difficult to approach until recently, and only with the collapse of the paradigm of tetraethyl lead as a "successful" invention, speaks to the the way in which authorities moderate the relationship between science and technology and the public interest. One aspect of the problem is the extent to which the public can be expected to understand the broad outlines of scientific information in order to guide policy decisions. Another aspect is the extent to which the public interest can be subordinated to private interests through the clever manipulation of information by expert authorities.

These twin facets of the problem of scientific understanding in policy issues -- how much the public can understand versus how much the scientists are willing to disclose -- are reminiscent of the "two cultures" debate which emerged around essays of scientist / author C.P.Snow in the 1950s. The intellectual life of the whole of Western society was increasingly being split into two polar groups, Snow said: literary intellectuals at one pole and scientists at the other. The result was that society could not "think with wisdom" and was missing "creative chances." The gap between the two cultures should be closed "for the sake of the intellectual life and ... for the sake of Western society living precariously rich among the poor who needn't be poor if there is intelligence in the world."[2]

Most of the attention in closing the gap has been focused on popularizing science, on making it accessible to the public. The Ethyl controversy is a problem which emerges from the other side of the equation, that is, from the scientific side of public understanding. Although scientists were deeply divided over the introduction of Ethyl leaded gasoline, those who opposed Ethyl were influenced by humanistic concerns. For example, Alice Hamilton's professional outlook was deeply rooted in the Hull House experience. Yandell Henderson had been deeply concerned about poison gas manufacturing during World War I.

As was noted in Chapter Eight, understanding and questioning scientific authority is not traditionally the long suit of journalists. In fact, science had been taken seriously by most newspapers only in the post World War I era, and reporting methods had not been well developed. For example, Walter Lippmann felt that "we would be able to do something effective only if we were supplied with the necessary technical information of which we have none, of course, ourselves." He would never have said this about politics. He would never have agreed that effectiveness in political reporting was a matter of <u>being supplied with</u> the necessary information, as opposed to going out and finding the information for himself. He tended to be as empirical, in that respect, as any scientist. Nevertheless, the Ethyl controversy demonstrates what can happen when the news media mistakenly believed that the responsibility had become too complex for its resources and too easily surrendered an independent perspective to the presumed safety of a false balance between news sources. The comparison between the World and the Times coverage of the Ethyl controversy in Chapter Seven tells us that editors chose different points at which to locate the fulcrum of the superficial balance. The discussion about science writing in Chapter Eight provides additional context. However, we also need to ask why so many critical points about the Ethyl controversy eluded the news media and the public when they were potentially so closely at hand. We need to ask what role scientific authority played in influencing the debate.

The Ring of Authority and the News Media

Charles Kettering once told a group of newspaper editors a story about a reporter who missed the news about the first airplane flight:

> When the Wright brothers made their first flight at Kitty Hawk, they telegraphed home to their sister Catherine in Dayton: "We have just completed first successful flight in heavier than air machine and will be home for Christmas."
>
> When Catherine received this telegram she called up the [Dayton] newspaper office ... "I have an item for your paper," she said, and she read the brothers' telegram.
>
> "Well," replied the reporter after several moments pause, "We are certainly glad to hear that the boys are going to be home for Christmas."
>
> [Later] the reporter ... said that everyone knew the Wright brothers were trying to fly, but no one believed they would succeed, because they had all been told by so many authorities that flying in a heavier than air machine was impossible.[3]

Kettering enjoyed the story because it demonstrated that presumably unassailable authorities could be quite wrong -- such as those who did not think heavier than air machines could work. Many scientists had challenged authority in previous ages and had dared to think and experiment for themselves. Kettering saw an important lesson in the turnover of authoritative views. He often encouraged other scientists and engineers to push back the limits of science and not be bound by the conclusions of those who had studied the problem before. It is a little ironic, although very much in character, that he also encouraged journalists to do the same.

At the time of the Ethyl controversy, Kettering's successes with the electric starter, the

Delco engine, anti-knock gasoline and other engineering problems had made him one of America's most respected scientists. His presidency of the Society of Automotive Engineers in the post-World War I era confirmed and reinforced his authority. Kettering's colleagues held him in high esteem, in part for his genius and in part for his jocular, collegial manner that set the style for a generation of engineers in the way that Chuck Yaeger set the style for a generation of test pilots and astronauts in the 1960s.

Kettering was a formidable authority, in a sense an "elevated" authority, rather than merely an expert. This is reflected even in the typography of the proceedings of the Public Health Service conference of May, 1925 published several months afterwards. In the table of contents, Kettering's opening discussion shares top billing with the Assistant Secretary of Treasury, the Secretary of Interior, and the Surgeon General. The rest of the speakers who followed Kettering are all listed under various subheadings, such as "industry" and "public health." Only Kettering appears to share authority with government officials. His discussion of the "history of tetraethyl lead in relation to gas engines" was, of course, an appropriate starting point for the P.H.S. conference; and since he represented Ethyl Gasoline Corp. and General Motors, no one would have expected him to give a completely disinterested account. Yet few could have known how deeply such interests would affect the issues at hand. The general faith in science and in the professionalism of engineering obscured the levels at which Kettering was capable of promoting corporate interests while appearing to be concerned with the public interest. That is, to take a page from public relations theory, Kettering practiced an asymmetrical approach to public controversy, although, as an elevated authority he was expected to take a symmetrical approach and incorporate broader public interest goals into his own thinking.[4]

As noted in Chapter Six, Kettering told the P.H.S. conference that G.M. had tried a number of materials that allowed high compression without engine knock. They were impractical because "in the great volume of the paraffin series we could not do that."[5] This conclusion skims across several overlapping assumptions: 1) first, that additives were needed, rather than more refining or blending of other fuels; 2) that they had to be made from the paraffin series, that is, from petroleum, and not some other resource; and 3) that non-petroleum additives did not exist or were not available.

Kettering's statement may be self serving, but was it a deliberate falsehood? Kettering knew that new catalytic refinery processes were twice as effective as tetraethyl lead and were being used at the time by Sunoco and Atlantic Richfield, according to correspondence written shortly after the P.H.S. conference concerning "substitutes" for Ethyl gasoline. He also knew that anti-knock additives were routinely made from coal, wood, farm crops, desert plants and even sea kelp, and they were often within the same price range as gasoline in both the U.S. and in Europe. G.M. researchers Midgley and Boyd had noted the technical qualities of these additives in several published papers and in many office memos to Kettering. They had contributed to professional research on non-leaded anti-knock additives. They had tested a 30 percent blend of ethyl alcohol and gasoline by driving a G.M. car running on the blend to a Society of Engineers meeting two months before tetraethyl lead was discovered. Yet Midgley later told a chemical engineering conference that "so far as science knows" only tetraethyl lead could bring about anti-knock results; and Kettering told the P.H.S. conference that alternatives were known but "we could not do that."[6]

Some distinction must be recognized between arguments to the effect that alternatives are expensive, impractical or problematic and arguments to the effect that alternatives do not exist, are not known to science, or cannot possibly be manufactured or used. The distinction is between a reasoned scientific judgment that may be open to question and an absolute and categorical denial that assumes full authority and admits no questions. By omitting many significant details and glossing over troublesome questions, Kettering assumed full authority and gave the P.H.S. conference a carefully crafted evasion concerning alternatives to tetraethyl lead. However much we may wish to avoid assessing 1920s industrial secrecy in modern terms, it is difficult to see the statements of Ethyl, G.M. and Standard officials as anything less than a distortion of the basis of public discussion by a shrewd and defensive manipulation of evidence. In other words, Kettering and Midgley created a technologically sophisticated falsehood, wrapped it in a smokescreen of jargon, and sealed it with the "ring" (or external appearance) of authority.

The ring, in this case, was false. Ethyl brand leaded gasoline was not the product of a scientific method which dispassionately considered all alternatives. Scientist and philosopher Carl Hempel notes that an adequate scientific explanation considers "first of all, what consequences each of the different alternative choices is likely to have."[7] The alternatives to tetraethyl lead were not discarded on the basis of their technical efficiency, their availability or their cost at the pump. Public health and economic issues aside, tetraethyl lead itself presented serious engine problems, as was evident in the crash of the airship Shenandoah. It was also less effective at raising octane than other processes (such as the new catalytic refining processes), and was less thermodynamically efficient than alcohols or benzenes.

Tetraethyl lead was chosen for non-scientific reasons. First of all, it had more profit-making potential for General Motors and Standard than the other alternatives. In 1923, Midgley estimated (as we saw in Chapter Three) that G.M. could capture about 20 percent of the gasoline market at three cents gross per gallon, or about 36 million dollars a year. In fact, by 1933, General Motors and Standard Oil split gross profits of at least a quarter billion dollars per year, an amount that grew to half a billion per year by the end of the decade. Other "octane boosting" techniques were technically and even economically feasible but they involved other companies, and the profits would be spread out among many corporations. Ethyl leaded gasoline, on the other hand, provided G.M. and Standard with concentrated profits. Aside from financial gain, another important motive was a desire to stay the course after so much company prestige had been invested. In addition, the view of public health concerns as sentimental, unmanly and even socialistic was also prevalent and weighed against any "slowing" of progress in the name of public health.

The myth encouraged by the Ethyl Gasoline Corp. for many decades was that its product emerged from scientific research, was the only anti-knock product available, and was temporarily subjected to public prejudice and hysteria whipped up by the news media. That, however, is an all too convenient fiction. The reality is that the nation's largest corporations decided on a technological direction that was most profitable and that they were scarcely concerned with their own workers or the general public health.

In the apparent absence of corporate responsibility, how are worker health and public health constraints to be applied? In the democracy Vannevar Bush and so many others fought to maintain in the 1940s, public opinion depends on scientific authority to adequately establish the premises of policy debates. In the Ethyl controversy we see scientific authority narrowly pigeonholed: public health scientists found it difficult to discuss the alternatives known to chemical and mechanical engineers, and industrial scientists could not (or would not) consider public health from their colleague's perspectives. Fragmented science led to an uncertain ground for public policy debate in the news media.

Cross disciplinary debate in the news media has been noted as a danger by historian Marcel LaFollette, who said the problem with news media over-reliance on scientific authority was that authorities would speak in areas for which they were not qualified and that journalists would "too often quote what is actually political or social commentary as scientific assertion of fact." So long as science is considered to be the paramount authority, La Follette concluded, "there will be significant potential for abuse."[8]

The opposite problem occurred in the Ethyl controversy. Here we find the abuse well inside the scientists' expertise and the public interest criticism emerging from scientists in other disciplines who were not considered to be qualified authorities. Oversight of scientists within their own area of expertise is clearly quite difficult for government, the press and ordinary people -- peer review is widely assumed to be the counterbalance. Yet dissenting expert opinion is almost always contained within a discipline, and peer review is hardly a substitute for public interest oversight. In order to speak out, scientists must rise above or ignore peer review. As Rae Goodell noted in her 1977 book, <u>The Visible Scientists</u>, those who were able to publicly speak within their areas of expertise tended to be established scientists free from peer pressure.[9] Few critics ever attain such a position. Moreover, peer review has not had a good track record in encouraging the application of technology to public interest ends rather than private goals.

One aspect of this long standing debate involves the problem of engineering professionalism. Edward Layton has seen the problem as an ideological struggle between conservative and progressive engineers.[10] David Noble saw it as a struggle by engineers in general to avoid capitulating to the business elite.[11] Samuel Fluorman took issue with both of these perspectives, saying that, realistically, corporate culture did not seem to consist of 'good' engineers seeking to protect the public from 'bad' managers. "Technological mishaps are almost never caused by unethical conduct and almost always by ignorance, carelessness or ineptitude," he said. Engineers usually identify with their company and feel little need to be "freed" to protect the public interest. The historical theory holds even less water today, Fluorman said, in an age where regulations, rather than professional ethics, stand in the way of technological disasters.[12]

Each of these models can be applied to the Ethyl controversy. Using Layton's model, progressive engineers like H.R. Ricardo backed alcohol fuel. Also, the "good" engineers of du Pont attempted to protect their workers from the "bad" management of G.M. and Standard because they appreciated the dangers of tetraethyl lead manufacturing.[13] Using Noble's model, engineers like Kettering and Midgley saw tetraethyl lead as a bridge to a better source of energy, but they were undercut by the corporations who removed them from management in 1925 and told them to go work on something else. Fluorman's idea that usually ignorance or carelessness is to blame does cover some of the ground, but it doesn't quite explain the deaths of 17 tetraethyl lead workers and the nationwide commercialization of Ethyl leaded gasoline.

On the broader point, however, the models don't work. The Ethyl controversy is not about conflicts among engineers or between engineers and managers. It is a conflict across scientific disciplines that, when intractable, turned political, and when volatile, turned public. When industry refused to withdraw, a symbolic resolution in the form of a well publicized conference and a blue ribbon committee restored at least the sense that such conflicts could be approached and that authority could be trusted. In other words, the paradigm of scientific authority was temporarily repaired. Industry held back regulation of leaded gasoline for 60 years, and only after "overwhelming" evidence piled up was anything done about what must be seen as the most obvious public health and environmental problem in history.

Were scientists and engineers expected to live up to a standard of conduct that went beyond private interests? Were they expected to be disinterested and objective? Of course they were. The theme of science delivering humanity and the sanctity of the scientific method are ideas which resonate throughout the literature of the 20th century. The accumulated hopes and dreams of generations were deeply attached to science. Lippmann and many others seriously expected science to replace religion and explicitly saw the scientific attitude as near holy.

To the extent that the discovery of Ethyl leaded gasoline was seen as "scientific," the product was associated with a greater good. Carleton Ellis, president of the New Jersey Chemical Society, was quoted as saying Ethyl gasoline “rests on a true scientific foundation.” The American Chemical Society saw the deaths at Bayway as insufficient reason for abandoning a way to increase the power of gasoline, and from this the New York Times took its cue: “As there is no measurable risk to the public ... the chemists see no reason why its manufacture should be abandoned. That is the scientific view of the matter, as opposed to the sentimental.”[14]

These conclusions were based on the assumption that the scientific method had been employed in developing tetraethyl lead and that the most scientifically objective course of action had prevailed in corporate policy -- an assumption that may seem naive in the modern era. Today it is commonplace that scientists and engineers are not necessarily objective in the sense that they can set aside their political and commercial interests. The scientific method guarantees very little and technological problems are not always approached by objectively weighing and balancing scientific facts. “Perfect objectivity” as one scientist said recently, “is a myth."[15] The bitter disputes in recent years over the safety of nuclear reactors, the effects of electromagnetic fields and toxic chemicals (such as dioxin) and a thousand other issues demonstrate that the scientific method alone cannot resolve many of the questions created by scientific and technological progress, much less address the broad social and human questions for which people held such hope at the dawn of the 20th century. In fact, many of the important controversies about science and technology involve not straightforward issues of technical policy but rather, as Carl Hempel said, "intricate complexes of technological and moral issues." The fundamental problem for Hempel was whether such complex issues could be solved by using the scientific method. Although science could not provide validation of categorical moral judgments, it could assist in clarifying moral decisions. "In order to make a rational choice between several courses of action, we have to consider, first of all, what the consequences each of the different alternative choices is likely to have. This affords the basis for certain relative judgments of value[16] ..." Of course, if we ignore the alternative choices, or are not informed about them, we have no basis for the relative judgments of value, which help form the independent perspective that was so lacking in the Ethyl controversy.

It is ironic that Walter Lippmann, who of all non-partisan observers had the clearest possible contemporary window into the Ethyl controversy, clung to the belief that science could validate categorical moral judgments and offer a way out of the morass and drift that characterized politics of the era. Lippmann and many others believed that political science could end wars and social science could create a free and classless society. Hadn't physics and chemistry revolutionized the world? What more would science do for mankind when applied to society? When Walter Lippmann gave science the leading role in rescuing civilization in his 1914 book, Drift and Mastery, he was simply amplifying an ideal of objective science that had taken deep roots at all levels of society. In 1928, several years after the Ethyl controversy, Lippmann again insisted that the spirit of objectivity was at the heart of the invention of automobiles, refrigeration and other technologies and said that it should be at the heart of journalism. In 1937, he promised that by uniting the authority of science and the authority of government we would at last realize the vision of Plato and the philosophers would become the kings. These ideas make it seem as if Lippmann did not understand the Ethyl controversy, or that he saw it as anomalous and not symptomatic.

Led by Lippmann and other positivists, Americans virtually begged their politicians to put on white lab coats in the opening decades of the 20th century. The threat of fascism in the late 1920s and 1930s further blurred the lines between American political and scientific authority. In the 1940s, the atomic bomb punctuated the power of that authority like no other event had ever done before. However, mounting uncertainties about the scientific enterprise and the challenges posed by technological dilemmas had already been eroding the authoritative ring of objective science. At first, after World War I, many of the flaws were seen only on the theoretical or academic levels. As the philosophy of naive empiricism began to crumble in the tide of cynicism, the Ethyl controversy represented an early indicator of the ill health of and pending reaction against the objective authority of science in the late 20th century. This reaction might not have been so strong had journalists of the 1920s realized that the ring of authority was not an intrinsically insurmountable holy sanctuary so much as it was one of many temporary and contingent constructs that promoted a few interests for a short time. Irenee du Pont, for example, said of Ethyl's board of directors following the Bayway disaster: "They didn't know what was going to happen to them." In another time, or in another country, they might very well have gone to jail. The terror from the inside of the ring of authority could not be felt or seen from the outside, where it appeared unassailable, but it was none the less real because only from inside did its temporary and contingent nature become apparent.

