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# HISTORY OF ETHYL CORPORATION
## 1923 - 1948

HISTORICAL SUMMARY

ETHYL CORPORATION

1923 - 1948

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## PREFACE

This draft is not complete and in some cases perhaps not accurate. It will be replaced at a later time by a finished manuscript. Corrections and suggestions, particularly additional facts that are not covered in this draft, will be welcomed.

PUBLIC RELATIONS DEPT.

## TABLE OF CONTENTS

# CHAPTER I

## An Idea That Nobody Wanted

The destiny of Ethyl Corporation was written between the lines of a patent granted to a distinguished German scientist 57 years before the company came into existence.

That patent, issued in 1867, granted Dr. Nicholas August Otto rights to his invention of the four-cycle compression engine--the invention which established the basic principle of internal combustion as it still is accepted. Dr. Otto's engine used an "outstroke" to draw charges of combustible gases into cylinders, the charges being "compressed by the instroke and then ignited." For what today we call satisfactory performance, it required that the "increase of pressure produced by the combustion (be) rendered gradual."

Following discovery of a way to hook the Otto engine to a buggy and thus make a self-propelled vehicle, the horseless carriage was born in 1896. As these "automobiles" were improved, adventuresome America offered its dollars for a ride and competing automotive engineers naturally sought to build ever better vehicles. Steam and electricity were used to provide power for some, it will be recalled. But the successful survivors had gasoline engines which employed the Otto principle. It was inevitable then that at some stage of progress in the development of the gasoline engine, engineers would overstep the limits of pressure which ordinary gasoline of that time could stand and still produce combustion "rendered gradual." It now seems just as inevitable that some engineer, upon realizing that the road to progress in automotive engine power was blocked by a whimsical characteristic of gasoline, would say: "We must find a way to prevent knocking."

But few heard the noise inside the engines as the knock of opportunity, and it remained for Charles F. Kettering, almost half a century after the Otto patent, to become the first man to seek the solution of the mystery of knock. Yet, the opportunity to develop or find a satisfactory antiknock agent was open to all. Mr. Kettering, in fact, issued such a call during a speech he delivered at the annual meeting of the Society of Automotive Engineers in New York in 1919.

Describing the work already done in the study of knock to overcome the shortcomings of ordinary gasoline, Mr. Kettering told the SAE members: "My idea has been to present this subject to you more as a means of stirring up your interest and exciting your curiosity than of supplying any fundamental engineering data."

No one else, however, accepted the challenge.

Under Mr. Kettering's aegis, Thomas Midgley, Jr. and his team of research men succeeded after long years in determining what causes knock in the gasoline-powered engine. Along with that knowledge they made what was described in a national magazine in 1942 as "the most important automotive discovery of the past 20 years." That discovery was tetraethyl lead as an agent that would effectively overcome knock in the internal combustion engine. Today, tetraethyl lead is known to motorists everywhere as the active ingredient of "Ethyl" antiknock compound or "Ethyl" fluid, as it is often called.

The painstaking and costly research that resulted in discovery of the knock-suppressing qualities of tetraethyl lead was begun a few years before the outbreak of the first World War. Just one indication of the strides that were to be made in the laboratory could be found in the fact that, of necessity, American combat planes in that war were flown on grades of gasoline far too inferior for automobile, truck, and bus engines of the modern day.

Even in the earliest days of the automobile, some automotive engineers realized that as the compression ratio of an engine was stepped up so, too, was its power output increased. But until 1912 no automobile had been marketed whose engine created more pressure and temperature than the gasoline of that day could stand without knocking. It happened that year in the Cadillac, however. The result was the "knock that was heard around the world."

Mr. Kettering's invention of the first practical electric self-starter was a standard equipment feature of the 1912 Cadillac. The starter and its accompanying battery ignition, another Kettering invention, were immediately blamed as the cause of the noisy and destructive bugbear.

Mr. Kettering did not then know what was responsible for the detonation in gasoline engines which came to be known as fuel knock, but he was certain his electric self-starter and battery ignition were not at fault. So he set out to prove his skeptics wrong--and at the same time answer the knock question.