In an essay on authority and social change, John Dewey once said that individualism in revolt against authority is an historical paradigm that we tend to take for granted because it has been a dominant historical model over the past few centuries. We tend to think that social authority is the enemy of individual freedom because of the historical experience of bloody revolutions against unreasonable authorities, especially in America and France. This is an immature perspective, he said. The more important problem is the ongoing relationship between authority and freedom. Dewey rejected laissez-faire economics that attacked all authority along with the concept of intransigent authority that created confusion and chaos by resisting change. He urged an organic union of freedom and authority employing corporate or “organized intelligence” such as that embodied by science.[17]

Late 20th century popular culture has carried the myth about social authority into the realm of scientific authority and reached the identical conclusion -- that it is the enemy of freedom -- despite the schizophrenia inherent in simultaneously depending upon technology and yet psychologically rejecting it. No doubt the many insults of science and technology -- the atom bomb, pesticides, radiation, air pollution and so on -- have led us to the conclusion that, as Barbara Tuchman put it, "the fairy godmother, Science, turns out to have brought us as much harm as good."[18] No doubt, as Lewis Mumford said, the "horn of plenty" is little more than a "magnificent bribe" meant to get us to overlook the insults of technology. The same idea is ubiquitous in popular science fiction -- from Mary Shelly's 1828 book Frankenstein to modern films such as E.T., Terminator II, Lawn Mower Man and many others. Scientists are the bad guys; technology is wrong; the individual human spirit (which must be at odds with technology) is what counts.

The cultural rejection of science and technology is an historic shift with tremendous consequences. Outright love of science and technology once was, as Jules Verne said, the American "birthright." Now the love affair is over, but the machine is still happily munching in the garden. The tragedy is in part the erosion of the possibility that a broader vision of science and technology could help solve some of the problems.

One day, when American science and technology is recognized as obviously second rate, a commission will be formed to discover just who sold the "birthright." The obvious scapegoat, so aptly identified by industry historians, will be the news media's negativity and pessimism, which snatched away American enthusiasm for the once hallowed domain. Right wing conservatives may well believe that the media lost the "war" for scientific supremacy just as they believe that it "lost" the war in Vietnam. Yet we can see in the Ethyl controversy just how convenient it is to blame the messenger for the message and just how accurate such an historical conclusion would be.

The venom directed toward the news media and public health reformers in the 1920s is similar to that of the modern era. As former New York Times reporter Phillip Shabecoff wrote in 1993:

> Opposition to environmentalism, of course, is as old as the movement itself. Those who used public resources to create wealth for themselves -- the timber and cattle barons, the mine operators, the oil companies, big agriculture, and industries that regarded the air and water as free commodities, as a commons into which the could pour their polluting effluents, predictably and consistently reacted to efforts to control their activities with the tolerance of a nest of angry rattlesnakes.[19]

By reporting facts and interpretations of facts, the news media could be considered an agent of control over activities that affect "the commons." Although not a policing agency, its watchdog function alone tends to arouse the ire of companies that expect to use public resources without question. Even when the news media tend to be supportive of industry, as were the New York Times and the Herald Tribune during the Ethyl controversy, the very existence of controversy is enough to trigger hypersensitivity. The Ethyl controversy shows how easily and effectively scientific and technological authority could be invoked by industry in the 1920s. It also shows that the public interest in science and technology is not always effectively guarded by the news media, whose institutional claim to disinterested guarding of the commons is theoretically valid but only as pragmatically sound as the length of its attention span.

As Jacob Brownowski once said, what is at stake in public understanding of science and technology is, in the end, democracy. For a bored public to abdicate an interest in science is "to walk with eyes open into slavery."[20] The problem remains one of public vigilance, the development of an independent perspective among citizens and an increase in appreciation for debate among scientists and engineers. Citizens may not understand all the technological details, but they may not need to so long as the salient points become part of the debate. Alternative technological approaches are not as difficult to understand or to implement as is often assumed, given access to data and an independent perspective. In short, the barriers to public understanding of science and technology are not necessarily insurmountable if the press and the people are awake.

An important conclusion that emerges from a study of the Ethyl controversy is that the ring of authority is tentative and the participation of the public is not contingent upon the mastery of every detail if at some point an independent perspective is brought to bear on "knowledge about" scientific and technological problems. In other words, the leaded gasoline question was never that difficult to understand, but it had to be resolved through political rather than scientific methods.

The Ethyl controversy was one of many reversals for the idea that science and technology would save humanity, an idea which opened and characterized much of the 20th century. One of history's great ironies must surely be that the century that began with such a grandiose notion now ends with so many intricate complexes of technological and moral issues dependent on political and social methods to resolve them.

---

1. A remotely relevant exception is William Hale of Dow Chemical Co. who denounced "poison spreading" gasoline in The Farm Chemurgic (Washington, D.C.: The Chemical Foundation, 1934). Hale was at the 1925 ACS conference where Midgley made his sweeping statement but he had been attempting to get a production contract for tetraethyl lead for Dow at the time.
2. C.P. Snow, The Two Cultures: A Second Look (London: Cambridge University Press, 1964), p. 3.
3. Charles F. Kettering, "Can the Principles of Scientific Research be Applied to Journalism?" Address to the Associated Press Managing Editors, Sept. 10, 1943, Chicago, Ill; G.M.I. Alumni Institute Collection of Industrial History, Flint, Mich.
4. James E. Grunig, "World View, Ethics and the Two Way Symmetrical Model of Public Relations," Paper presented to the Herbert Quandt Communication Circle, Third Specialist Meeting on Normative Issues of Public Relations, Munich, Germany, March, 1993.
5. Proceedings of a Conference to Determine Whether or Not There is a Public Health Question in the Manufacture, Distribution, Or Use of Tetraethyl Lead Gasoline, Public Health Bulletin

No. 158, Treasury Department, (Washington, D.C.: Government Printing Office, 1925), p. 6.

6. Ibid.

7. Carl G. Hempel, Aspects of Scientific Explanation, (New York: MacMillan, 1965), p. 96.

8. Marcel LaFollette, "Authority, Promise and Expectation: The Images of Science and Scientists in American Popular Magazines," 1910-1955, Ph.D. Dissertation, Indiana University, 1979. p. 268.

9. Rae Goodell The Visible Scientists (Boston: Little, Brown & Co., 1977).

10. Edwin Layton, The Revolt of the Engineers (Baltimore, Md.: Johns Hopkins University Press, 1986).

11. David F. Noble, America by Design, (Oxford: Oxford University Press, 1979), p. 33.

12. Samuel C. Florman, "An Engineer's Comment," Technology and Culture, 27:4, October 1986, p. 680.

13. Of course, du Pont also lost eight workers. However, this should be seen in the context of having produced approximately 1.3 million pounds (100,000 gallons) of tetraethyl lead, or about enough to treat 120 million gallons of gasoline, in 1924 and 1925. In contrast, Standard lost five workers and produced several hundred pounds and GM lost two and produced a few thousand pounds.

14. "No Reason for Abandonment," New York Times Nov. 28, 1924, p. 20.

15. William W. Lowrance, "Choosing our pleasures and our poisons: Risk Assessment for the 1980s," in Albert H. Teich, ed., Technology and the Future, (NY: St. Martin's Press, 1986), p. 232.

16. Carl G. Hempel, Aspects of Scientific Explanation (New York: Free Press, 1965), p. 96.

17. John Dewey, "The Revolt Against Science," The Humanist, Autumn 1945, reprinted in ed. Jo Ann Bydston, John Dewey, The Later Works, (Carbondale, Ill: Southern Illinois University Press), Vol. 15, p. 188.

18. Barbara Tuchman, Practicing History (New York: Knopf, 1981), p. 268.

19. Phillip Shabecoff, A Fierce Green Fire (New York: Hill & Wang, 1993), p. 205.

20. Jacob Bronowski, The Ascent of Man (Boston: Little, Brown & Co., 1973) p. 431.

Text

Appendix 1

Chronology of leaded gasoline

(Note: This version reflect improvements over the original dissertation as of 2013.)

3000 BCE — First significant mining and refining of metalic lead.

500 BCE-300 AD — Roman lead smelting produces dangerous emissions.

c. **400** BCE – Hippocrates describes lead poisoning

250 BCE — Greek philosopher Nikander of Colophon in 250 BC reported on the colic and anemia resulting from lead poisoning.

200 BCE – 400 AD — Development of lead mines in Spain and Greece; Extensive use of lead in household utensils and cooking ware; Widespread use of sweet-tasting "sapa," a sweet aromatic syrup from grapes containing about one gram of lead per liter. Because of its sweet taste, many Romans used it in food. Upper class Roman lead intake of lead is estimated at 35 mg/day to about 250 mg/day.

c. **200** BCE Greek poet and physician Nicandor describes lead poisoning

100 BCE — Greek physicians give clinical description of lead poisoning.

c. **100** AD   Pliny the Elder describes primitive respirators made of ox bladders used by workers producing vermilion (to avoid breathing mercury fumes). Pliny the Younger says lead poisoning is prevalent amongst mine slaves.

1400s – 1500s – Lead used as a poison by Lucrezia Borgia, Catharine de Medici and others. (Lewis, 1985).

1621 — Lead first mined in North America.

1700 — Bernardo Ramazzini observes: "The skin [of lead workers] is apt to bear the same color of the metal … Demons and ghosts are often found to disturb the miners."

1767 – George Baker investigates the Devonshire Colic, finds cider mills have lead-lined presses. (Smith, 1986).

1829 —   Description of lead poisoning by an anonymous Roman hermit translated by Humelbergius Secundus, 1829 (Lewis, 1985).

Hence gout and stone afflict the human race;

Hence lazy jaundice with her saffron face;
Palsy, with shaking head and tott'ring knees.
And bloated dropsy, the staunch sot's disease;
Consumption, pale, with keen but hollow eye,
And sharpened feature, shew'd that death was nigh.
The feeble offspring curse their crazy sires,
And, tainted from his birth, the youth expires.

1853 – Tetraethyl lead (TEL) discovered by Carl Jacob Loewig (1803 – 1890), chemistry professor at the University of Zurich.

1857 — Scientific American notes:

It is remarkable that this metal (lead), when dissolved in an acid, has the property of imparting a saccharine taste to the fluid. Thus the common acetate of lead is always called 'sugar of lead.' It was perhaps on this account that the Greeks and Romans used sheet lead to neutralize the acidity of bad wine — a practice which now is happily not in use since it has been found that all combinations of lead are decidedly poisonous. (Aug. 29, 1857, p. 403).

1860 – Charles Dickens writes of lead poisoning in the Uncommercial Traveler

I saw a horrible brown heap on the floor in the corner, which, but for previous experience in this dismal wise, I might not have suspected to be 'the bed.' There was something thrown upon it and I asked what it was.
'Tis the poor craythur that stays here, sur; and 'tis very bad she is, 'tis very bad shes been this long time, and 'tis better she'll never be … and 'tis the lead, sur.'
'The what?'
'The lead, sur. Sure, 'tis the lead-mills, where women gets took on at 18 pence a day, sur, when they makes application early enough, and is lucky and wanted; and 'tis lead pisoned she is, sur, and some of them gets lead pisoned soon, and some of them gets lead pisoned later, and some but not many, niver; and 'tis all according to the constitooshun, sur, and some constitooshuns is strong, and some is weak, and her constitooshun is lead pisoned, bad as can be, sur … '

1887 — US medical authorities diagnose childhood lead poisoning.

(Also see Timeline of Lead, Coalition to end Childhood Lead Poisoning).

1906 — US lifts tax on non-beverage ethanol to encourage use as fuel and competition for oil industry. (For information about ethanol as an alternative to leaded gasoline, see Timeline of Alcohol Fuel on Wikipedia.)

1909. France, Belgium and Austria ban white-lead interior paint.

1910 — Alice Hamilton's pioneering study of lead industries for state of Illinois finds extensive worker poisoning and conditions that would close factories in Europe. Hamilton becomes America's foremost expert in lead poisoning.

1914 — Pediatric lead-paint poisoning death from eating crib paint is described.

1916 — Dayton Electric Light Co. (DELCO) president Charles F. Kettering asks researcher

Thomas A. Midgley to begin working on problem of engine knock in DELCO electric generators used in rural areas for electric lighting. Midgley discovers iodine as anti-knock but it's too expensive.

— Delco sold; Kettering starts Dayton Metal Products Co. (DMPC).

1917 — Kettering and Midgley test fuels for Army Air Corps at Wright airfield. Alcohols and benzenes are listed as best anti-knock substances available but unsuitable to aircraft engines except in blends with gasoline.

1918 — Kettering and Midgley manufacture cyclo-hexane "Hecter" from benzene; war ends before production can begin.

— Midgley patents benzene / gasoline blend as anti-knock.

1919 – General Motors buys DMPC and makes Kettering research vice president

– Midgley discovers analine anti-knock additive after being given two weeks to find something to make Detroit GM headquarters happy. But analine is expensive, dangerous and foul-smelling.

— Mounting concern about long term petroleum supplies and declining quality of gasoline. Some automotive engineers advocate lowering compression ratio to enable use of low-quality fuels. In a speech to the Society of Automotive Engineers, Kettering says that would be wasteful and advocated high compression engines and improving the quality of gasoline with additives.

– Alice Hamilton invited to join Harvard School of Public Health.

1920 – Anti-knock research proceeds but frustration sets in. Du Pont disagrees with idea of analine injectors.

— Midgley patents analine injectors; also patents anti-knock blend of ethyl alcohol and cracked (olefin) gasolines.

— Scientific American says that because of its antiknock effect in blends with gasoline, there is a "universal assumption that [ethyl] alcohol in some form will be a constituent of the motor fuel of the future." (Dec. 11, p. 593. Also see "Henry Ford, Charles Kettering and the Fuel of the Future.")

1921 — Anti-knock research almost abandoned; Midgley discovers potential of selenium and tellurium by accident.

— (July) Boyd explores ethyl alcohol production from cellulose at Yale.

— (August – December) Systematic tests of metallic elements for antiknock.

— (October) Midgley demonstrates 30 percent ethyl alcohol blend in gasoline as anti-knock to Indiana Society of Automotive Engineers meeting. According to unpublished notes from the meeting now among documents at Flint University archives, Midgley said:

"Alcohol (ethanol) has tremendous advantages and minor disadvantages… (such as) clean burning and freedom from any carbon deposit… [and] tremendously high compression under which alcohol will operate without knocking… Because of the possible high compression, the available horsepower is much greater with alcohol than with gasoline…"

— (December 9) First tests of tetraethyl lead in GM labs by Thomas Midgley. Substantial decrease in engine knock.

— (December) Kettering proposes product name "Ethyl" because solvent (ethyl alcohol) used to suspend lead in fuel, but the choice confuses (perhaps deliberately) the "high percentage" route to anti-knock additives with the "low percentage" route.

1922 – Continued tests of tetraethyl lead. Valve, spark and exhaust failures are problems. Scavenger such as ethylene di-bromide (EDB) needed.

— Strong letters of concern about safety of tetraethyl lead by fellow scientists and Public Health Service to General Motors.

— September — First demonstrations of effect of tetraethyl lead on engine knock\ at American Chemical Society (ACS) convention.

— Continued interest by Kettering, Midgley and Boyd in ethyl alcohol as the fuel of the future.

– League of Nations bans interior lead paints.

1923 — January — Midgley takes a few months off to recuperate from lead poisoning.

— February 1 — First commercial sale of Ethyl Gasoline in Dayton, Ohio. GM production line goes into full operation. No health tests conducted at this time.

— March — Midgley awarded American Chemical Society Nichols Medal for discovery of tetraethyl lead's anti-knock effect in gasoline.

— Two dead, 40 "under observation" from lead poisoning at GM pilot scale lead production plant in Dayton Ohio. Dates unknown.

– September — Du Pont begins production at Deepwater, N.J. (across bay from Wilmington, Del.) Frank W. Durr, 37, first worker known to die of lead poisoning Sept. 21 from TEL process.

— September — First safety tests begin at Bureau of Mines, Pittsburgh, Pa.

— October 20 — Sim Jones, 47, janitor, becomes the second Du Pont worker to die of lead poisoning from TEL process. Jones apparently absorbed the TEL fluid through holes in his boots.

1924 — January– Contracts for exclusive sales rights to Standard of New Jersey (Exxon), Standard of Indiana (Amoco) and Gulf Oil Co. specify that three grams tetraethyl lead produces anti-knock value of 40 percent benzene.

— February — New "ethyl chloride" process goes into operation at du Pont. Medical committee formed with du Pont, GM and Standard physicians, W. Gilman Thompson presiding.

— New ethyl chloride process planned by du Pont. Medical committee formed with du Pont, GM and Standard physicians.

— June –Standard Oil of New Jersey plans ethyl chloride mini-process (semi-works) at Bayway, N.J., across bay from New York City. Kettering and Midgley insist on stepped-up production, calling it "war orders" due to competition for octane additives which, they will later insist, does not exist.

— July 20 — Frank Hanley, 23, another du Pont worker, dies of lead poisoning as production is tripled over original capacity.

— August 12 — Joseph Clancy, 23, another du Pont worker, dies of lead poisoning as production is tripled over original capacity.

— August — Ethyl Gasoline Corp. formed as 50 / 50 partnership between General Motors and Standard Oil of N.J. Kettering made president and Midgley made vice president of operations.

— September — Du Pont engineers voice grave concerns about safety of Standard semi-works at Bayway. Concerns brushed aside.

— September 26 – October 30 — Six Standard Oil refinery workers die violently insane following daily exposure to tetraethyl lead fumes at Bayway Ethyl plant. They are: Henry C. Becker, Ernest Oelgert, Walter Dymock, William McSweeney, William Kresge, and Herbert Fuson, all of Elizabeth N.J. An additional 33 workers are hospitalized. Some, like Joseph Leslie, will spend the rest of their lives at Graystone Psychiatric Hospital, and from 1932 on, at the Marlboro Psychiatric Hospital, both in New Jersey. (Note: Sometimes this is noted as five deaths. The first, Henry C. Becker, occurred Sept. 26, a few weeks earlier than the others, and is sometimes omitted).

— October 11 — Kettering sails for France on the White Star liner Homeric to attend secret negotiations between I.G. Farben and Standard Oil Co. at the Hotel Crillon in Paris. Kettering is particularly interested in Farben's iron carbonyl additive.

— October 27 — First headlines in New York city newspapers about leaded gasoline deaths at Bayway.

— December 23 — Ethyl board of directors meets at 26 Broadway in New York. The board authorizes $100,000 compensation to workers, considers variety of alternatives to tetraethyl lead, and worries about legal consequences from Bayway accident.

— December 24 — Kettering and du Pont technical director W.F. Harrington meet with Surgeon General Hugh Cumming in Washington D.C.

1925 — February — Criminal charges are dropped against Standard by a New Jersey grand jury investigating the deaths and injuries.

— February 13, 16, 28 — Three more workers die at the du Pont Ethyl plant in Deepwater, NJ: Federick DeFiebre, Robert F. Huntsinger, and Loring M. Boody.

— February — I.G. Farben licenses iron carbonyl anti-knock additive to a du Pont Corp. subsidiary, retains 35% rights.

— March 27 — James Connell is the last worker to die at the du Pont Deepwater plant before it is closed down.

— April 6 — Midlgey claims at an American Chemical Society meeting: "So far as science knows at the present time, tetraethyl lead is the only material available which can bring about these [anti-knock] results." The claim is a bald-faced lie that contradicts Midgley's own published research.

— April 21 — Kettering and Midgley are secretly fired as president and vice president of Ethyl Corp. at a meeting of the Ethyl board of directors at 26 Broadway. Both continue to work for General Motors. Kettering continues to pretend to be the president of Ethyl in official meetings that summer.

— April 30 — Yale university public health scientist claims Ethyl gasoline represents "the greatest single question in the field of public health which has ever faced the American public."

— May 4 — Joseph Leslie and an unknown number of other victims from the Bayway plant quietly transferred from Reconstruction Hospital in New York City to Greystone Psychiatric Hospital in New Jersey. Leslie will spend the next 40 years in psychiatric institutions due to nerve damage. His family is devastated.

— May 15 — Dept. of Commerce quietly publishes report on alternative anti-knock fuels used in 19 foreign countries; report is not discussed in interviews, in the press or at PHS in May 20 conference.

— May 20 — US Public Health Service holds conference to discuss viewpoints on Ethyl controversy and appoints blue-ribbon committee to conduct independent inquiry. Alice Hamilton and others insist that alternative anti-knock compounds are available, but consideration of alternatives is suspended as conference is cut back from two to three days to only one day. According to a 1950 memoir by T.A. Boyd, a confrontation between Hamilton and Kettering took place in a hallway during the conference recess, in which Hamilton privately said to Kettering: "You are nothing but a murderer" and "There are thousands of things better than lead to put in gasoline." Kettering laughs at Hamilton.

Frank Howard of Standard Oil says: "As a result of 10 years research … we have this apparent gift of God of three cubic centimeters of tetraethyl lead… It would be an unheard-of blunder if we should abandon a thing of this kind merely because of our fears." Responding to Howard was Grace Burnham, director of the Workers Health Bureau, who pointed out that tetraethyl lead "was not a gift of God when those … men were killed or 149 men were poisoned."

— *The Youth's Companion* says of the leaded gasoline controversy: "No one disputes the facts of the case, which are that much of the lead in the gasoline comes out of the exhaust pipe as a fine impalpable dust, which, if breathed into the lungs in sufficient quantity, is capable of setting up lead poisoning in the body. And any physician will tell you that lead poisoning is a very serious matter… The question is whaether the lead dust would be produced in sufficient quantity and under such conditions as to become a danger to public health. Some chemists are sure that it would and that the use of ethyl gasoline ought to be forbidden by law. Others are equally sure that it would not." (June 11, 1925, p.398)

— September 4 — USS Shenandoah, Navy dirigible, wrecks in heavy storm over Ohio following engine failure, killing 26 crew members. Contribution of Ethyl fuel to engine failure does not emerge in U. S. inquiry. When the British scientific publication *Engineering* blames the crash on the use of Ethyl gasoline in March, 1926, a flurry of G.M. memos confirms that the Shenandoah used Ethyl.

— Sept. 25 — Frank Howard writes a private memo to Kettering noting three "substitutes" for Ethyl then on the market: 1) vapor-phase cracked products; 2) benzol blends; 3) gasoline from napthenic-base crudes.

— October — Public Health Service study of 252 drivers and auto mechanics in Dayton and Cincinnati Ohio begins. Researchers find that drivers exposed to leaded gasoline showed somewhat higher "stippling" damage to red blood cells, while garage workers exposed to leaded gasoline showed much more damage to red blood cells, and one quarter of garage workers had over one milligram of lead in fecal samples. In the final published report in 1927, the Surgeon General's Committee says blood cell stippling was found "to a relatively high degree" in garage mechanics whose exposure had been relatively short — as little as two and a half days.

— December 22 — Surgeon General's Committee member David L. Edsall of Harvard objects that "we would be presenting a half-baked report" unless the committee studies "the effects this is going to have on others."

1926 — January 26 — PHS committee releases a report that finds "no good grounds" for prohibiting Ethyl gasoline but insists on continued tests:

Owing to the incompleteness of the data, it is not possible to say definitely whether exposure to lead dust increases in garages when tetraethyl lead is used. It is very desirable that these investigations be continued… It remains possible that if the use of leaded gasolines becomes widespread, conditions may arise very different from those studied by us which would render its use more of a hazard than would appear to be the case from this investigation. Longer exposure may show that even such slight storage of lead as was observed in these studies may lead eventually in susceptible individuals to recognizable lead poisoning or chronic degenerative disease of obvious character… The *committee feels this investigation must not be allowed to lapse.*

No independent tests are conducted until 1960s. Also, a list of alternatives to tetraethyl lead proposed by C.E.A. Winslow of Yale is kept from final report.

— Market strategy becomes rigid standardization, restricted selling and development of demand for "Ethyl" brand until April, 1933.

— Earl Webb, Ethyl's new president, visits American Research Co. in Denver, Colorado and observes a lack of precautions. "It's surprising someone hasn't died in your outfit," Webb says. Later that year, Irenee du Pont overrules Webb in an Ethyl board of directors meeting and insists that the contract be cancelled. "The risk of serious catastrophe is too great to be considered," du Pont says.

1927 — Du Pont and I.G. Farben sign agreement for anti-knock iron carbonyl marketing in the U.S.

– Final report on TEL health studies published by Bureau of Mines.

– Robert A. Kehoe of the University of Cincinatti begins experiments with TEL, finds "no effect" below a certain threshold. (Note: Kehoe's work was financed by Ethyl, and is seen by historians as an example of industry hegemony over science. See Rosner & Markowitz, 1989.)

1928 — Controversy over use of leaded gasoline breaks out in Britain; scientists concerned, London Daily Mail articles discuss lead; Ethyl gets approval from UK government.

– September — Julius Stieglitz of the University of Chicago, who had been a member of the 1925 Surgeon General's Committee on tetraethyl lead, along with N.P. Leach, a director of the American Medical Association, write to complain about an "infraction of the spirit if not the letter of the regulations" on tetraethyl lead from spillage and other workplace exposures to concentrated Ethyl fluid.

1933 – Farmers advocate mandatory or tax-encouraged use of ethyl alcohol as fuel anti-knock instead of Ethyl leaded gasoline. Iowa State University and several Midwestern companies begin experimenting with and selling 10 percent ethyl alcohol in gasoline as anti-knock fuel. American Petroleum Institute urges oil industry to fight back vigorously.

— April — Ethyl marketing strategy switches to broad unbranded use in any gasoline; wholesalers begin to be licensed by Ethyl. Sales shoot up.

– Ethyl Corp. denies license to sell Ethyl to wholesalers using ethyl alcohol blended gasolines, selling cheaper than majors or violating "business ethics" as defined by Ethyl and Standard, according to F.B.I. report.

– U.S. Navy researchers at Annapolis find that Ethyl leaded gasoline and 20 percent ethyl alcohol blends in gasoline were almost exactly equivalent in terms of brake horsepower and useful compression ratios. The 1933 report was never published.

1934 — January — Standard Oil public relations expert Ivy Ledbetter Lee meets with Adoph Hitler to offer advice on how to reconcile Americans to the Nazi government. In July, Lee is brought before an outraged House Un-American Activities Committee for questioning about contacts with the Nazis. He died Nov. 9 of that year from a brain tumor.

1935 — Ethyl and Standard agree to provide I.G. Farben technology and know-how to manufacture tetraethyl lead in Germany. A similar agreement is reacheed with Montecatini for TEL manufacture in Italy.

1936 – Chemical Foundation finances factory to turn grain into ethyl alcohol for blending into anti-knock gasoline. "Agrol" fuel (10 to 20 percent ethyl alcohol with gasoline) sold in 2,000 stations across Midwest. The plant goes bankrupt by 1939.

– June 13 — Cushing Gasoline and Refining Company is ordered to cease disparaging remarks about Ethyl. Cushing advertised its gasoline was not "doped" and said: "It stands on its own merits and needs no dangerous chemicals — hence you can offer it to your customers without doubt or fear." The Federal Trade Commission said this was an unfair trade practice. Ethyl gasoline "is entirely safe to the health of [motorists] and to the public in general when used as a motor fuel, and is not a narcotic in its effect, a poisonous dope, or dangerous to the life or health of a customer, purchaser, user or the general public." Ethyl was "said to be the only chemical used commercially for mixture with gasoline for the purpose of eliminating the 'knocking'…" the FTC said in a press release about the decision.

1937 — Ethyl Gasoline Corp. indicted for violations of Sherman Anti-Trust Act related to enforcing business "ethics" on the market by denying wholesalers licenses to sell Ethyl. Some 10,000 out of 12,000 wholesalers in the US are licensed. Ethyl appeals and loses suit in Supreme Court 1940.

– January 8 — Midgley awarded ACS Perkins medal.

1938 — Standard transfers technical know-how for tetraethyl lead production to I.G. Farben of Germany; Farben promises but never delivers synthetic rubber production technology in return.

1939 — Ethyl Corp.'s tetraethyl lead is marketed in virtually all American gasolines except Sunoco, which uses select crudes, more expensive refinery processing and tertiary-butyl alcohol to reach regular and premium octane levels.

1942 — Sen. Harry S. Truman's war investigating committee exposes a treasonous pre-war relationship between American companies Ethyl, Standard Oil (Exxon), General Motors and DuPont on the one hand and the German chemical company I.G. Farben on the other. By the mid 1930s, Farben had been taken over by the Nazis. Standard company memos described the relationship as a "full marriage" which was "designed to outlast the war" no matter which side won.

GM, Ethyl and Standard Oil gave the Nazis leaded gasoline production technology in return for a patents on synthetic rubber, a critical strategic material. Although the U.S. companies did very little research of their own, they vigorously protected the German synthetic rubber patents.

When the war opened, supplies of natural rubber from southeast Asia were cut off by the Japanese, and meanwhile, the Standard – Nazi connection was blocking the development of synthetic rubber. The episode is considered to be a classic case of economic warfare , and was recognized as such at the time; British intelligence, for example, called Standard Oil a "hostile and dangerous element of the enemy." (Stephenson, 1976; Borkin, 1978).

1943 — Three quarters of US synthetic rubber production comes from alcohol based butadiene process rather than petroleum processes.

1944 – November 2 — Thomas Midgley found strangled by a harness he was using to get out of bed at his home in Columbus, Oho. It was probably a suicide. Midgley had been unable to walk for the previous four years, although he had given an address at the ACS meeting Sept. 11, 1944.

1945 — US Army says it wants "a method of removing tetra-ethyl lead from leaded gasoline so that the gasoline can be burned in stoves, lanterns and small engines." (April 29, 1945, NYT, p. E9).

1950 — Dr. Arie Haagen-Smit identifies causes of smog in LA as interaction of hydrocarbons (cars largest source) and oxides of nitrogen. Additional concerns about leaded gasoline begin emerging.

— Eugene Houdry, a petroleum engineer, announces development of a catalytic converter for auto exhaust to cut down carbon monoxide. (WSJ, Dec. 4, 1950) The combination of the catalytic converter and unleaded fuel would not be implemented for another 30 years.

1952 — General Motors and du Pont face a federal anti-trust suit for restraint of trade in gasoline additives, automotive paints and other chemical industries. US Supreme Court rules that research collaboration is not a violation of the Anti-Trust Act.

1953 – First serious post-war concerns about lead as an air pollutant surface in Los Angeles. Kettering follows issues closely through memos from industry observers as well as clips from newspaper articles.

1954 — Octel begins TEL production in England.

1958, 1959 — US Sen. Richard Neuberger and Rep. Paul Schenck introduce legislation requiring the US Surgeon General to hold public hearings on exhaust fumes and control standards. Schenck said the auto industry opposed the legislation "with everything it could throw into it." (WP Feb. 26, 1960).

1959 — US Public Health Service approves Ethyl Corp. request to increase lead in gasoline.

1959 – California becomes first to impose automotive emissions standards, requiring "blow-by" valve to recycle crankcase emissions back through the carburetor. Automakers combine to fight mandatory use of the $7 device, a fight which leads to an anti-trust suit by the U.S. Justice Dept. that is not settled until 1969.

1960 – Health, Education and Welfare Secretary Arthur S. Fleming urges adoption of "smog killer" devices on cars. (WP Feb. 26, 1960).

— Sept. 9 — Eight workers die handling TEL, according to an article in American Industrial Hygiene Journal, Dec. 1960, p. 515-17.

1962 — General Motors and Standard Oil of New Jersey (Exxon) abandon Ethyl Corp., selling it to Albemarle Paper Co. for $200 million in a leveraged buyout which the corporations themselves finance.

1965 – Clair Patterson publishes "Contaminated and Natural Lead Environments of Man," the first to show that high lead levels in industrial nations are man-made and endemic. (Arch Environ Health. 1965 Sept 11:344-60.)

— Sept. 9 — American Petroleum Institute responds to Patterson, saying that while the findings "may be of academic interest … they have no real bearing on the public health aspects of lead. Contrary to Mr. Patterson's conclusion, the mass of evidence proves unquestionably that lead isn't a significant factor in air pollution and represents no public health problem in any way." (WSJ Sept. 9, 1965)

— December 13 – 15 — Public Health Service holds a symposium on leaded gasoline, hearing from Robert Kehoe and Clair Patterson. Kehoe tells the scientists: "There is not enough lead in our environment to be a health hazard to anybody. Those who say there is are ignoring the substance of the scientific work that has been done." (WP Dec. 19, p. A14). Harriet Hardy of MIT argues that small doses of lead could be a contributing factor to disease, and cites studies that suggest links between lead and mental retardation. (NYT Dec. 16, p. 22).

1966 – June 8 — Hearings on leaded gasoline begin in U.S. Senate and include testimony from Robert Kehoe, a scientist working for industry, and Clair Patterson, a UCLA scientist who exposed Kehoe1s fraudulent industry research.

In one of the most sterling moments in public health and environmental history, Patterson tells the committee:

"It is not just a mistake for public health agencies to cooperate and collaborate with industries in investigating and deciding whether public health is endangered – it is a direct abrogation and violation of the duties and responsibilities of those public health organizations."

The hearings, chaired by Sen. Edmund Muskie, lead to extended debate about the need for new regulatory agencies and new approaches to regulations.

— US Public Health Service publishes report "Protecting the Health of Eighty Million Americans" stating that old problems of worker safety and health were not solved and new technological challenges were complex. The report leads to a reorganization of the PHS and the establishment of OSHA in 1970.

1969 — Auto makers settle suit by Justice Department for conspiracy to delay the development of pollution-control devices.

1970 — Jan. 22 — General Motors president Edward Cole promises "pollution free" cars by 1980 and urges the elimination of lead additives from gasoline in order to allow the use of platinum-based catalytic converters. The irony of GM abandoning leaded gasoline is not lost on the public — or Ethyl Corp. — since GM scientists discovered the anti-knock (octane boosting) effect of lead in 1921.

1971 – Ethyl Corp. officials claim to be victims of a "witch hunt," and say environmentalists are using "scare tactics" by blaming lead for the fall of the Roman Empire.

"The clincher by all prophets of doom is that someone started the rumor that lead was the cause of the fall of the Roman Empire… The legend always gets fuzzy — sometimes it is caused by lead-lined aqueducts, other times it is from their wine being drunk from lead-lined flasks." — Ethyl vice president Lawrence E. Blanchard, Jr. "Washington Press Briefing," National Press Club, Jan 18, 1971.

1972 — Feb 22 — EPA announces that all gasoline stations will be required to carry "non-leaded" gasoline in the future to protect catalytic converters (which reduce other auto exhausts such as carbon monoxide). EPA asked the Dept. of Health Education and Welfare "to provide a health basis for the planned reduction…" But HEW "informed EPA that they could not support the reduciton of lead in gasoline for reasons of adverse health effects since no medical or scientific data were available to indicate that it was a hazard to health." EPA delays setting standards until 1973, then is sued by Ethyl Corp.

– July 1 — Lancet reports death of four workers cleaning a tank that held TEL. Blood lead levels were between 64.2 and 92.5 ug/dL.

1974 — May 7 – 8 — Hearings before the Panel on Environmental Science and Technology of the Subcommittee on Environmental Pollution of the Committee on Public Works. Sen. Joe Biden (D-Del) calls for "a panel of medical scientists having expertise in the field" to perform a literature review, but concludes: "In my opinion, lead from auto emissions does not constitute a public health hazard."