He started his study on a specially-equipped 1912 Cadillac four-cylinder engine. At that time it was not generally recognized that the trouble rested with the fuel. Nearly everyone claimed it was "spark knock." Consequently, the first tests conducted were those employing all kinds of spark. But thin or heavy, the type of spark had no bearing on the presence or effects of knock except as related to ignition timing.

Mr. Kettering meanwhile had undertaken the development of a small engine and generator that could produce electric light for farms, country homes and other isolated buildings. This apparatus, called the Delco lighting unit, was rapidly becoming such an important project that Mr. Kettering found it necessary to devote his full attention to its further improvement. The knock testing engine and records were stored away in his office until such time as he could return to that problem.

Gasoline, of course, was the logical fuel to make the Delco lighting unit engines function to their full advantage, but the insurance underwriters' code prohibited the storage of more than a small amount of gasoline in private homes. Still, it was to private rural residents that Mr. Kettering hoped to sell his engine so that electricity might replace the old-fashioned kerosene lamp. The fire insurance restrictions forced him to decide on kerosene as the normal fuel for the engine. But, it turned out, the knock that was annoying him in automobile engines also cracked the cylinder heads and pistons of the Delco light plants when he ran them on kerosene. There was nothing to do but lower the compression--and thus reduce the efficiency--of the Delco engine so that it could burn kerosene without ill effects.

Once more the aggravating obstacle of knock had bobbed up in Mr. Kettering's path. That it had been encountered in two such comparatively unrelated power plants as an automobile engine and a stationary motor for generating electrical current loomed as proof that neither the automobile electric self-starter nor battery ignition was the cause of knock. Too, there now was more than a hint that fuel was the villain in the plot.

## CHAPTER II

## A Challenge Accepted

As his Delco lighting unit and electric self-starter grew into major business enterprises, Mr. Kettering found himself more than ever lacking the time to return to the study of knock.

But one day in June 1916, something happened that was to stir up the probe. At the time it seemed merely a routine event--the hiring of a laboratory assistant for the Dayton Research Laboratories Company which Mr. Kettering had just formed in Dayton, Ohio. However, the man engaged was to become one of the nation's foremost chemists of his generation. He was Thomas Midgley, Jr., a young mechanical engineer just a few years out of Cornell University.

Mr. Midgley was employed as the first technical member of Mr. Kettering's new Dayton laboratory. The association of these two creative men was to prove a long and fruitful one. Even after Mr. Kettering sold his laboratories to General Motors early in 1920, both he and Mr. Midgley continued the study of knock. Mr. Kettering was named director of the General Motors research organization and Mr. Midgley was appointed head of the laboratory group working on motor fuels.

(Mr. Kettering served General Motors as a vice president and as general manager of its Research Laboratories until June 2, 1947, when he announced his retirement. However, he remained with General Motors as a director and consultant, and with Ethyl Corporation as senior director.)

"Midge's" first assignment for "Boss Ket" was to perfect a built-in-hydrometer for indicating the degree of charge in the storage battery of the Delco lighting unit. When that project was finished, he asked Mr. Kettering what he should tackle next.

"Well," replied Mr. Kettering, "in my office you'll find a box of instruments. Let's set up one of those engines and go back and try to find out what really makes an engine knock. Now we know fuel has a lot to do with it. Let's get the instruments and start to work and see if we can determine what the thing is."

Mr. Midgley eagerly accepted the challenge. A makeshift knock research laboratory was set up in an old dwelling house in Dayton. T. A. Boyd, who in later years became head of the Organic Chemistry Department of the General Motors Research Laboratories, was assigned to work with Mr. Midgley. From time to time, other laboratory men were to aid in the project. Chief among these were Charles A. Thomas, Carroll A. Hochwalt, and James P. Andrew. Dr. Thomas, incidentally, served as president of the American Chemical Society in 1948, an office which Mr. Midgley held in 1944.

Mr. Midgley and the others realized that their job would be difficult and tedious. They never dreamed though that success was some five years away or that during those years they would spend tens of thousands of dollars to, as someone has put it, "stop a noise."

Their task was difficult in part because combustion in a cylinder occurs at high temperature and pressure--and within less than 1/100th of a second.

Mr. Midgley started his experiments by installing a quartz window in an additional spark plug opening of a laboratory test engine so that he could see, as well as hear, what took place. Through the window, a colored flame was seen during normal combustion, but a white flame showed through when knocking occurred. Since a white flame is hotter than a colored flame in most cases, it was apparent that high temperature, if not responsible for the motor noise, at least was a companion of knock.

Next, Mr. Midgley developed the optical indicator that bears his name. This is a high-speed recording device which shows the pressure curve inside a cylinder during the split-second of combustion. The Midgley indicator established, among other things, that knock and preignition were two entirely different phenomena in that the disturbance of knock came several degrees after the ignition spark. Indicator cards, the first of which was obtained November 16, 1916, plainly demonstrated the difference among normal combustion, genuine preignition, and knock.

Study of the graphs produced by the optical indicators showed the researchers that normal combustion was not an instantaneous explosion. Instead, the compressed mixture of fuel vapor and air, after being ignited by the spark plug, begins to spread out from the spark plug in a flame wave which moves across the combustion chamber until all the fuel is burned. From this normal combustion, the piston receives a smooth power thrust as if a mighty hand were inside the combustion chamber to push the piston down at just the right moment.

What happens when gasoline is not good enough for the engine in which it is being used is something else again.

In knocking combustion, the compressed mixture of fuel vapor and air starts to burn exactly the same as it does in normal combustion. The flame wave spreads through the combustion chamber until most of the fuel is ignited.



ETC 36600

But at this point, the similarity ends. Instead of the smooth flow of flame until the fuel is completely burned, the unburned portion of the fuel vapor and air mixture becomes heated and compressed due to the pressures and temperatures created by that part of the mixture which has burned. When the combination of pressure and temperature becomes too great for the gasoline to withstand, the entire last portion of the mixture blows spontaneously in a wild, almost instantaneous explosion. This explosion sets up violent vibrations in the compressed mixture. These vibrations, in turn, are transmitted to the cylinder head and other engine parts and are heard as a sharp metallic ping.

During knocking combustion, the pressure in the combustion chamber is developed so rapidly that the piston receives a suddenly-supplied hammer-like blow, in contrast to the smooth power push delivered in normal combustion. Obviously, the piston cannot move down fast enough to absorb this heavy blow. The result is that much of the energy from that portion of the gasoline which detonated is wasted in the form of heat. That is why engines usually lose power and overheat during prolonged detonation. More seriously, the high temperatures and suddenly-applied forces of detonation may crack and burn pistons, gaskets, and spark plug insulator noses.

The need then was for a gasoline additive that would control combustion so that the fuel vapor and air mixture could withstand high temperatures and pressures during combustion without detonation taking place. If such an additive could be found, the gasoline engine might be doubled or even tripled in power with no increase in size or weight. Little did the antiknock research pioneers realize the tremendous contribution they were to make to engine progress and to better living for everyone.

So it was that Messrs. Kettering, Midgley, Boyd and the others arrived at the first milestone in overcoming the motor noise. They had proved definitely that it is the fuel and not the engine that knocks!

In thinking about the different "coloring" of normal combustion as compared with knocking combustion, Mr. Kettering recalled that a little flower, the trailing arbutus, was often in bloom before the snow had left the ground. The reason, according to botanists, was that the back of the arbutus leaf, being red, absorbed heat. Mr. Kettering thus suggested that gasoline dyed a reddish color might absorb more heat and thereby avoid knock.

Red aniline dye was the natural choice for the color experiment but fate was present in the laboratory stockroom that day in the form of an absence of such a dye. Mr. Midgley then asked Fred L. Chase, an assistant chemist, if he could suggest a chemical that would both dissolve in gasoline and redden it. Mr. Chase took a hurried mental inventory of the bottles on the shelves and finally reached for a container of violet-red crystals. What he handed Mr. Midgley was a bottle of iodine, the same chemical that is dissolved in alcohol to make the tincture of iodine so often used for painting cuts and wounds.