J. Julian Chisolm also testifies about a "normal population without undue exposure to lead" having blood lead in the range of 10 to 30 ug/dL. "No adverse health effects have been demonstrated in such groups," Chisolm says, though he cautions that some may show blood metabolism effects. He also blames lead paint for most of the country's problems: "The extent to which the removal of lead from gasoline would ameliorate this problem is uncertain, but probably quite small." Others, notably Herbert Needleman, disagree.

1975 — New car models made with catalytic converters which require unleaded gasoline. Ethyl Corp. unsuccessfully proposes "lead tolerant" catalytic converters.

1976 – March 19 — Preliminary decision in Lead Industries Association v EPA; court says EPA has authority to regulate leaded gasoline. Even if there is no certainty that lead in gasoline is a danger, "awaiting certainty will often allow only for reactive not preventive regulation," says judge J. Skelly Wright. The lead phasout begins, and by June 1979, nearly half of all US gasoline is unleaded.

1978 — Energy Tax Act creates ethanol tax incentive, expanding use of ethanol anti-knock fuel additives in US.

1977 – Testing by public health scientists shows correlations between high levels of lead in children's blood and brain damage, hypertention and learning disorders.

1979 — Herbert Needleman begins first large study of behavior and intelligence as influenced by lead exposure.

1980 — June 27 — Final decision in Lead Industries Association v. EPA, affirms EPA regulations for leaded gasoline, allowing the phase-out to go forward. Judge J. Skelly Wright says:

The national ambient air quality standards for lead were the culmination of a process of rigorous scientific and public review which permitted a thorough ventilation of the complex scientific and technical issues presented by this rulemaking proceeding… To be sure, even the experts did not always agree about the answers to the questions that were raised. Indeed, they did not always agree on what the relevant questions were. These disagreements underscore the novelty and complexity of the issues that had to be resolved,

— National Academy of Sciences says that leaded gasoline is the greatest source of atmospheric lead pollution, and estimated daily intake of 0.3mg per person.

— National Security Act of 1980 requires that all gasoline be blended with a minimum of 10 percent ethanol. Mandate is dropped during Reagan administration.

— Gasohol Competition Act requires oil companies to stop their discrimination against sales of ethanol – gasoline blends.

— Ethyl reports it has expanded overseas business tenfold between 1964 and 1981.

1981 — Vice President George Bush's Task Force on Regulatory Relief proposes to relax or eliminate US leaded gas phaseout, despite mounting evidence of serious health problems.

1982 — Reagan Administration reverses opposition to lead phaseout.

1983 — EPA reports that between 1976 and 1980, amount of lead consumed in gasoline dropped 50 percent and corresponding blood-lead levels dropped 37 percent. The benefits of the lead phaseout exceed its costs by $700 million.

— Howard Mielke first reports that leaded gasoline in city soils are a factor in childhood lead poisoning, beginning a long record of research on the topic.

1983 — University of Virginia press publishes UVA historian Joseph C. Robert's corporate history: "Ethyl: A History of the Corporation and the People Who Made It." He acknowledges Ethyl's role in underwriting the costs of the book in the preface. Many factual details are grossly inaccurate and interpretive perspective is entirely hagiographic.

1984 — City of Chicago first to order end of all leaded gasoline sales since New York City ended ban on leaded gasoline in 1928. Newspapers conclude the Chicago order is first in the nation, indicating extent of historical amnesia concerning the Ethyl controversy.

1985 — Jack Lewis of EPA writes "Lead Poisoning: An Historical Perspective," in which the 1921 development of leaded gasoline is depicted as technologically inevitable. "… Other substances had all fallen by the wayside in the frantic search for a fuel additive that would improve engine performance and reduce engine knock." This is far frolm true. Lewis' depiction of recommendations for more research were shunted aside, he says, "… during the gin-soaked, jazz-crazed Roaring Twenties."

1986 — Citing conclusive evidence of brain damage from leaded gasoline, phase-out of 92 percent of all lead in gasoline ordered by EPA. Practical effect is banning of tetraethyl lead from U.S. market.

1986 – Primary phaseout of leaded gas in US completed. Study shows health benefit to technology cost ratio at 10:1.

— Safe Drinking Water Act amended to set standards for 83 contaminants and ban use of lead pipes and solder in new drinking water systems.

1990 - Leaded gasoline is "The Mistake of the 20th Century" according to C.M. Shy of the UNC School of Public Health in a paper published by the World Health Statistics Quarterly.

The environmental health calamity caused by lead in petrol could have been avoided if the initial warnings had been heeded and better preliminary research of the health issues had been carried out. Nevertheless, incontrovertible proof of causality should not be required before regulations are made to protect public health. (Shy, C.M. "Lead in petrol: the mistake of the XXth century." World Health Stat Q. 1990;43(3):168-76.)

1991 – OECD says that phasing out leaded gasoline was the most important lead poisoning prevention action possible for any national government.

1992 — Rio environmental summit calls for worldwide lead phaseout.

1994 – US researchers declared "lead poisoning remains the single most significant preventable disease associated with an environmental and occupational toxin"; and "Although lead in gasoline represents only 2.2 percent of total global lead use, leaded gasoline is by far the single most significant source of lead exposure in urban areas"

— UN Commission on Sustainable Development called on all governments to eliminate lead from gasoline.

— Blood lead levels show 78 % declines from 1978 to 1991 during leaded gasoline phase-out.

— American Academy of Pediatrics study shows direct relationship between lead exposure and IQ deficits in children.

1995 — December – Final US phase out leaded gasoline for road-use vehicles. US EPA press release says: "The elimination of lead from gas is one of the great environmental achievements of all time," [EPA Administrator Carol M] Browner said. "Thousands of tons of lead have been removed from the air, and blood levels of lead in our children are down 70 percent. This means that millions of children will be spared the painful consequences of lead poisoning, such as permanent nerve damage, anemia or mental retardation." The actions taken today, although procedural, mark the end of a quarter-of-a-century of work to keep Americans safe from exposure to lead from gas."

— April 14 — Ethyl v. EPA — The only reason to ban a gasoline additive is to prevent the failure of emissions control systems, the US Court of Apeals for the District of Columbia says. Public health concerns were not a sufficient reason for the denial of Ethyl's application to sell MMT (methylcyclopentadienyl manganese tricarbonyl) as a gasoline additive.

1996 — Feb 20 – OECD member nations, World Bank, signed a Lead Declaration placing lead petrol phase-out as the number one action for each OECD country. The report links public health with economics and notes that the health costs of leaded gasoline are far higher than the benefits to a few refiners and gasoline distributors.

— Lead poisoning is linked to anti-social behavior in a study by Dr. Herbert Needleman, a psychiatrist at the University of Pittsburgh Medical Center. The study is published in the Journal of the American Medical Association and caps a long line of studies about physical and behavioral problems caused by leaded gasoline and lead paint. "I'm not saying that lead exposure is the cause of delinquency. It is a cause and one with the biggest handle to prevention." He explained: "Lead is a brain poison that interferes with the ability to restrain impulses. It's a life experience which gets into biology and increases a child's risk for doing bad things." (Aggressiveness and Delinquency In Boys Is Linked to Lead in Bones by Jane Brody, Feb. 7, 1996, New York Times.)

1999 – Rick Nevin submits How Lead Exposure Relates to Temporal Changes in IQ, Violent Crime, and Unwed Pregnancy Environmental Research, Volume 83, Issue 1, May 2000, Pages 1-22. "Long term trends in population exposure to gasoline lead were found to be remarkably consistent with subsequent changes in violent crime and unwed pregnancy," Nevin says.

2000 – Jan 1 — European Union bans leaded gasoline as a public health hazard.

— US Senate resolution declares last week of October as national childhood lead poisoning prevention week. Information at the Centers for Disease Control lead pages. International lead poisoning awarness day is towards the end of October.

2001 — June -- Declaration of Dakar sets timetable for removal of leaded gasoline from Sub-Saharan Africa through United Nations Partnership for Clean Fuels and Vehicles.

— May 25 — Gilbert Grosvenor, chairman of the National Geographic Society and former editor of National Geographic magazine, is elected to another term on the Board of

Directors of the Ethyl Corp.

2002 – the World Summit on Sustainable Development (WSSD) took two decisions to protect children's health from exposure to lead. Firstly, the WSSD Plan of Implementation (POI) called for: "Supporting the phasing out of lead in gasoline." One result of WSSD 2002 was that the United Nations Environment Programme (UNEP) set up the Partnership for Cleaner Fuels and Vehicles (PCVF) with a core goal of global elimination of leaded petrol.

1999 – 2001 – Reginald Smith Jr., et al, v. Lead Industries Association et al, Case No. 24-C-99-004490, Circuit Court of the City of Baltimore, plaintiffs alleged damage through leaded paint and leaded gasoline to six Baltimore children. Case dismissed on preliminary motion, all documents sealed at request of Ethyl Corp.

2004 – Ethyl Corp. changes its name to New Market. Gilbert Grosvenor leaves board.

– Nov. 19 — Ethyl chair Bruce Gottwald funds Virginia Military Institute center for *"ethics*." Gottwald says he "believes the Institute's mission of transforming young men and women into tomorrow's leaders is more important today than ever."

2005 – The LEAD Group of Australia publishes a tally of 67 countries that were still selling leaded petrol.

2006 — January – Octel changes its name to Innospec.

— Jun 6 – SAICM (Strategic Approach to International Chemicals Management) releases Global Plan of Action, including a primary goal of eliminating lead in gasoline within the 2006-2010 timeframe. (SAICM Global Plan of Action page 33 of 84, 6 June 2006).

–Sept 9 – LEAD Group web-publishes Lead Mining Stewardship – Grey Lead and the Role of The LEAD Group fact sheet, which proposes "preventing lead from mining companies from being sold to the one manufacturer who uses lead to make the leaded petrol additive, that is, Innospec in the UK. If Innospec could not buy lead, hundreds of millions of children in the … countries still selling leaded petrol would not have to wait until 2010 for the SAICM … goal of a global lead petrol ban to be achieved."

2007 – International crime trends linked to pediatric lead exposure by Rick Nevis. The study found "a very strong association between preschool blood lead and subsequent crime rate trends over several decades in the USA, Britain, Canada, France, Australia, Finland, Italy, West Germany, and New Zealand."

2008 – Beijing PCFV meeting acknowledges it will fail to meet its original target of a 2008 global leaded gasoline phaseout.

— LEAD Group calls for a ban on Australian lead exports for TEL for road-use and asks Xstrata to stop supplying lead to Innospec via Britannia.

2010 — March 18 – Leaded gasoline producer Innospec pays Securities & Exchange Commission $40 million in fines for corrupt practices in marketing leaded gasoline, including bribes to public officials in Indonesia and Iraq before and after the 2003 US invasion. See SEC v. Innospec, Inc., Civil Action.

The US SEC Complaint against Innospec also names Swiss-based Alcor, "a wholly owned subsidiary of Innospec" and states Alcor's "financial results were consolidated with those of Innospec throughout the relevant period.

2011 April –The estimated global annual impacts of lead in vehicle fuels were found by Hatfield and Tsai in a United Nations-commissioned report to be:

- Close to 1.1 million deaths;
- A loss of 322 million IQ points;
- Close to 60 million crime cases;
- Economic loss of USD 2.4 trillion per year (4% of global GDP)

— June 17 – LEAD Group says that Afghanistan, Algeria, Iraq, Myanmar (Burma), North Korea and Yemen are the six remaining countries where leaded gasoline is possibly still being sold.

— August 25 – The LEAD Group sends a formal complaint to the OECD NCPs of Switzerland, Australia, US and UK re: non-compliance of Innospec and Xstrata with the OECD Guidelines for MNE. The US NCP requests a detailed complaint (sent Oct 25).

— Oct. 26 United Nations Partnership for Clean Fuels and Vehicles reports that leaded gasoline use is almost phased out worldwide.

– Dec. 17 – John Rosen, a pediatrician who fought for higher lead standards since the 1960s, dies of natural causes in New York.

2012 – Lead paint is still being sold in many developing nations, Occupational Knowledge International reports.

———————————-

Sources:

Joseph Borkin, The Crime and Punishment of I.G. Farben (Free Press, 1978).

Elizabeth O'Brien, "Brief history of the Leaded Petrol Death Trade," unpublished memo, The Lead Group, Nov. 17, 2011.

Coalition to End Childhood Lead Poisoning, "Timeline of Lead," on the web, accessed Nov. 2011.

Lydia Denworth, Toxic Truth: A Scientist, a Doctor, and the Battle over Lead. Beacon Press, 2009. (About Clair Patterson).

Charles Dickens, The Uncommercial Traveler, 1860- 1869.

Kevin Drum, America's Real Criminal Element, Mother Jones, Jan. 2013.

Peter English, Old Paint: A Medical History of Childhood Lead-Paint Poisoning in the United States to 1980. Rutgers Press, 2001.

Alice Hamilton,"What Price Safety, Tetraethyl Lead Reveals a Flaw in Our Defenses," The Survey Mid-Monthly, Vol. 54, June 15, 1925, p. 333.

Alice Hamilton, "Nineteen Years in the Dangerous Trades," Harpers, Oct 1929.

Jamie Kitman, The Secret History of Lead, Nation Magazine, March, 2000.

William (Bill) Kovarik, The Ethyl Controversy, PhD Dissertation, University of Maryland, 1993.

William (Bill) Kovarik, Charles F. Kettering and the 1921 Discovery of Tetraethyl Lead In the Context of Technological Alternatives, Society of Automotive Engineers, Fuels & Lubricants conference, 1994. (Pdf version.) Note error p. 44: milligrams per deciliter (μg/dl) is the correct standard.

William (Bill) Kovarik, The 1920s conflict over leaded gasoline and alternative fuels, Ameican Society of Environmental Historians, conference paper, 2003.

William (Bill) Kovarik, Ethyl leaded gasoline: How a classic occupational disease became an international public health disaster, International Journal of Occupational and Environmental Health, October 2005. (PDF)

Jack Lewis, Lead poisoning: An historical perspective, EPA Journal, May, 1985.

Alan Loeb, Birth of the Kettering Doctrine: Fordism, Sloanism and the discovery of tetraethyl lead, Business and Economic History, Fall 1995, Vol. 24:1, pp. 72 – 87.

C.P McCord, "Lead and Lead Poisoning in Early America: Benjamin Franklin and Lead Poisoning," Ind. Med. Surg. 22, 393-9, cited in Smith, p. 21.

Herbert Needleman, History of lead poisoning in the world, c. 1998.

Jerome O. Nriagu, The rise and fall of leaded gasoline, The Science of the Total Environment, 1990, Vol. 92, 13-28.

Jerome O. Nriagu, A history of global metal pollution, Science, April 12, 1996, p. 223-224.

David Rosner, Gerald Markowitz, A Gift of God? The public health controversy over leaded gasoline in the 1920s, American Journal of Public Health, April 1985, Vol. 75:4, pp. 344-352.

David Rosner, Gerald Markowitz, Dying for Work: Workers Safety and Health in Twentieth

Century America (Indiana University Press, 1989)

David Rosner, Gerald Markowitz, Standing Up to the Lead Industry: An Interview with Herbert Needleman Public Health Reports / May–June 2005 / Volume 120. (PDF)

David Rosner, Gerald Markowitz, Lead Wars: The Politics of Science and the Fate of America's Children, University of California Press, 2013.

Christopher Sellers, Hazards of the Job: From Industrial Disease to Environmental Health Science (UNC Press, 1999).

Dietmar Seyferth, The rise and fall of tetraethyl lead, Organometallics, 2003. (Part 1 – Vo. 22, 2346-2357; Part 2 — Vol. 22, 5154-5178).

Marjorie Smith, "Lead in History," eds. Richard Lansdown and William Yule, Lead Toxicity: History and Environmental Impact, (Baltimore, Md.: Johns Hopkins University Press, 1986) p. 20.

Robert A. Solo, "The Saga of Synthetic Rubber," Bulletin of Atomic Scientists, April 1980, p. 31.

William Stephenson, A Man Called Intrepid (Ballentine, 1976)

U.S. Senate, Automotive lead emissions : Hearings before the Panel on Environmental Science and Technology of the Subcommittee on Environmental Pollution of the Committee on Public Works, United States Senate, Ninety-third Congress, second session, May 7 and 8, 1974.

Christopher Warren, Brush with Death: A Social History of Lead Poisoning (Johns Hopkins University Press, 2001).

———-

Also see: Compilation of papers at Harvey Mudd College, Dept. of Chemistry.

———-

Abbreviations: — NYT, New York Times — WP, Washington Post — WSJ, Wall Street Journal

Version 1.4 Sept. 3, 2012 / Originally posted Nov. 18, 2011.

Text

GLOSSARY

Alkyl series: The simplest hydrocarbons form a series from one carbon (surrounded by hydrogen) methane to two-carbon ethylene, to propane (3 carbon atoms), butane (4), pentane (5), hexane (6), septane (7), octane (8), etc. (Kettering called this the parrafin series).

BTU -- British Thermal Unit, the amount of heat it takes to raise on pound of water one degree Farenheit. Gasoline has about 120,000 BTUs per gallon; ethyl alcohol 80,000; and methyl alcohol 60,000.

Compression ratio -- The amount that the air/fuel charge is compressed in the compression cycle of an internal combustion engine. Before the 1920s, engines typically had 4:1 compression ratios. After tetraethyl lead, ethyl alcohol, catalytic reforming and other octane boosting additives were developed, compression ratios of 8:1 became common.

Ethyl -- Unstable "radical" which binds readily to many other compounds, made up of two carbon and five hydrogen atoms. With a sixth hydrogen it becomes ethylene gas; with an oxygen and hydrogen it becomes ethyl alchol. Three ethyl radicals and a molecule of lead is tetraethyl lead.
(See diagram next page)

Ethyl alcohol -- (Ethanol) -- Common "grain" alcohol found in alcoholic beverages. Used in a blend of 10 to 30 percent in gasoline. Ten percent (called "Agrol" in the U.S. in the 1930s and "Gasohol" in the 1970s) boosts octane 4 to 5 points; 20 percent boosts octane 9 to 10 points (depending on base gasoline). Popular in Europe and Latin America beginning in 1920s.

Ethyl Gasoline Corp. -- Company formed as a 50 - 50 partnership of General Motors and Standard Oil of New Jersey on August 18, 1924.

Ethyl leaded gasoline -- Three grams of tetraethyl lead, along with halowax oil and ethylene dibromide, added to a gallon of gasoline, boosts octane 9 - 10 points. Developed in December, 1921, first marketed in February, 1923. Initial health impact studies begun Sept. 1923. Public controversy broke out October, 1924.

Gasoline -- A seasonally variable blend of several flamable explosive liquids distilled from petroleum; usually made up of five-carbon to 12-carbon alkyl and complex compounds. Octane rating usually between 55 and 65 before catalytic reforming.

Iron carbonyl -- Octane boosting additive like Ethyl leaded gasoline; non-poisonous but said to hurt cylinder lubrication. Added at rate of 12 grams per gallon. Sold in alcohol blend as "Motolin" in Germany in the 1930s.

Knock -- Uneven burning of gasoline in cylinder which causes piston to knock against sides of cylinder; minor knocking is not a serious problem, but loud knocking indicates engine damage in progress. Knocking usually occurs because fuel octane (or anti-knock power) is too low for the compression ratio of the engine.

Lead -- Pliable metal used in art, construction and household items since antiquity. Lead poisoning is associated with high infertility, mortality and morbidity rates in ancient Rome, where sheets of lead were used to line wine and grape vats to give a sugary-sweet taste. Blended into gasoline in the US between 1923 - 1986. Still used as octane booster in Third World.

Octane -- A reference system for anti-knock property of gasoline developed in the late 1920s and based on iso-octane (an eight carbon gasoline compound) as having an anti-knock value of 100.

Methyl alcohol -- (methanol) -- Common wood alcohol, a one-carbon alcohol also made from coal. Poisonous to drink but a useful fuel or fuel additive. Octane value 110.

Reforming -- High temperature and pressure refinery treatment for ordinary gasoline of 55 to 65 octane; boosts octane by 20 to 30 points. Developed between 1913 and late 1920s, perfected by Sun Oil Co. Severe reforming boosts octane within modern ranges by increasing content of benzene and benzine-related compounds in gasoline. Many modern premium fuels are simply 40 percent toluene (methyl benzene) blended with gasoline.

Tetraethyl lead -- (Three ethyls and lead) First synthesized by German chemist Loewig in 1852; highly poisonous with casual cumulative contact, causing hallucinations, labored breathing and in severe cases, spasms and asphyxiation. Blended by Ethyl Gasoline Corp. into gasoline at rate of 1200:1 or three grams per gallon to provide about 9 point octane boost.

```
    H  H
H   C - C -            ETHYL
    H  H

    H  H
H   C - C - H          ETHYLENE (GAS)
    H  H

    H  H
H   C - C = OH         ETHYL  ALCOHOL
    H  H


    H  H       H  H
```

H C - C = Pb = C - C H
H H | | H H
H C H
H C H
H

TETRA ETHYL LEAD

Text

APPENDIX THREE
TABLE FOUR

Tetraethyl lead and the competition:
Anti-knock premium (octane boosting) fuels of the 1920s and 1930s

	Octane Rating	Wholesale Cost (aprox)	Region & Dates Used Composition of Fuel
"Regular" gasoline	56	$.10	Global, 1880s - 1930s
Ethyl gasoline	68	$.13	Global, U.S. 1923 - 1986 Base + 3 grams tetraethyl lead
Benzol, Fordsol, etc.	68	$.14	U.S., common in 1920s Base + 40% benzene
Agrol, gasohol, etc.	65	$.115	U.S. 1930s, 1970s - present Base + 10% ethanol
Proalcool (Brazil)	75 (aprox)	$.13	Europe, Latin America 1900 -1930s, 1970s, Base + 20% ethanol
Carburant Nacionale	80 (aprox)	$.16	French program1923 - 1939 Base + 30% ethanol
Iron carbonyl	80	$.13	"Motolin" Germany, 1930s Base + 12 grams iron
Catalytic reforming	84	$.12 - .14	Global, 1925-present; "Blue Sunoco," "White Flash" (ARCO)

Note: Cost data is based on 10 cents per gallon pre-tax wholesale gasoline cost and 25 cent per gallon alcohol cost, which are wholesale rates in place in 1925 - 1935 time frame. (Some oil industry data at the time used 40 cent per gallon alcohol cost). Substitution of base fuel with 10 percent ethyl alcohol involves 9 cents worth of gasoline added to 2.5 cents worth of alcohol. Twenty percent ethyl alcohol is 8 cent gasoline + 5 cent alcohol.

Sources: Iowa State College, "The Use of Alcohol In Motor Fuels, Progress Report Number III," Divs. of Industrial Science, Engineering, Agriculture; Jan. 20, 1933. Also: Rayburn D. Tousley, The Economics of Industrial Alcohol, Washington State University, 1945; R.B. Gray, "On the Use of Alcohol-Gasoline Mixtures with Motor Fuels," US Dept. of Agriculture, unpublished, April 1933 (National Agricultural Library manuscript collection, Beltsville, Md.) Also "Who would Pay for Corn Alcohol?" Iowa Petroleum Commission pamphlet, 1935, American Petroleum Institute library, Washington, D.C. N. P. Wescott, Origins and Early

History of the Tetraethyl Lead Business, June 9, 1936, Du Pont Corp. Report No. D-1013, Hagley Museum & Library, Wilmington, Del.

AppENDIX THREE
TABLE FIVE

Tetraethyl lead and the ethanol:
Octane, compression and horsepower ratings

	Octane Rating	Compression	Horse-Power **
"Regular" gasoline	66	5.6	24.6
Ethyl gasoline	78	6.5	-*- / 50.7
10 % ethanol	74	6.1	26.0
20 % ethanol	80	6.5	27.2 / 54.1

Note: * Not tested.
** NACA engine tests compared horsepower of base gasoline with 10 and 20 percent alcohol blends. A second test using a high compression (8:1?) tractor engine compared Ethyl leaded gasoline with 20 percent alcohol in the base gasoline.

These tests were performed by the U.S. Navy at Annapolis, Md. for USDA by special request. They were never published.

Source: Octane, Compression and Horsepower from R.B. Gray, "On the Use of Alcohol-Gasoline Mixtures with Motor Fuels," US Dept. of Agriculture, unpublished, April 1933, National Agricultural Library manuscript collection, Beltsville, Md.

Text

APPENDIX 4
ALTERNATIVES TO TETRAETHYL LEAD
USED COMMERCIALLY 1920 - 1940

Tetraethyl lead was only one of many ways to improve fuel and decrease engine knock. Although General Motors and Standard Oil of N.J. settled on tetraethyl lead, other oil companies in the U.S. and other countries routinely used alternative octane boosting techniques. Most of these were already commercial in 1925. This appendix provides a short description of known commercially available alternatives during this period, with some emphasis on ethyl alcohol due to its widely acknowledged prominence.

"Cracking" crude oil

William Burton of Standard Oil of Indiana is credited with discovering in 1913 the secret of "cracking" longer chain low volatility fuels (like kerosene) into higher volatility gasoline by applying a combination of high temperature and high pressure. Early experiments in an Indiana refinery involved heating rows of corked-up vats of crude petroleum to "cherry-hot" conditions -- a rather serious safety risk. One unexpected benefit of cracking was the rise in anti-knock value of the fuel.[1] However, the cracked fuel had problems with gum formation if it was stored for a few months. In 1917, Standard Oil of New Jersey developed the "tube and tank" process which was very similar to two or three other cracking operations in use by the Texas Company (Texaco), Pure Oil Co. and Universal Products Co. A series of lawsuits followed in 1922, and an agreement to pool patent rights was challenged by the U.S. government in 1924.[2] The significance of the new processes was that petroleum chemists were now able to improve fuel without additives. For example, the president of the New Jersey chemical society, Carleton Ellis, said in November 1924 that refineries could improve the anti-knock value of gasoline in the future "without resort to additions such as lead Ethyl."[3]

Following the Bayway disaster and Ethyl's temporary withdrawal from the market in 1925, refiners increasingly turned their attention to premium antiknock gasolines without tetraethyl lead. Increased octane "could be achieved through increased thermal cracking, blending stocks of natural gasoline (gasoline absorbed from natural gas) or adding benzol [benzene]."[4] In 1925, Gulf introduced "No-Nox" gasoline using benzene at a three cents premium over regular, while Texaco, Sinclair and others offered other premium anti-knock gasolines without Ethyl. Sun Oil Co. resisted using Ethyl for decades and developed "Blue Sunoco" anti-knock gasoline by using crudes with high napthenic / aromatic (benzene and toluene) contents as well as their own improved thermal cracking processes. Blue Sunoco had an anti-knock rating of 70 to 73 octane in 1926, a rating which was comparable to Ethyl premium gasoline. Regular unleaded gasoline at this time had an octane rating in the 60s or slightly lower, while engine compression ratios hovered between 4 or 5 to 1. By 1941, the average engine compression ratio approached 7 to 1, while octane ratings of fuels ranged from 80 to 85.

Iron carbonyl

Aside from changes in petroleum refinery operations, a variety of other alternatives to tetraethyl lead were known to exist in 1925. One of the most interesting was iron carbonyl, a metal compound developed in the early 1920s by the German chemical monopoly I.G. Farben. Like tetraethyl lead, iron carbonyl was soluble in gasoline.

Ethyl Corp., GM and du Pont officials became greatly interested in iron carbonyl in the months after the Bayway disaster. After Kettering tested iron carbonyl on his 1924 European trip (as noted in Chapter Five), du Pont and I.G. Farben representatives met at Wilmington, Del. on April 28, 1925. Farben officials offered attractive financial terms partly because their U.S. patent position was weak (or more accuratly, had been weakened). It took 3 grams of tetraethyl lead to boost a gallon of gasoline by about 10 to 12 octane points while it took 12 grams of iron carbonyl. Due to the cost of isolating the high temperature, high pressure process, however, 3 grams of tetraethyl lead were twice as expensive as 12 grams of iron carbonyl.[5] The iron carbonyl option was “attractive as offering [a] possible escape from poison difficulties [of leaded gasoline],” according to du Pont’s internal history of leaded gasoline.[6] In an August 10, 1925 meeting, a tentative agreement was called off because Kettering said the iron caused more serious engine problems than had originally been thought. And yet, on Jan. 10, 1927, G.M, Ethyl and Farben signed a contract to join together in world exploitation of iron carbonyl with Farben’s patent rights recognized. Iron carbonyl was marketed in Germany, Italy and other European nations as "Motolin" and "Monopolin" beginning in Sept. 1926 and it was “favorably received due to its anti-knock qualities.”[7] The fuel was endorsed by a famous German race car driver of the era, Herbert Ernst. It was also marketed “to a limited extent” in the U.S. “until it became generally recognized that the great increase in engine wear which its abrasive combustion products produce makes its use impractical,” Ethyl’s Graham Edgar said in 1951. Edgar also said that “tremendous [research] effort to reduce this wear” had been undertaken, but no specifics were given. Interestingly, I.G. Farben always maintained that problems had been exaggerated. “Troubles in the lubricating system have never -- not even by way of intimation -- been found...”[8]

Aromatics from coal

Aromatic or benzine-like compounds were another alternative to leaded gasoline, and as noted above, they can be derived from refining high-napthenic crude petroleum (such as California crude), or they can be added separately when made from other feedstocks, especially as a byproduct of the coking process with coal. This class of chemicals includes benzene, toluene (methyl benzene) and xylene (dimethyl benzene). Aromatics were known as early as the 1880s as a hazard which “poisoned the blood,” but they did not become major workplace hazards until the development of pneumatic tires and other rubber goods required the use of powerful solvents. Ethyl officials pointed out in the 1970s when defending the use of leaded gasoline that, as an alternative to lead, benzene is a poor choice because it is carcinogenic.[9] Although the cancer-causing aspect was unclear at the time, Alice Hamilton was concerned about the expanding use of benzene in industry and in the fuel supply in 1922. "To the manufacturer, the introduction of this cheap and powerful solvent may seem an advantage," Hamilton wrote. "To the physician, interested in the producer more than the product, it can only seem a disastrous innovation in industry."[10] Of special concern to Hamilton was the use of benzene "as a substitute for motor car fuel." The Bureau of Mines was also concerned about benzene, and noted at the Public Health Service conference May 20, 1925, that blends of benzene and gasoline were more toxic to guinea pigs than leaded gasoline.[11] The Times noted the evidence and also noted that Surgeon General Cumming "called for a list of motor fuels containing benzene."[12] No such list is found in the archives, but some benzene would be found in virtually all gasoline, especially after catalytic reforming processes were widely adopted in the 1920s and 30s by the oil industry.

Not only did oil refineries use processes which encouraged the formation of aromatics in gasoline, but many refiners added benzene to boost octane. Surplus solvent made for World War I flooded the fuel market in the 1920s. Ford Motor Co., for example, used benzene from coking operations in "Benzol" fuel from the mid-1920s through the 1950s,[13] as did many other gasoline marketers at the time.

Along with petroleum refining and coal coking, two other German processes were being developed in the 1920s which also yielded aromatics and synthetic fuels from coal subjected to high temperatures and pressures. These were the "direct" addition of hydrogen to coal (hydrogenation) and the "indirect" gaseous separation and recombination of carbon, oxygen and hydrogen. Either route will produce aromatics or gasoline-like compounds, although the indirect route is best suited to produce methanol and is somewhat easier to develop on a large scale. The processes were developed by subsidiaries of I.G. Farben. By the mid-1920s, the coal processes had been well developed and were attracting international attention.[14] Coal based synthetic methanol was a source of concern in May, 1925, when American methanol producers who had been using a 60 to 90 cent per gallon wood methanol process appeared to be losing their markets to a 10 to 20 cent per gallon coal methanol process.[15]

The development of alternative fuel from coal in Germany alarmed Standard Oil Co. of New Jersey, and with a pending oil crisis of the early 1920s, Standard scrambled to place itself in a competitive position. Frank Howard and other Standard agents met frequently with Farben officials and began a relationship in 1924 designed to stifle international competition in fuels and chemicals. It is likely that Kettering's European trip, in which he accompanied Howard and GM's patent attorneys to visit Farben officials in Germany, was part of the beginning of this relationship.

After new oil fields were opened in the US in the late 1920s, and the oil "crisis" seemed remote, Standard continued to integrate its patents and other operations with Farben. The relationship was publicly exposed with the outbreak of war in 1942 in then-Sen. Harry S. Truman's War Investigations Committee. Former Assistant US Attorney General Joseph Borkin described the secret contract drawn up between Standard and Farben in a 1978 book: The Crime and Punishment of I.G. Farben. Borkin explained how the Farben and Standard agreed that Farben would stay out of all fuel markets except for those in Germany, while Standard in turn would help Farben protect its patents in the international chemical market. Standard and Farben officials met secretly over the years, and the agreement was renewed after World War II started in 1939. Officials said the "marriage" of their two companies would "operate through the term of the war, whether or not the US came in."[16] To seal the bargain, Standard gave Farben the technology and know-how to produce tetraethyl lead. Standard was later accused of becoming "a hostile and dangerous element of the enemy" by British security coordinators,[17] and U.S. Attorney General Thurmond Arnold privately insisted that Standard's board of directors either face criminal charges or step down and let others run the company during the war years.[18] Ethyl's relationship with I.G. Farben was severely criticized in the American press as well, despite protests by Standard and Ethyl officials that sale of tetraethyl lead technology to Germany had been approved by the government.[19]

Ethanol and methanol (ethyl and methyl alcohol)

Along with iron carbonyl and aromatics from various processes, a third type of alternative was so well known in the 1920s that its widespread use had been considered the "universal assumption" of scientists before leaded gasoline.[20] Alcohols were widely acknowledged as anti-knock fuels, even by G.M. researchers who invented tetraethyl lead.[21]

As an aviation fuel, alcohol in blends with benzene and gasoline was the preferred high-performance anti-knock fuel before tetraethyl lead was available. Navy tests in 1923 provided "very satisfactory results," with a 30 percent alcohol blend in gasoline that would "soon take the place of gasoline altogether."[22] A Naval Advisory Committee report said in 1925 noted the anti-knock value of alcohol / gasoline blends. It cautioned that alcohol might "reduce the amount of food products and its economic soundness is open to question," but also noted that alcohol from vegetation was not an exhaustible resource and in an emergency could be produced in unlimited quantities.[23] Also in 1925, a New York Times article quoted Charles F. Roth of the American Chemical Society saying that "the chemical world stands ready to produce synthetic wood alcohol ... at a price as low as, or lower than, gasoline now brings."

The U.S. history of alcohol fuels has been well explored in the 1930s period by Giebelhaus,[24] Bernton[25] and Kovarik,[26] but international history of alcohol as a fuel has not. In the years between the development of the automobile and World War I, a lively competition with races and expositions took place between electric, steam and internal combustion engines as well as various kinds of liquid fuels. An exhibit of alcohol fueled vehicles and appliances filled the Paris exhibition hall in 1902, and alcohol fuel was common in Europe -- and especially France and Germany -- before, during and after World War I.