Back at the test engine, Mr. Midgley added enough iodine to the gasoline to turn it deep brownish red. As if by magic, the detonation ceased. A knock-suppressor had been discovered! No antiknock research files were kept until the fall of 1917, but the reported date of the discovery of iodine as an antiknock was December 2, 1916.

However, the joy of that day in the Dayton laboratory was short-lived. Iodine was a knock-suppressor beyond a doubt, but it required only simple mathematics to conclude that its high cost would add too much to the price of a gallon of gasoline.

A few days later, the theory that a dark color might absorb heat in such a way as to eliminate knock was shattered through unsuccessful tests employing several different oil soluble aniline dyes. But while these dyes failed to reduce the fuel knock, they did serve to spotlight a vital factor--it was a peculiar chemical effect of iodine, and not its coloring, that made it an antiknock. Could not some other chemical, or chemicals, stop knock?

At this point, the United States had entered World War I and Mr. Kettering's laboratory diverted its attention from the general study of knock to an urgent wartime assignment. (The name of the organization was changed at this time from the Dayton Research Laboratories Company to the Research Division of the Dayton Metal Products Company, a firm which Mr. Kettering also owned.) In cooperation with the Bureau of Mines, and with the moral and financial support of the War Department, Messrs. Midgley and Boyd and their associates were asked to develop an aviation fuel much freer of knock than the 55-octane (present-day equivalent) gasoline then in use.

The investigation that followed revealed for the first time that the behavior of a fuel in respect to knock is controlled by the molecular structure of the components of a fuel; not by physical characteristics, such as gravity and volatility, as had been supposed. Further, the experiments showed that improved aviation gasoline of the needed chemical composition could not be obtained from natural sources. Consequently, an intensive effort was made to produce a suitable fuel by synthetic means.

On the basis of information of this research, it was decided to try a mixture of cyclohexane and benzene. This mixture proved comparatively free from knock and gave promise that it could be manufactured in quantity.

After overcoming several obstacles, such as the destructive effect of sulfur on the nickel catalyst, several hundred gallons of the synthetic fuel were produced for a series of flight, ground, and dynamometer tests. The synthetic fuel was found to permit the compression of airplane engines to be boosted from the 5.5 to 1 then generally used to about 8 to 1.

Government orders to build a plant to manufacture the improved aviation fuel were issued, but the construction plan was dropped a few days afterward with the signing of the Armistice.

(Another wartime project to which Mr. Midgley contributed was an aerial torpedo, similar to the German buzz bomb of World War II. The aerial torpedo was never used in combat because, again, the Armistice was signed before mass production could get under way.)

Although it was never put to practical use, Mr. Midgley's mixture of 70 parts cyclohexane and 30 parts benzene represented the first synthetic "high octane" aviation fuel ever made.

His development of this fuel, plus the earlier discovery that iodine---a chemical element---would change the tendency of gasoline to knock, had a profound effect on Tom Midgley's professional interests. He turned now entirely to the endeavors that were to win him honors as one of the greatest chemists of his day.

## CHAPTER III

### The Antiknock Discovered

Determined to learn chemistry "on the run," as he himself put it, Mr. Midgley began his career as a chemist by taking up once more the search for a chemical antiknock agent. The goal was clear now. Success would permit further progress in automotive engine design. Failure meant that General Motors would be stymied for want of better fuels to match better engines.

The antiknock research, which had been suspended in favor of the development of the synthetic aviation fuel, was resumed in the middle of December 1918. Six weeks later, on January 30, 1919, the observation, or discovery, that aniline was a knock-suppressor superior to iodine was made.

This was an important discovery in more ways than one, for it probably precluded premature abandonment of the search for a practical antiknock agent. Only two days before the value of aniline was noted, instructions had been issued that the laboratory would give up its antiknock research if there were no new developments during the succeeding 14 days. This was but one of many occasions in which the element of luck cropped up during the several years of antiknock laboratory work.