By the mid-1920s ethyl alcohol was routinely blended with gasoline in every industrialized nation and even, to a limited extent, in the oil-rich United States. However, ten to twenty five percent alcohol blends with gasoline were more common in Scandinavian countries, where alcohol was made from paper mill wastes; in France, Germany and throughout continental Europe, where alcohol was made from surplus grapes, potatoes and other crops; and in Australia, Brazil, Cuba, Hawaii, the Philippians, South Africa, and other tropical regions, where it was made from sugar cane and molasses. In some countries, especially France, gasoline retailers were required to blend in large volumes of alcohol with all gasoline sold. Germany, Brazil and others more or less followed the "mandatory blending" model. In other countries, such as Sweden, Ireland and Britain, alcohol blends received tax advantages.[27]

A tractor operator for American Sugar Co. in Cuba in the 1921-24 period recalled using cheap molasses derived alcohol by the barrel at a time when gasoline was expensive to import. The practice was to start the tractors with gasoline (which cost 40 to 50 cents per gallon) and then run them on alcohol (at 5 cents per gallon) for the rest of the day. When the tractors were to be idled over a weekend or between harvests, a little gasoline was injected into the cylinders to minimize corrosion.[28] Cuba continued using alcohol fuels throughout the 20th century, especially after the communist revolution of 1960, in order to stretch petroleum supplies from the former Soviet Union.

Economic advantages were important in other tropical nations, but were not the foremost factor in making alcohol blends mandatory in European nations. In France, insecure supplies of oil during World War I led to a research program at the Pasteur Institute on sources of alcohol, including vast marine biomass resources like kelp.[29] Continued research by a national fuels committee appointed in 1921 led to a recommendations of a national fuel consisting of 40 to 50 percent alcohol, and on Feb. 28, 1923, "Article 6" required gasoline importers to buy at alcohol from a state monopoly at a volume of at least 10 percent of their gasoline imports. "Article 7" provided a five-Franc per hectoliter tax on gasoline to help subsidize the alcohol monopoly. The blend was not accepted by consumers, who were using engines which were specifically adapted to gasoline. At a minimum, carburetor settings needed to be changed to allow a greater fuel volume when the percentage of alcohol in the gasoline rose above 20 to 30 percent, and bitter complaints flowed in from motor clubs and garages.[30] Amendments to the law in 1926 and 1931 helped create a more workable blend, and alcohol fuel use rose from 7.8 million gallons per year in 1925 to 20 million gallons in 1932.

Although the French government was initially one of the most enthusiastic toward alcohol, by 1932 so many other nations had surpassed the French effort that one proponent explained the "slowness" in reviving alcohol fuels use. It "is due in part to the poor results obtained when such fuels were first introduced and also to the casting of discredit upon such fuels by its adversaries who profit in the fuel business," said Charles Schweitzer, a research chemist in the Melle complex.[31]

National initiatives were also under way in Britain, Italy and Germany, and tax incentives were passed in all three nations to encourage the use of alcohol or alcohol blended fuels.

In England, a Departmental Committee on Industrial Alcohol reported in 1905 that alcohol from potatoes would be more expensive than gasoline, even though farmers wanted an alcohol industry built to absorb crop surpluses. In 1915 "agitation" for an alcohol industry was noted.[32] A Fuel Research Board experimented with alcohol production between 1917 and 1924, and reported that while economics of traditional crops were marginal, novel crops like Jerusalem artichokes might be useful. "The most economical source [of alcohol] may be found ultimately in some of the luxuriant tropical growths within the Empire," an article in SAE Journal said. "Looking at the fuel question very broadly, the dominant fact is that almost all the fuel supplies at present used are what lawyers call wasting securities... As mineral fuels grow dearer, the advantage of fuels of vegetable origin must become accentuated."[33] By the 1930s, two major blends of up to 30 percent alcohol -- Cleveland Discoll (partly owned by Standard Oil of N.J.) and Cities Service -- were widely used. Discoll continued to be used until the 1970s.

German firms such as I.G. Farben had by the early 1920s come up with a process for making synthetic methanol from coal, a development which was widely reported in the popular and technical press and which worried Standard Oil Co. of New Jersey, as we have noted. Observing the synthesis of methanol and other fuels, the editor of Industrial and Engineering Chemistry said: "We do not predict that these will necessarily be the fuels to supplement our diminishing petroleum reserves ... But who shall say? The field is new and the opportunities are correspondingly great."[34] The German ethyl alcohol monopoly of the pre World War I (the

Centrale fur Spiritus Verwerthung) had apparently fallen apart in the post-war chaos, but with Monopolin blend of iron carbonyl, alcohol use in fuel climbed from a quarter million gallons in 1923 to 46 million gallons in 1932.[35] In 1930 gasoline importers were required to buy from 2.5 to 6 percent alcohol relative to their gasoline import volumes, but around 1933, I.G. Farben and several oil companies, including an American company (probably Standard), acquired 51 percent of Monopolin.[36] Production of alcohol climbed by 1937 to about 52 million gallons per year as part of Hitler's war preparations.[37]

In Italy, the first Congress of Industrial Chemistry which took place in April 1924 focused strongly on fuel problems, with a large percentage of the papers concerned with alcohol fuels. A strong scientific endorsement of the idea of using surplus crops in the national fuel mix led to a national decree on mandatory use of alcohol fuels in 1925.[38] Other nations, such as Hungary, Poland, and Brazil would follow the French and Italian examples with mandatory alcohol and gasoline blends in national fuels around this time, while the tax incentive approach was adopted by many other European nations such as Switzerland, Sweden, Germany and Britain.[39] The blends usually fell in the 20 percent range, and tended to be used in countries with the biggest farm surpluses, biggest defense needs and most limited access to oil.

The total use of alcohol as a substitute fuel in Europe may have never exceeded five percent, according to one conservative estimate or it may have been somewhat higher.[40] Synthetic gasoline and benzene created by I.G. Farben from coal substituted for seven percent and 6.5 percent respectively of European petroleum by 1937. Synthetic gasoline was cheaper (at 17 to 19 cents per gallon) than alcohol at around 25 cents per gallon.[41]

In the United States, variety of attempts to market a competitor for Ethyl included a Standard Oil experiment in Baltimore in 1923 and "Vegaline" fuel in Spokane, Washington in the 1920s. Competition sprouted up throughout the Midwest in the late 1920s and 1930s. Brands included Square Deal, Coryelle, Gurney, Agrol, Alcoline and HyBall.

Stockpiling of solvents and crop failures between 1937 and 1939 ended most of the European alcohol fuels programs, and crop surpluses disappeared with the outbreak of war. In the U.S., alcohol distilleries turned to war production, especially solvents for smokeless gunpowder and synthetic rubber. The era of cheap oil in the years following World War II put an end to many of the alcohol fuels programs, although some countries -- notably Brazil, Ireland, New Zealand and South Africa -- continued with substitute fuels programs of one sort or another to the present day.

---

1. Paul H. Giddens, Standard Oil Company (Indiana): Oil Pioneer of the Middle West (New York: Appleton Century Crofts, Inc., 1983).

2. August W. Giebelhaus, Business and Government in the Oil Industry: A Case Study of Sun Oil, 1876-1945 (Greenwich, Ct.: JAI Press, 1980), p. 70.

3. New York Times, Nov. 9, 1924.

4. Giebelhaus, Business and Government in the Oil Industry, p. 75.

5. Graham Edgar, "Tetraethyl lead," Advances in Chemistry Series No. 5, Proceedings of the American Chemical Society annual meeting, Sept. 3, 1951.

6. N.P. Wescott, "Origins and Early History of the Tetraethyl Lead business," June 9, 1936, Longwood Ms Group 10, Series A, Hagley library and Museum, Wilmington, Del.

7. E.I. Fulmer, R.M. Hixon, L.M. Christensen, W.F. Coover in "The Use of Alcohol in Motor Fuels: Progress Report Number I, A Survey of the Use of Alcohol as Motor Fuel in Various Foreign Countries," May 1, 1933, unpublished manuscript, Iowa State University archives.

8. "Experiences with Iron Carbonyl in Germany," I.G. Farben, Govt trial exhibit No. 722, US v E. I. du Pont de Nemours et. al., 1953. It is difficult to know which side of this technical debate to believe. In many cases research performed in preparation for contract negotiations is defensive. It is likely that the buyer (GM) overstated the problem while the seller (Farben) understated it. As a

point of comparison, I.G. Farben was anxious to get tetraethyl lead technology for aviation aircraft in the 1930s, which it would not have needed had iron carbonyl been such a superior product. Thus, GM's technological views may have merit.

9. Lawrence E. Blanchard, Jr., Executive vice president Ethyl Corp., "Washington Press Briefing," National Press Club, Jan. 18, 1971, p. 16.

10. Alice Hamilton, "The Growing Menaced of Benzene (Benzol) Poisoning in American Industry," Journal of the American Medical Association, Vol. 78:9, March 4, 1922, p. 627.

11. Proceedings of a Conference to Determine Whether or Not There is a Public Health Question in the Manufacture, Distribution, Or Use of Tetraethyl Lead Gasoline, Public Health Bulletin No. 158, Treasury Department, (Washington, D.C.: Government Printing Office, 1925) p. 29. The experimental design emphasized the question of immediate toxicity to guinea pigs of airborne concentrations of gasoline, leaded gasoline, "benzol" fuel and gasoline / benzene blends. Alcohol blends and iron carbonyl blends were not studied.

12. New York Times, May 21, 1925.

13. Personal communication, David R. Crippen, Reference Archivist, Ford Archives, Greenfield Village and Henry Ford Museum, March 18, 1980.

14. Arnold Krammer, "Fueling the Third Reich," Technology and Culture, Vol. 19:3, July 1978, pp.394 - 442.

15. New York Times, May 8, 1925.

16. Joseph Borkin, The Crime and Punishment of I.G. Farben (New York: Free Press, 1978), p. 92. quoting Thurmond Arnold testimony to a U.S. Senate committee.

17. William Stephenson, A Man Called Intrepid (New York: Ballentine, 1976), p. 284.

18. U.S. Congress, Special Committee Investigating National Defense Program, Testimony of Attorney General Thurmond Arnold, March 26, 1942.

19. Borkin, The Crime and Punishment of I.G. Farben,; also W.S. Farish, Standard Oil Co., to Sen. Guy M. Gillette, Sept. 17, 1942; Department of Justice file 60-57-107, National Archives, Washington, D.C.

20. Scientific American, Dec. 11 1920, p. 593.

21. "A Report of Fuel Research by the Research Division of the Dayton Metal Products Co. and the U.S. Bureau of Mines," July 27,1918, Midgley unprocessed files, GMI, Flint Michigan. Also see T.A. Boyd, "Motor Fuel From Vegetation," Journal of Industrial and Chemical Engineering, Vol. 13, no. 9, Sept. 1921, pp. 836 - 841; Thomas Midgley, "Discussion of papers at semi-annual meeting," SAE Journal, Oct. 1921 p. 269; and Thomas A. Midgley and T.A. Boyd, "Detonation Characteristics of Some Blended Motor Fuels," Society of Automotive Engineers Journal, June 1922, page 451.

22. Washington Post, July 24, 1923

23. Stanwood W. Sparrow, "Fuels for High Compression Engines," Report No. 232, U.S. Naval Advisory Committee for Aeronautics, 1925, National Archives. The report also noted that benzol and alcohol blends would not be safe as primary fuels for aircraft because of the potential for blends to separate under extremely low temperatures at high altitudes. However, alcohol was used as a secondary injector fuel for aircraft in World War II.

24. Augustus W. Giebelhaus, "Resistance to Long-Term Energy Transition: The Case of Power Alcohol in the 1930s," paper to the American Association for the Advancement of Science, Jan. 4, 1979.

25. Hal Bernton, Bill Kovarik, Scott Sklar, The Forbidden Fuel: Power Alcohol in the 20th Century (New York: Griffin, 1982).

26. Bill Kovarik, Fuel Alcohol: Energy and Environment in a Hungry World, (London: International Institute for Environment and Development, 1982).

27. World Trade in Gasoline, Bureau of Domestic & Foreign Commerce, US Dept. of Commerce monograph, Trade Promotion Series No. 20, May 15, 1925.

28. Personal communication, Fred R. Robinson to columnist Jack Anderson, April 24, 1978.

29. "Seaweed as a Source of Alcohol," Scientific American, Nov. 9, 1918, p. 371. A weak acid hydrolysis technique yielded only about 10 gallons per ton, about half the yeild from wood using the same technique.

30. "What French Motorists Say about Alcohol-Gasoline Motor Fuel Blends," Washington, D.C.: American Motorists Association, Dec. 15, 1933. The association reprinted letters to the magazine of the French National Federation of Automobile, Bicycle, Aeronautical and Related Trades. In a decidedly non-random poll, the majority of 40 letter writers disapproved of the inconveniences of alcohol blends, primarily citing problems with cork floats in carburetors and hesitation and stalling with high volume alcohol blends used in unadapted engines. Note that GM changed cork floats to metal floats in the early 1920s to deal with this problem.

31. Charles Schweitzer, "L'Etat Actuel De La Question De L'Alcool Carburant," Chimie & Industrie Vol. 28, No. 1, 1932; Translated and abstracted by E.I. Fulmer, R.M. Hixon, L.M. Christensen, W.F. Coover in "The Use of Alcohol in Motor Fuels: Progress Report Number I, A Survey of the Use of Alcohol as Motor Fuel in Various Foreign Countries," May 1, 1933, unpublished manuscript, Iowa State University archives.

32. New York Times, Nov. 28, 1915.

33. "Power Alcohol from Tubers and Roots, SAE Journal, May, 1925, p. 546. Also, Nathan, "Alcohol for Power Purposes."

34. Industrial and Engineering Chemistry, April 1925, p 334 .

35. E.I. Fulmer, "The Use of Alcohol in Motor Fuels."

36. Ibid.

37. Gustav Egloff, Motor Fuel Economy of Europe (Washington, D.C.: American Petroleum Institute, Dec. 1940).

38. "Italian Congress of Industrial Chemistry," Industrial and Engineering Chemistry, July 10, 1924, p. 6.

39. World Trade in Gasoline, Bureau of Domestic & Foreign Commerce, US Dept. of Commerce monograph, Trade Promotion Series No. 20, May 15, 1925.

40. Egloff, Motor Fuel Economy of Europe.

41. Ibid.

Text

BIBLIOGRAPHY

MANUSCRIPT COLLECTIONS CONSULTED

American Petroleum Institute Library, Washington, D.C.

Raymond H. Berry papers, National Consumers League, Library of Congress Manuscript Division, Washington, D.C.

Grace Burnham papers, Tammament Library, New York University, New York, N.Y.

Leo M. Christensen papers, Iowa State University, Ames, Iowa.

Farm Chemurgy collection, University of Nebraska, Lincoln, Neb.

Everett M. Dirksen papers, Dirksen Congressional Center, Peoria, Ill.

James T. Grady papers, Columbia University, New York, N.Y.

Alice Hamilton papers, Schlesinger Library Manuscript Collection on the History of Women in America, Radcliffe, Harvard University, Cambridge, Mass.

Charles F. Kettering papers, Thomas A. Midgely papers, Kettering Oral History Collection, and unclassified papers, General Motors Institute (GMI) Alumni Foundation's Collection of IndUStrial History, Flint, Mich.

Ivy Lee Papers, Princeton University, Princeton, N.J.

Walter Lippmann papers; C.E.A. Winslow papers, Yale University, New Haven, Conn.

Charles E. North papers, Special Collections, National Agricultural Library, Beltsville, Md.

Joseph Pew papers, E.I. du Pont de Nemours Corp. papers, Hagley Library and Museum, Wilmington, Del.

History of Advertising collection, Museum of American History, Smithsonian Institution, Washington, D.C.

U.S. Public Health Service, U.S. Bureau of Mines, U.S. Dept. of Justice, U.S. Bureau of Naval Aeronautics, U.S. National Agricultural Library, U.S. National Archives, Greenbelt, Md., Suitland, Md. and Washington, D.C.

Dissertations and Theses consulted

Nola Kay Gibson, "A History of Medical Journals in the United States," Master's thesis, University of Missouri, 1983.

Carolyn D. Hay, "A History of Science Writing in the United States and of the National Association of Science Writers, Inc.," Master's Thesis, Northwestern University, 1970.

Marcel LaFollette, "Authority, Promise and Expectation: The Images of Science and Scientists in American Popular Magazines," 1910-1955, Ph.D. Dissertation, Indiana University, 1979.

Genevieve Gardner McBride, "No Season of Silence: Uses of Public Relations in 19th and Early 20th Century Reform Movements in Wisconsin, Ph.D. Dissertation, University of Wisconsin, 1989,

Gail R. Meadows, "Scientific American: A Mirror of Scientific Progress, 1845-1968," Master's Thesis, University of Missouri, 1969.

John Palen, "Science and Walter Lippmann," Master's Thesis, University of Michigan, 1984.

Calder M. Pickett, "Six New York Newspapers and their Response to Technology in the 19th Century," Ph.D. Dissertation, University of Minnesota, 1959. Also, see Idem, "Technology and the New York Press in the 19th Century," Journalism Quarterly, 37: 398-407, Summer 1960.

David J. Rhees, "A New Voice for Science: Science Service Under Edward Slosson, 1921-29," Master's Thesis, University of North Carolina, 1979.

David J. Rhees, "The Chemists Crusade," Ph.D. Dissertation, University of Pennsylvania, 1987.

Volkmer, Richard M., "Edward Livingston Youmans and the Popular Science Monthly: A Study in 19th Century American Science-Technology Journalism," Master's Thesis, Iowa State University, 1969.

Angela Nugent Young, "Interpreting the Dangerous Trades: Worker's Health in America and the Career of Alice Hamilton, 1910-1935," Ph.D. Dissertation, Brown University, 1982

SELECTED PUBLISHED WORKS

Frederick Lewis Allen, Only Yesterday: An Informal History of the 1920s, (New York: Harper & Row, 1931).

Oscar Anderson, The Health of a Nation: Harvey W. Wiley and the Fight for Pure Food (Chicago: University of Chicago Press, 1958)

W.H.G. Armytage, A Social History of Engineering (Cambridge, Mass.: MIT Press, 1961).