But luck of a reverse order visited the men in Dayton only a couple of weeks after their discovery of the knock-suppression qualities of aniline. On February 13 and 14, 1919, they came so near, and yet so far, from discovering the miraculous antiknock properties of tetraethyl lead almost three years ahead of time. An attempt was made to prepare an alkyl compound of lead in order to obtain an oil soluble compound to test the antiknock effectiveness of lead. First, Mr. Midgley and his co-workers produced a small amount of lead-sodium alloy by means of fusing the two metals together in a metallurgical muffle furnace. The alloy was then heated for a time in a flask with ethyl bromide, after which the ethyl bromide was distilled off and the residue extracted with ether.

No ethyl lead was obtained on that occasion. Although the reasons were not clear then, it is now known why. Some ethyl lead almost certainly would have resulted had the research crew employed ethyl iodide instead of ethyl bromide (which needs a catalyst to make it react), and if the lead-sodium alloy had been extracted with wet ether or if plain water had been added and the ethyl bromide then distilled out in the presence of steam.

There were at least two good reasons why no further attempt was made to prepare ethyl lead at that time: (1) The muffle furnace became disabled, and (2) there was no particular reason to believe that tetraethyl lead possessed the powerful antiknock qualities it is now known to have.

The aniline discovery was pursued vigorously in the laboratory for the next couple of years. So convinced were the research men of the practicability of aniline as a commercial antiknock that manufacturing and marketing plans were seriously discussed. Too, much of the work during the last half of 1920 and early 1921 leaned toward the development of an aniline injector. This was a mechanical attachment for supplying the proper amount of the aniline antiknock compound to gasoline as the fuel was consumed by a vehicle. It was estimated that injecting aniline into the fuel only when the vehicle was being operated at full, or nearly full, throttle would require but one-tenth the aniline demanded by a car using it at all speeds. Mr. Midgley obtained a patent on an aniline injector he had invented, but the device was never marketed.

The reason the injector was never commercialized was that continuing tests with aniline and aniline compounds indicated more and more that the best answer to fuel knock still had not been found. The biggest obstacle was the disagreeable exhaust odor given off by the unburned, or partially burned, aniline. Mr. Midgley expressed himself as doubtful if "humanity, even to doubling their fuel economy, will put up with this smell."

In two years from the time aniline as an antiknock was discovered until the decision to abandon it was reached--early 1919 to early 1921--three other noteworthy events took place:

1. On February 27, 1920, an Army major, R. W. Schroeder, of McCook Field, Ohio, reached the then exceedingly high altitude of 36,020 feet on a flight with a fuel that contained xylidine, a knock-suppressor supplied by Mr. Kettering's laboratory. This is the first recorded use of an antiknock agent by the American military.

2. In March 1920, Mr. Midgley and Mr. Boyd developed a system of demonstrating detonation in a glass tube--a demonstration that is still employed in some Ethyl Corporation shows and exhibits. This effective experiment was originally prepared for use by Mr. Midgley in talks before the Dayton Engineer's Club on March 16, 1920, and later before a group in Buffalo, New York. After a dismal beginning--it failed completely at the Dayton Engineers Club meeting--the demonstration has amazed thousands of persons who have viewed it during the past three decades.

3. In March 1920, General Motors Corporation purchased and assumed control of the various Dayton interests of Mr. Kettering and those associated with him. As part of the agreement, "Boss Ket" was to organize and dir-

ect a pioneering research laboratory for General Motors, using the personnel of the Research Division of the Dayton Metal Products Company as a nucleus. The General Motors Research Laboratories "set up shop" in Moraine City, near Dayton, in the spring of 1920 and were incorporated on June 12 of that year.

Early in 1921, when it was realized that aniline would not prove a successful commerical antiknock, the spirits of the men in the laboratory ebbed to a new low. There was renewed talk of abandoning the antiknock research. Even Mr. Midgley, a patient and tireless worker, suggested that it might not be worthwhile to pursue the endeavor much longer.

But again, luck or fate or destiny stepped in. Tests on April 11, 1921, disclosed that selenium oxychloride, a compound of selenium, was an exceedingly more effective antiknock agent than anything discovered heretofore. In turn, its discovery led, two days later, to an alkyl compound of the similar element, tellurium. This compound, diethyl telluride, proved to be about 20 times superior in antiknock value to aniline.

Effective as it was, the tellurium compound had an outstanding drawback, as the research men found out much to their personal embarrassment.

Tellurium bore a pungent garlic-like odor. Although the laboratory workers were so accustomed to bad chemical smells by now that they could not detect the offensive odor about each other, their families and friends refused to approach them any closer than six feet.

"Going out at night was a problem," Mr. Midgley later recalled, "but I found one neat solution. When we went to the movies, I would look around until I found a man of foreign extraction, and we would sit down beside him. Presently people would scowl at him from all directions as they got my perfume, but we were secure and comfortable."

With discovery of the remarkable knock-suppressing qualities of the various selenium and tellurium compounds later tested, a bright new avenue of investigation stretched before the laboratory crew which only a week or two before had been so discouraged and disappointed. Taken together with the information already obtained on compounds of iodine and nitrogen, and then viewed in the light of a special periodic arrangement of the elements to which the researchers had access, the discovery of the effects of selenium and tellurium strongly indicated that the antiknock property might be a period function.

The special arrangement of the Langmuir-Lewis Theory of Atomic Structure had been prepared by Dr. Robert E. Wilson, now board chairman of Standard Oil Company (Indiana) but then director of the Research Laboratory of Applied Chemistry at Massachusetts Institute of Technology.

(It was a significant coincidence that Mr. Midgley and Dr. Wilson should have shared in the search for a successful commercial antiknock. Not only were both born in Beaver Falls, Pennsylvania, but they were delivered by the same physician. They also had used the same folding bed in early childhood. When Mr. Midgley was four years old, his parents moved to Trenton, New Jersey. Before leaving Beaver Falls, they sold to their townsfolk, the Wilsons, for use by infant Bob, the collapsible bed that had cradled their own offspring).

How Mr. Midgley happened to know of the Periodic Table is an interesting story. He was first introduced to this indispensable working chart of the laboratory in the 1900s while a student at Betts Academy in Stamford, Connecticut, preparing to enter Cornell. The instructor, Prof. H. M. Robert, described the Table and advanced the thought that this regular arrangement of the atoms was evidence of the existence of God. In Mr. Midgley's own words, "I disagreed and we argued." Young Tom contended that the grouping of the atoms indicated only that the atoms were made up of still smaller particles. The "argument" between teacher and student continued all the time that Mr. Midgley remained under Prof. Robert's tutelage, and served to impress a knowledge of the Periodic Table upon the mind of the young student. It was later described by Mr. Midgley as "one of those peculiar incidents...which was destined to be of great value to me later on."

About the same time the decision to follow the guide posts of the atomic chart was reached, Mr. Midgley and Mr. Boyd succeeded in August 1921 in perfecting the bouncing pin indicator, a knock-rating piece of equipment that was attached to the Midgley optical indicator. The bouncing pin, called a "diddle pin" by its creator, had been conceived outside the General Motors Laboratories as a device merely for establishing or detecting the presence of knock. By their perfections, Messrs. Midgley and Boyd converted it into an instrument for measuring the degree of knock.

Employing the bouncing pin indicator, the research men began to rate the several compounds that were prepared during the summer of 1921 for use in investigating the periodic function of the elements in respect to their effect upon fuel knock. Previous records and experience caused the laboratory workers to center their investigation in the first four groups of elements at the extreme right in the lower grouping of Dr. Wilson's special periodic system arrangement. The four groups were Carbon, Nitrogen, Oxygen, and Fluorine. All compounds tested were the ethyl, amyl, or phenyl compounds of the respective elements.

By October 28, 1921, the studies had reached the point where tetraethyl tin was to be rated. Tin, the first element in the Carbon Group to be tested, proved to be a highly effective knock-suppressor, despite the fact that it was found to induce preignition.