George Basalla, The Evolution of Technology (Cambridge University Press, 1988)

Hal Bernton, Bill Kovarik, Scott Sklar, The Forbidden Fuel: Power Alcohol in the Twentieth Century (New York: Griffin, 1982)

Meyer Berger, The Story of the New York Times 1851-1951 (New York: Simon and Schuster, 1951).

John M. Blair, The Control of Oil, (New York: Random House, 1976),

Lester J. Bilsky, ed., Historical Ecology: Essays on Environment and Social Change, (Port Washington, N.Y.: Kennikat Press, 1980).

Joseph Borkin, The Crime and Punishment of I.G. Farben (New York: Free Press, 1978).

T.A. Boyd, Professional Amateur (New York: E.P. Dutton, 1957).

Jacob Bronowski, The Ascent of Man (Boston: Little, Brown & Co., 1973).

Vannevar Bush, Modern Arms and Free Men: A Discussion of the Role of Science in Preserving Democracy (New York: Simon and Schuster, 1949).

Butti, Ken, A Golden Thread: Two Thousand Years of Solar Architecture and Technology, (NY: Van Nostrand Reinhold, 1980).

Jo Ann Bydston, ed., John Dewey, The Later Works, (Carbondale, Ill: Southern Illinois University Press, 1989).

Rachel Carson, Silent Spring, (Boston: Houghton, Mifflin & Co., 1962).

Marquis Childs and James Reston, Walter Lippmann and His Times (NY: Harcourt, Brace, 1959)

B.L. Cohen, Before It's Too Late: A Scientist's Case for Nuclear Energy (New York: Plenum, 1983).

Michael P. Cohen, History of the Sierra Club, 1892-1970 (San Francisco, Sierra Club Books, 1988).

Lyle Cummins, Internal Fire (Warrenton, Pa.: Society of Automotive Engineers, 1989).

Stephen H. Cutcliffe, Robert C. Post, eds., In Context: History and the History of Technology (Bethlehem, Pa.: Lehigh University Press, 1984).

Ludwell Denny, We Fight For Oil (NY: Knopf, 1928).

Edith Efron, The Apocalyptics (New York: Simon & Schuster, 1984)

Elizabeth Eisenstien, The Printing Revolution in Early Modern Europe (Oxford: Oxford University Press, 1983).

Jacques Ellul,The Technological Society, (New York: Alfred Knopf, 1964).

Edwin Emery and Michael Emery, The Press and America, 6th edition (Englewood Cliffs, N.J.: Prentice Hall, 1988)

Harold Faulkner, The Quest for Social Justice, 1898-1914 (New York: Macmillan, 1934).

Barrett Fine, A Giant of the Press: Carr Van Anda (Oakland, Calif.: Acme Books, 1968).

Jean Folkerts and Dwight L. Teeter, Jr., Voices of a Nation (New York: McMillan Publishing Co., 1989)

John M. Fowler, Energy and the Environment, (New York: McGraw Hill 1984)

Robert Friedel, Edison's Electric Light: Biography of an Invention (New Brunswick, N.J.: Rutgers University Press, 1987)

Stephen Fox, John Muir and his Legacy: The American Conservation Movement (Boston, Little Brown & Co. 1981)

G.S. Gibb, E.H. Knowlton: History of Standard Oil Co., 1911-1927 (NY 1956).

Paul H. Giddens, Standard Oil Company (Indiana): Oil Pioneer of the Middle West (New York: Appleton Century Crofts, Inc., 1983).

August W. Giebelhaus, Business and Government in the Oil Industry: A Case Study of Sun Oil, 1876-1945 (Greenwich, Ct.: JAI Press, 1980).

Rae Goodell, The Visible Scientists (Boston: Little, Brown & Co., 1977).

Andrew Goudie, The Human Impact: Man's Role in Environmental Change (Cambridge, Mass: MIT Press, 1984)

William Graebner, Coal Mining and Safety in the Progressive Period, (Lexington, Ky.: University Press of Kentucky, 1976).

Madeleine P. Grant, Alice Hamilton: Pioneer Doctor in Industrial Medicine, (London: Abelard-Schfuman, 1967)

L. F. Haber, The Poisonous Cloud: Chemical Warfare in the FIrst World War (Oxford: Clarendon Press,1986)

Samuel Hays, Conservation and the Gospel of Efficiency: The Progressive Conservation Movement 1890-1920 (NY Athenium 1959).

Carl G. Hempel, Aspects of Scientific Explanation, (New York: MacMillan, 1965).

Ray Hiebert, Courtier to the Crowd: The Story of Ivy Lee and the Development of Public Relations (Ames, Iowa: Iowa State University Press, 1966)

David Hounshell and John Smith, Science and Corporate Strategy: Du Pont R&D, 1902-1980 (New York: Cambridge University Press, 1988)

Thomas P. Hughes, Networks of Power: Electrification in Western Society, 1880-1930 (Balt. Johns Hopkins U. Press, 1983).

J. Hughs, Ecology in Ancient Civilizations, (Albequerque, N.M., University of New Mexico Press, 1975) .

Neil F. Jacoby, Corporate Power and Social Responsibility (New York: Columbia University Press, 1973).

Justin Kaplan, Lincoln Stephens: A Biography (NY: Simon & Schuster, 1974).

John F. Kasson, Civilizing the Machine: Technology and Republican Values in America, 1776-1900 (New York: Penguin Books, 1986).

Thomas S. Kuhn, The Structure of Scientific Revolutions (Chicago: University of Chicago Press, 1972).

Ruth deForest Lamb, American Chamber of Horrors: The Truth about Food and Drugs (New York: Farrar & Rinehart, 1936)

Craig L. LaMay and Everette E. Dennis, Media and the Environment (Washington DC: Island Press, 1991).

Edward Layton, Revolt of Engineers: Social Responsibility and the American Engineering Profession (Baltimore, Md.: Johns Hopkins University Press, 1986)

Aldo Leopold, Sand County Almanac, (Oxford University Press, 1949).

Stuart Leslie, Boss Kettering (New York: Columbia University Press, 1983).

Walter Lippmann, Drift and Mastery (New York: Mitchell Kennerly, 1914).

Walter Lippmann, Public Opinion (New York: MacMillan, 1923).

Walter Lippmann, A Preface to Morals (New York: MacMillan, 1929).

Walter Lippmann, The Good Society (Boston: Little, Brown & Co., 1937).

Alan I. Marcus and Howard P. Segal, Technology in America: A Brief History (New York: Harcourt, Brace, Jovanovich, 1989).

Leo Marx, The Machine in the Garden (London: Oxford University Press, 1964).

Stephen F. Mason, A History of the Sciences (New York: MacMillan, 1962)

Henry F. May, The End of American Innocence (New York: Knopf, 1959)

Louis Mumford, Technics and Civilization (New York: Harcourt, Brace & World, 1932).

Nelkin, Dorothy, ed., Controversy: Politics of Technical Decisions (London: Sage Publications, 1979).

Allen Nevins on History, ed. A.R. Billington, (NY: Scribners 1975).

Alan Nevins, The Constitution Makers and the Public, 1785-1790, (New York: Foundation for Public Relations Research and Education, 1962).

David F. Noble, America by Design: Science, Technology and the Rise of Corporate Capitalism (Oxford: Oxford University Press, 1977).

Peter Novick, That Noble Dream: The Objectivity Question and the American Historical Profession (London: Cambridge University Press, 1988).

Jerome Nriagu, Lead and Lead Poisoning in Antiquity (New York: Wiley Interscience, 1983)

A.J. Pacey, The Maze of Ingenuity (Cambridge, Mass: MIT Press, 1974, 1986).

A.J. Pacey, Technology in World Civilization (Cambridge, Mass.: MIT Press, 1990)

Joseph M. Petulla, American Environmentalism: Values, Tactics Priorities (College Station, Texas: Texas A&M University Press,1980.

J.A. Pimlott, Public Relations and American Democracy (Princeton, N.J.: Princeton University Press, 1951)

James Ridgeway, Powering Civilization (New York: Pantheon, 1982)

Joseph C. Robert, Ethyl: A History of the Corporation and the People Who Made It (Charlottesville, Va.: University Press of Virginia, 1983).

David Rosner and Gerald Markowitz, eds., Dying For Work: Workers Safety and Health in 20th Century America, (Bloomington, Indiana: Indiana University Press, 1989)

George Rosen, A History of Public Health, (New York: MD Publications, 1958).

Charles Rosenberg, No Other Gods: On Science and Social Thought (Baltimore, Md.: Johns Hopkins University Press, 1976).

Kirkpatrick Sale, The Green Revolution (New York: Hill and Wang, 1993)

Lucy Maynard Salmon, The Newspaper and the Historian (New York: Oxford University Press, 1923)

Anthony Sampson, The Seven Sisters (New York: Viking 1975)

Wulbur Schramm The Story of Human Communication, (New York: Harper & Row, 1988).

Michael Schudson Discovering the News: A Social History of American Newspapers (New York: Basic Books, 1978).

Sam H. Schurr and Bruce C. Netschert, Energy in the American Economy 1850 - 1975; An Economic Study of its History and Prospects (Baltimore, Resources for the Future, Johns Hopkins Press: 1960).

Edward L. Schapsmeier, Frederick H. Schapsmeier, Walter Lippmann Philosopher-Journalist (Washington, D.C.: Public Affairs Press, 1969).

Phillip Shabecoff, A Fierce Green Fire (New York: Hill and Wang, 1993).

William David Sloan, American Journalism History: An Annotated Bibliography (New York: Greenwood Press, 1989).

W.G. Smillie, Public Health: Its Promise for the Future, A Chronicle of the Development of Public Health in the United States 1607 - 1914 (New York: McMillan, 1955).

Barbara Sicherman, Alice Hamilton: A Life in Letters (Cambridge, Mass: Harvard University Press, 1984)

Carl Solberg, Oil Power: The Rise and Imminent Fall of an American Empire (New York: Mason Charter Publishers, 1976).

W.G. Smillie, Public Health: Its Promise for the Future, A Chronicle of the Development of Public Health in the United States 1607 - 1914 (New York: McMillan, 1955).

Edward M. Spiers, Chemical Warfare (Chicago: U. of Ill Press, 1986)

James D. Startt and William Sloan, Historical Methods in Mass Communication (Hillsdale, N.J.: Lawrence Erlbaum Associates, 1989)

John Staudenmier, Technology's Storytellers (Oxford: Oxford University Press, 1988).

Ronald Steele, Walter Lippmann and the American Century (New York: Little, Brown & Co., 1980)

Mitchell Stephens, A History of News From the Drum to the Satellite (New York: Viking, 1988),

William Stephenson, A Man Called Intrepid (New York: Ballentine, 1976).

Mark Sullivan, Our Times (NY: Scribner's, 1926)

Albert H. Teich, ed., Technology and the Future, (New York: St. Martin's Press, 1986)

Alexis de Tocqueville, Democracy in America, (1835) eds. J.P. Mayer and Max Lerner (New York: Harper & Row, 1966)

John Tosh, In Pursuit of History: Aims, Methods and New Directions in the Study of Modern History (New York: Longman, 1991)

Barbara Tuchman, Practicing History (New York: Knopf, 1981).

William Tucker, Progress and Privilege (New York: Doubleday, 1983).

W. Warren Wagar, Good Tidings: The belief in Progress from Darwin to Marcuse (Bloomington, Ind.: Indiana University Press, 1972).

Spencer Weart, Nuclear Fear: A History of Images (Cambridge, Mass.: Harvard University Press, 1988).

Leonard W. Weiss, "Introduction: The Regulatory Reform Movement," in Leonard W. Weiss & Michael W. Klass, eds., Case Studies in Regulation (NY: Little, Brown & Co., 1981).

Harold F. Williamson & Arnold R. Daum, The American Petroleum Industry, 1859-1899, The Age of Illumination (Evanston Ill NW U Press, 1959).

Langdon Winner, Autonomous Technology (Cambridge, Mass.: MIT Press, 1977).

L.M. Wolfe, Son of the Wilderness, the Life of John Muir (NY: Knopf, 1945).

Daniel Yergin, The Prize: The Epic Quest for Oil, Money & Power (NY: Simon & Schuster, 1991).

Rosamond Young, Boss Ket (New York: Longmans, Green & Co., 1961)

Gerard Colby Zilg, DuPont: Behind the Nylon Curtain (Englewood Cliffs., N.J.: Prentice Hall, 1974)

Howard Zinn, A People's History of the United States (New York: Harper & Row, 1980).

Terra Ziporyn, Disease in the Popular American Press (Westport, Ct. Greenwood Press, 1988).

______ "Battle for Wilderness," The American Experience series, Public Broadcasting Service documentary, 1989.

SELECTED PUBLISHED ARTICLES

Peter Andrews, "Lighter than Air" Invention & Technology, 9:1, Summer 1993.

Maurine Beasley, "The Women's National Press Club: Case Study of Professional Aspirations," Journalism History, Winter 1988, 112-121.

James W. Carey, "The Problem of Journalism History," Journalism History, Vol.1 No. 1 Spring 1974.

James W. Carey, "Putting the World at Peril," Journalism History, Vol. 12, No. 2, Summer 1985.

Maurice Goldsmith, "The Popularization of Science," Nature, 250:751-53, August 1974.

Madeleine P. Grant, Alice Hamilton: Pioneer Doctor in Industrial Medicine, (London: Abelard-Schfuman, 1967).

Alice Hamilton, “Is Science For or Against Human Welfare?” The Survey Mid Monthly, Feb. 5, 1916.

Alice Hamilton, “The Growing Menaced of Benzene (Benzol) Poisoning in American Industry,” Journal of the American Medical Association, Vol. 78:9, March 4, 1922, p. 627.

Alice Hamilton, “Nineteen Years in the Dangerous Trades,” Harpers, Oct 1929.

Herbert Hosking, “The Automobile of James F. Hill Was Ordered Off the Street in 1885,” Automotive Industries, May 2, 1931.

Thomas P. Hughes, "Inventors: The Problems they Chose, The Ideas They Have, and the Inventions they Make," in Patrick Kelly and Melvin Kransberg, Eds., Technological Innovation: A Critical Review of Current Knowledge (San Francisco: San Francisco Press, Inc., 1978).

Richard B. Kielbowicz and Clifford Scherer, “The Role of the Press in the Dynamics of Social Movements,” in Research in Social Movements, Conflicts and Change, Vol. 9 (Greenwich, Ct.: JAI Press Inc., 1986),

Stuart W. Leslie, “Charles F. Kettering and the Copper Cooled Engine,” Technology & Culture Oct 1979, 20:4 p 752 .

Carolyn Merchant, "The Women of the Progressive Conservation Crusade: 1900-1915," in Environmental History, ed., Kendall E. Bailes (New York: University Press, 1985).

William J. Paisley, “Public Communication Campaigns: The American Experience,” in Public Communication Campaigns, eds. Ronald E. Rice and William J. Paisley (Beverly Hills, Calif.: Sage Publications, 1981).

Stephen Ponder, “The Progressive Drive to Shape Public Opinion 1898-1913,” Public Relations Review, Vol. 16, No. 3, Fall 1990.

Frank Popoff, “Life After Rio: Merging Economics and Environmentalism,” Speech for Chemical Week Conference, Oct. 15, 1992, Houston, Texas.

Michael Schudson, “The Present in the Past, versus the Past in the Present,” Communication, Vol. 11, pp. 105-113.

Nelson Smith and Leonard J. Theberge, eds., Energy Coverage Media Panic (New York: Longman, 1983).

Peter N. Stearns, “Trends in Social History,” in Michael Kammen, ed, The Past Before us: Contemporary Historical Writing in the United States (Ithaca, N.Y.: Cornell University Press, 1980)

Angela Nugent Young, “Organizing Trade Unions to Combat Disease: The Workers Health

Bureau, 1921-1928," Labor History, 1983, p. 424-446.

SELECTED PUBLISHED WORKS ON ETHYL ALCOHOL AND ETHYL LEAD

American Petroleum Institute, "Analysis of Technical Aspects of Alcohol Gasoline Blends," API Special Technical Committee, No. 216, April 10, 1933.

American Petroleum Institute, "What French Motorists Say about Alcohol-Gasoline Motor Fuel Blends," Washington, D.C.: American Motorists Association, Dec. 15, 1933.

American Petroleum Industries Committee, Victor H. Scales, Publicity Director, "Economic Aspects of Alcohol-Gasoline Bleds," API, May 1, 1933

American Petroleum Industries Commitee, "A Reply to The Deserted Village, No. 6 of the Chemical Foundation," 1935.

Anon., "Alcogas as Aviation Fuel Compared with Export Gasoline," SAE Journal, June 1920, p. 397.

Anon., "Liquid Fuels of the Future," Industrial & Engineering Chemistry, Vol. 17, No. 6, April 1925, p.334.

Anon., "Power Alcohol from Tubers and Roots, SAE Journal, May, 1925, p. 546.

Anon., The Story of Ethyl Gasoline, pamphlet (New York: Ethyl Gasoline Corp., 1927), American Petroleum Institute Library, Washington, D.C.

Anon., "The Trail of the Arbutus," pamphlet probably published either by Ethyl Corp. or General Motors, Aug. 29, 1951, GMI, Flint, Mich.

Silas Bent, "Tetraethyl Lead Fatal to Makers," New York Times, June 22, 1925.

Lawrence E. Blanchard, Jr., "Washington Press Briefing," The Ethyl Corp., Jan 18, 1971, National Press Building, Washington, D.C.

Christy Borth, Chemists and Their Work (New York: Bobbs-Merrill, 1938).

T. A. Boyd, The Early History of Ethyl Gasoline, Report OC-83, Project # 11-3, Research Laboratory Division, G. M. Corp., Detroit Michigan, (unpublished) June 8, 1943, GMI, Flint, Mich.