Following the encouraging tests with tetraethyl tin, Mr. Midgley instructed the research crew to evaluate tetraethyl lead, since lead is the element immediately below tin in the Carbon Group.

The first tetraethyl lead exploratory test was conducted a few weeks before Christmas 1921 by Messrs. Boyd and Hochwalt. Results were instantaneous. Mr. Midgley was in New York that day, but rushed back to Dayton upon receipt of an enthusiastic telegram from the laboratory.

The group double-checked the trial run on the following day, December 9. There was great excitement as Mr. Midgley started the engine. Again tetraethyl lead quickly stopped the metallic jangle of the ear-splitting knock. Those who were working on the problem actually "danced a non-scientific jig around the laboratory."

A solution of one percent tetraethyl lead by volume in kerosene was originally prepared for the test. Kerosene, rather than gasoline, was employed in the various antiknock research ratings for two reasons: It was more prone to knock than gasoline, and it gave more uniform performance in the Delco experimental engines than did some gasolines. The idea was to compare the one percent tetraethyl lead solution with bracketing reference fuels of two percent aniline in kerosene and one persent aniline in kerosene.

But, from the outset, it was obvious that the tetraethyl lead mixture was much too free from knock to be matched with the aniline solutions. By diluting the original mixture, successively weaker solutions of tetraethyl lead were readied and tested. Finally, it was decided that a solution containing but 1/40th of one percent of tetraethyl lead in kerosene could be closely compared with the two aniline reference fuels. Quantitative ratings employing the bouncing pin indicator bore out this observation, revealing that the 1/40th of one percent of tetraethyl lead in kerosene was equivalent to 1.3 percent aniline in kerosene. Further checks demonstrated the astounding fact that tetraethyl lead was by volume a knock-suppressor 50 times more powerful than aniline. And aniline was the very chemical which Mr. Kettering's laboratory at one time had believed might be the best commercial antiknock that could be developed.

At last, after more than five years of experiments with countless chemicals and chemical compounds, as well as many metallic materials, the laboratory crew had found success.

The goal had been reached. Some 143 other knock-preventives had been noted along the way (as well as 31 materials and compounds that would induce knock), but none could compare with tetraethyl lead. This superiority still holds true today. Millions of dollars spent in research and product development have made it possible to improve the "Ethyl" antiknock compound formula from time to time, but always tetraethyl lead has remained the prime ingredient of the product.

Tetraethyl lead, as a chemical, was discovered in 1854. Tetraethyl lead, as an antiknock agent, was discovered on December 9, 1921.

The mere discovery of tetraethyl lead as an antiknock did not, however, solve all the problems. Its use was found to leave a deposit of grayish-yellow oxide of lead in the engine cylinders. The next job for research, therefore, was to find a substance which would unite with the lead molecules in the air-fuel mixture during combustion before they combined with oxygen, and then carry them off in the exhaust gases.

Compared to the years spent seeking the satisfactory antiknock agent, solution of this latter problem was a relatively short, albeit far from simple task.

Beginning at the logical starting point, Mr. Midgley and his associates sought a chemical which, when mixed with tetraethyl lead, would change the grayish-yellow oxide of lead into something else. Such a chemical seemed to be carbon tetrachloride--the liquid used in fire extinguishers--since it could change the lead oxide into lead chloride. This proved to be a satisfactory agent, but it was felt that a still better "scavenger" might be obtained.

Since chlorine and bromine belong to the same chemical family, the next step was to try a bromine compound. Here was a more successful antidote. When mixed in proper proportion with a compound of bromine, tetraethyl lead combined with the bromine to form a gas that was blown out the exhaust pipe of the vehicle without building up objectionable engine residue.