T.A. Boyd, "Motor Fuel From Vegetation," Journal of Industrial and Chemical Engineering, Vol. 13, no. 9, Sept. 1921, pp. 836 - 841.

T.A. Boyd, "Pathfinding in Fuels and Engines." Society of Automotive Engineers Transactions, April 1950, pp. 182-183.

John K. Brachvogel, Industrial Alcohol: Its Manufacture and use, (New York: Munn & Co., 1907).

H.L. Calendar, Capt. R.O. King, Lt. C.J. Sims, "Dopes and Detonation," Engineering, April 9, 1926, p. 475.

Congress des Applications de L'Alcool Denature, 16 au 23 Dec., 1902, Automobile-Club de France, National Agricultural Library, Beltsville, Md.

Donald Despain, The One and Only Solution to the Farm Problem (New York: Vantage Press, 1956).

Harold B. Dixon, "Researches on Alcohol as an Engine Fuel," SAE Journal, Dec. 1920, p. 521.

Gustav Egloff, Motor Fuel Economy of Europe (Washington, D.C.: American Petroleum Institute, Dec. 1940).

Graham Edgar, "The Manufacture and use of Tetraethyl lead," Industrial and Engineering Chemistry, Dec. 1939, Vol. 31, p. 1439-1446.

Farm Chemurgic Council, Proceedings of the Third Dearborn Conference, Farm Chemurgic Journal, Dearborn, Mich., 1937. Many other references to Chemurgy are available.

E.C. Freeland and W.G. Harry, "Alcohol Motor Fuel from Molasses," Industrial and Chemical Engineering News, Part I, June 1925; Part II, July 1925.

E.I. Fulmer, R.M. Hixon, L.M. Christensen, W.F. Coover in "The use of Alcohol in Motor Fuels: Progress Reports May - October, 1933 (Ames, Iowa: Iowa State University, 1933).

Augustus W. Giebelhaus in "Resistance to Long-Term Energy Transition: The Case of Alcohol Fuels," paper to the American Association for the Advancement of Science, August 1980.

William Graebner, "Hegemony through Science: Information Engineering and Lead Toxicology, 1925 - 1965, in Rosner & Markowitz, eds., Dying for Work.

William J. Hale, The Farm Chemurgic, Alpine Press, Boston, 1934.

William J. Hale, Prosperity Becons: Dawn of the Alcohol Era (Boston: The Stratford Co., 1934).

Alice Hamilton, Paul Reznikoff and Grace Burnham, "Tetra Ethyl Lead," Journal of the American Medical Association, May 16, 1925, pp. 1481-1486.

Alice Hamilton, "What Price Safety? Tetraethyl Lead Reveals a Flaw in Our Defenses," The Survey Mid-Monthly, June 15, 1925.

Horst Hardenberg, Samuel Morey and his Atmospheric Engine (Warrendale, Pa.: Society of Automotive Engineers, Feb. 1992), SP922.

S.D. Heron, Development of Aviation Fuels, (Cambridge, Mass.: Harvard University Graduate School of Business Administration, 1950).

Rufus Frost Herrick, Denatured or Industrial Alcohol, (New York: John Wiley & Sons, 1907).

Harold Hibbert, "The Role of the Chemist in Relation to the Future Supply of Liquid Fuel," Journal of Industrial and Chemical Engineering, Vol. 13, no. 9, Sept. 1921, p. 841.

Iowa Petroleum Industries Committee "Who would Pay for Corn Alcohol?" Des Moines, Iowa, 1933, library, American Petroleum Instutute, Washington, D.C.

Iowa Petroleum Public Relations Committee," The ABCs of Alky-Gas," 1936, library, American Petroleum Instutute, Washington, D.C.

Robert A. Kehoe, "Antiknock Compounds and Public Health," Ethyl News, May-June, 1962

Charles F. Kettering, "The Story of Ethyl Gasoline," Experimental draft, 1946, GMI Alumni Foundation Collection of Industrial History, Flint, Mich.

Bill Kovarik Fuel Alcohol: Energy and Environment in a Hungry World, (London: Earthscan, 1982).

John C. Lane, "Gasoline and Other Motor Fuels," Encyclopedia of Chemical Technology, (New York: John Wiley & Sons, 1980), p. 656.

C.P McCord, "Lead and Lead Poisoning in Early America: Benjamin Franklin and lead poisoning," Ind. Med. Surg. 22.

John Geddes McIntosh, Industrial Alcohol (London: Scott, Greenwood & Son, 1907).

Thomas A. Midgley, "How We Found Ethyl Gas," Motor Magazine, Jan. 1925, p. 92 - 94.

Thomas A. Midgely, "Our Liquid Fuel Reserves," Paper to the Society of Automotive Engineers, Oct. 13, 1921, Indiana section.

Thomas A. Midgely, "Tetraethyl Lead Poison Hazards," Industrial and Engineering Chemistry, August 1925 p. 827

Thomas A. Midgely and T.A. Boyd, "The Application of Chemistry to the Conservation of Motor Fuels," Industrial and Engineering Chemistry, Sept. 1922, p. 850.

Thomas A. Midgley and T.A. Boyd, "Detonation Characteristics of Some Blended Motor Fuels," Society of Automotive Engineers Journal, June 1922, p. 450.

Harry Miller, "Alcohol Gasoline Engine Fuels," University of Idaho Agricultural Experimental Station, Dept. of Agricultural Engineering, Bulletin No. 204, June 1934 (National Agricultural Library, Beltsville, Md.)

G.W. Monier-Williams, Power Alcohol:Its Production and Utilization (London: Oxford Technical Publications, 1922.

Michael R. Moore, "Lead in Humans," in Richard Lansdown and William Yule, eds., Lead Toxicity: History and Environmental Impact (Baltimore: Johns Hopkins University Press, 1986),

Col. Sir Frederic Nathan, "Alcohol for Power Purposes," The Transactions of the World Power Congress, London, Sept. 24 - Oct. 6, 1928.

New York Times, "Launching of a Great Industry: The Making of Cheap Alcohol," Nov. 25, 1906, Section III p. 3.

Stanton P. Nickerson, "Tetraethyl Lead: A Product of American Research," Journal of Chemical Education, Vol. 31, Nov. 1954, p. 567.

W.R. Ormandy, E.C. Craven, and H.R. Ricardo, Report of the Empire Motor Fuels Committee, 1923-24.

S.J.W. Pleeth, Alcohol: A Fuel for Internal Combustion Engines (London: Chapman & Hall, 1949).

Joseph A. Pratt, "Letting the Grandchildren do it: Environmental Planning During the Ascent of Oil as a Major Energy Source," The Public Historian, Vol. 2 No. 4, 1980

Boverton Redwood et al, "The Production of Alcohol for Power," Chemical Age, 1919, cited in Chemical Abstracts, 13:2271

H.R. Ricardo, "The Influence of Various Fuels on Engine Performance," Automobile Engineer, Feb., 1921.

R.R. Sayers, A.C. Fieldner, et al., "Experimental Studies on the Effect of Ethyl Gasoline and its Combustion Products," U.S. Bureau of Mines (Washington, D.C. U.S.GPO, 1927).

A.W. Scarratt, "The Carburetion of Alcohol," SAE Journal, April 1921.

G.J. Shave, "Fuel Mixtures on London Omnibuses," SAE Journal, Dec. 1920, p. 556.

Charles Simmonds, Alcohol: Its Production, Properties and Applications (London: Macmillan & Co., 1919).

Stanwood Sparrow et al., "Alcogas as Aviation Fuel Compared with Export Grade Gasoline," SAE Journal, June 1920, p.397.

Marjorie Smith, "Lead in History," in eds. Richard Lansdown and William Yule, Lead Toxicity: History and Environmental Impact, Johns Hopkins University Press, 1986.

Robert N. Tweedy, Industrial Alcohol (Dublin, Ireland: Plunkett House, 1917).

U.S. Dept. of Agriculture, C.E. Lucke, Columbia University, and S.M. Woodward, U.S.DA, "The Use of Alcohol and Gasoline in Farm Engines," U.S.D.A. Farmers Bulletin No. 277, (Washington: GPO, 1907).

U.S. Dept. of Agriculture, "On the use of Alcohol-Gasoline Mixtures with Motor Fuels," R.B. Gray, unpublished report of tests at Annapolis, April 1933 (National Agricultural Library, Beltsville, Md.).

U.S. Dept. of Commerce, World Trade in Gasoline, Bureau of Domestic & Foreign Commerce, Dept. of Commerce Trade Promotion Series No. 20, May 15, 1925.

U.S. Dept. of Interior, Robert M. Strong, "Commercial Deductions from Comparisons of Gasoline and Alcohol Tests on Internal Combustion Engines," U.S. Geological Survey, Bulletin 392, (Washington: GPO, 1909).

U.S. Dept. of Interior, R.M. Strong and Lauson Stone, "Comparative Fuel Values of Gasoline and Denatured Alcohol in Internal Combustion Engines," Bureau of Mines Bulletin No. 43, (Washington: GPO, 1918).

U.S. Public Health Service, Proceedings of a Conference to Determine Whether or Not There is a Public Health Question in the Manufacture, Distribution or use of Tetraethyl Lead Gasoline, U.S. Treasury Dept., PHS Bulletin No. 158, August 1925.

U.S. House of Representatives, Free Alcohol Hearings, House Ways & Means Committee, 59th Congress, Feb.-Mar. 1906.

U.S. Navy, Stanwood W. Sparrow, "Fuels for High Compression Engines," Report No. 232, U.S. Naval Advisory Committee for Aeronautics.

U.S. Senate, Free Alcohol Law, Senate Finance Committee Hearings on HR 24816, Feb. 1907, Doc. No. 362

U.S. Senate, Hearings on SB 522, Senate Finance Committee, May 1939.

U.S. Senate, "Utilization of Farm Crops," Hearings of a Subcommittee of the Committee on Agriculture and Forestry, United States Senate, S. Res. 224, (1942 - 1950).

U.S. Senate Finance Commitee, Hearings on HR 24816, "Free Alcohol Law," Feb. 1907, Doc.

No. 362.

U.S. Tariff Commission, Industrial Alcohol, War Changes in Industry Series, Report No. 2, (Washington, GPO: Jan. 1944).

Welsbach Gas Co., History of Light, Philadelphia Penn, 1909, Smithsonian Institution History of Advertising collection.

M.C. Whitaker, "Alcohol for Power," Chemists Club, New York, Sept. 30, 1925. Cited in Hixon, "use of Alcohol in Motor Fuels: Progress Report No. 6," Iowa State College, May 1, 1933.

Reynold Millard Wik, "Henry Ford's Science and Technology for Rural America," Technology and Culture, Summer 1963.

DOCUMENTS MISSING OR WITHHELD FROM ARCHIVES

"The Lead Diary," a collection of several thousand original documents from which T.A. Boyd and Charles Kettering refreshed their memories as their memoirs were written in the 1940s. Last reference is in "Green Book" histories by General Motors public affairs officers, 1950s. Unlikely to have been destroyed; probably still in headquarters offices of G.M.

Test diaries and day-to-day records of experiments conducted during 1920 - 22 period when tetraethyl lead was discovered by G.M. researchers in Dayton, Ohio.

Correspondence and submissions of members of the Surgeon General's Committee concerning alternatives to tetraethyl lead anti-knock agents. Fragments found in the Yale archives. Committee members specifically requested such files to be established at the Public Health Service; however, none are found in the U.S. National Archives.

Original 1922 - 23 correspondence to Midgley and Kettering from Krause, Hunt, Wilson, Henderson and others concerning the dangers of tetraethyl lead, some of which may have been in the Lead Diary.

Minutes of the Board of Directors of the Ethyl Corp 1924 to 1940.

Minutes of the "Medical Committee" of du Pont, G.M. and Standard, 1924 to 1925.

Records or memos concerning the deaths of two G.M. employees in Dayton, Ohio, April, 1924.

Telegrams exchanged between Charles Kettering in Paris and Ethyl Corp.headquarters in New York during Oct., 1924.

Du Pont study of resource base for pure ethyl alcohol fuel, 1919, cited in a memo by T.A. Boyd in 1921.

Reports of the Standard Oil Co.of New Jersey experiment with alcohol fuel blends in Baltimore, Md. in 1923 and (possibly) correspondence with G.M. researchers about the experiment.

Report on the use of the century plant in Mexico to produce alcohol at 7 cents per gallon, cited in 1922 memo from Midgley to Kettering.

Records or memos relating to "Synthol" experiments, Dayton G.M. labs, summer 1925.

Text

Appendix 6

Research Notes

6.1 Papers and interviews about leaded gasoline and biofuels by Bill Kovarik since 1993

Agenda Setting in the 1924 – 1926 Public Health Controversy over Ethyl (Leaded) Gasoline, AEJMC, 1994. One of the nations first controversies over public exposure to dangerous chemicals. The American oil industry, uncomfortable with even the mildest criticism, blamed the media for its own problems.

Charles F. Kettering and the 1921 Discovery of Tetraethyl Lead, Society of Automotive Engineers, 1994. Paving the way for non-petroleum alternatives (such as ethanol) was the "original special motive" for leaded gasoline.

Henry Ford, Charles Kettering and the Fuel of the Future, Society of Automotive Historians, May 1998. Based on a presentation to the SAH in 1995 on the 60th anniversary of the original Farm Chemurgy conference. Essentially, Ford supported biofuels as one economic component of value-added farm products; Kettering saw ethanol as improving octane and allowing engines to be more efficient.

Chemcases: Fuels and Society, NSF Funded chemistry education project, Kennesaw State University, 2001. The fuels section is one of several concerning scientific issues in modern culture and describes the steps leading up to and choices parallel to the introduction of leaded gasoline.

With Good Reason, interview, April 7, 2001. Virginia Public Radio.

ETHYL The 1920s Environmental Conflict Over Leaded Gasoline and Alternative Fuels, Paper to the American Society for Environmental History Annual Conference March 26-30, 2003 Providence, R.I.

Late Lessons, Early Warnings,Express TV (Denmark) – Award winning documentary has interview with Dr. Kovarik

Ethyl leaded gasoline: How a classic occupational disease became an international public health disaster, International Journal of Occupational and Environmental Health, October 2005.

(Based on 2003 ASEH paper).

Looking South:The world ethanol industry is booming – thanks to the Brazilian example, Com Ciência Ambiental (Sao Paulo, Brazil), winter 2007.

Ethanol's first century: Blending programs in Europe, Asia, Africa and Latin America, paper to the 30th International Symposium on Alcohol Fuel, Rio de Janeiro, Brazil, November 2006.

National Public Radio interview, Feb 15, 2007

Back to the Fuel of the Future, Life Sciences Symposium, University of Missouri, March, 2007.

Freedom Fuels, 2007, documentary about the history and need for biofuels.

Special Motives:Automotive Inventors and Alternative Fuels in the 1920s Paper to the Society for the History of Technology, Oct. 19, 2007

Biofuels: History and public debate,(Slide show) University of Maryland School of Public Policy, April 11, 2008

Biofuels in History, for World Cafe at Concordia University Montreal, Nov. 20, 2010 and Missouri School of Journalism, Food, Fuel and Society conference, Oct. 12, 2010.

National Public Radio interview, Dec. 21, 2010. http://wap.npr.org/story/132082560

European Environment Agency's "Late Lessons, Early Warnings" report, Jan. 23, 2013. See especially: Part A – Lessons from health hazards

Interview with The Tyee, April 10, 2013 http://thetyee.ca/News/2013/04/10/Plants-Into-Gas/

The history of biofuels – for CABI (Commonwealth Agricultural Bureau International) the international development information organization, published May 2013.

6.2 Further research needed

Many thousands of pages of historical documents are still privately held by the Ethyl Corp., Afton Chemical, New Market Corp., Exxon and General Motors, although many DuPont documents appear to have been released to the Hagley Library in Wilmington, Del.

The most important missing piece of the puzzle is The Lead Diary, a collection of several thousand original documents from which T.A. Boyd and Charles Kettering refreshed their memories as their memoirs were being written in the 1940s. The last reference to the Lead Diary is in the Green Book histories by General Motors public relations staff created in the 1950s. It is unlikely to have been destroyed; and probably is still in the archives of Ethyl or G.M.

Items missing or withheld from public archives include:

• The "Lead Diary" / several hundred linear feet of records (possibly 50 to 500 boxes of files) about fuels research from the DELCO / GM Dayton labs in the 1917 - 1950s time frame.
• Test diaries and day-to-day records of experiments conducted during 1920 – 22 period when tetraethyl lead was discovered by GM researchers in Dayton, Ohio.
• Correspondence with & from members of the Surgeon General¹s Committee concerning alternatives to tetraethyl lead anti-knock agents.
• Original 1922 – 23 correspondence to Midgley and Kettering from Krause, Hunt, Wilson, Henderson and others concerning the dangers of tetraethyl lead, some of which may have been in the Lead Diary.
• Minutes of the Board of Directors of the Ethyl Corp.
• Minutes of the Medical Committee of du Pont, G.M. and Standard.
• Records or memos concerning production issues in Dayton, Ohio, April, 1924.
• Telegrams exchanged between Charles Kettering in Paris and Ethyl Corp.headquarters in New York during Oct., 1924.
• Du Pont and other studies of the resource base for pure ethyl alcohol fuel and other high-quality fuel components. (One crucial 1919 study was cited in a memo by T.A. Boyd in 1921.)
• Reports of the Standard Oil and DuPont experiments.
• Memos from Midgley to Kettering about fuel additives, for example, "Synthol" experiments, Dayton G.M. labs, summer 1925.
• Records or memos of contacts with public officials , especially contacts with Treasury Secretary Mellon, with Surgeon General Cummings, and (then) Commerce Secretary Herbert Hoover.