On April 15, 1922, four months after discovery of the supreme antiknock agent, application was made for a United States patent covering the use of tetraethyl lead in motor fuels. This patent was granted February 23, 1926. Later patents covered other ingredients necessary to form a successful antiknock compound, and a better manufacturing method which was invented by Drs. Kraus and Callis. The Kraus-Callis manufacturing patent expired at midnight December 31, 1947, at which time a competitor company (DuPont) entered the tetraethyl lead antiknock field. Until then, Ethyl Corporation had held a legal patent monopoly. The company was ever-mindful of its privileged status, and takes pride in the fact that it exercised its patent rights to the benefit of all.

The use of "Ethyl" antiknock compound containing tetraethyl lead has done more than overcome the handicap of knock. It has enabled petroleum refiners to produce superior gasoline in large quantities. This, in turn, has made possible the design of engines that give greater power per pound of weight and per gallon of gasoline consumed. As a result of the better engines and better fuels, motorists today realize 50 percent more value from a gallon of gasoline than they did 25 years ago--and at a saving of one billion dollars a year in their motor fuel bill. (On the basis of 1950 figures, it was estimated that the nation's annual consumption of motor gasoline would be more than five billion gallons greater if tetraethyl lead antiknock compound were not available.)

Recent estimates indicate that the use of tetraethyl lead antiknock compounds may save the world as much as a billion dollars annually in the production of the high octane gasoline needed to meet the demands of the modern high compression engine. Within limits, it is the cheapest method available to the refining industry for increasing the octane number of gasoline. Further than that, "Ethyl" antiknock fluid is an extremely flexible tool. It permits the balancing of day-by-day octane variation in gasoline runs to desired levels; it helps meet fluctuations in refining operation; and it aids in meeting market requirements, since it can be added to improve quality after the gasoline is made.

Mr. Kettering in 1948 figured that "Ethyl" antiknock compound conserved more than one billion barrels of crude oil during the first 25 years it was on the market. That is an amount nearly equal to the cumulative crude petroleum production of Pennsylvania from the time oil was first discovered there in 1859 through 1947. On 1948's market the saving was equal to two and a half billion dollars worth of oil.

## CHAPTER IV

### Tom Midgley--Creator, Genius

It has been said of Thomas Midgley, Jr., that to base his fame primarily on the discovery of tetraethyl lead as an antiknock is to do him a great injustice. He was, in addition, inventor of the Freons, the non-toxic, non-inflammable refrigerants that were a boon to refrigeration and air conditioning. He pioneered in the research of chemistry of rubber. He contributed to the development of a method of extracting bromine from sea water.

For these accomplishments, Mr. Midgley was awarded the most coveted medals in the field of American chemistry, the only man to be honored with all of the following: The Nichols medal from the New York Section of the American Chemical Society in 1923, the Longstreth medal from the Franklin Institute in Philadelphia in 1925, the Perkin medal from the Society of the Chemical Industry in 1937, the Priestley medal from the American Chemical Society in 1941, and the Willard Gibbs medal from the Chicago Section of the American Chemical Society in 1942. In addition, he received honorary Doctor of Science degrees from Wooster College and Ohio State University.

Mr. Midgley died at his home in Worthington, Ohio, on November 2, 1944, three years after an attack of poliomyelitis that had deprived him of the use of his legs. He was 56. He had been chairman of the board of the American Chemical Society since 1934 and at the time of death was president of the Society as well--the first time that both offices had been filled by the same man. Mr. Midgley had served as a vice president of Ethyl Corporation and the Ethyl-Dow Chemical Company, both of which enterprises came into being as a result of his successful probe into the cause of knock and its remedy. He was also vice president of Kinetic Chemicals, Inc., which was formed after his invention of the Freons.

Of Mr. Midgley, a fellow-chemist once declared: "Through experience, the layman will also attest his indebtedness to one who has contributed so greatly to more pleasant and efficient living. He (Midgley) has made science a liberator, and we rejoice with him in the satisfaction that must be his in seeing the fruits of his labor. Posterity will acknowledge their permanent value."

The logical conclusion of this chapter was stated by Mr. Midgley himself in 1939. In that year, he delivered a paper which set forth as these the benefits and values of his most famous discovery:

> Tetraethyl lead broke down one of the barriers that was blocking the road to automotive progress--the barrier of knock.
>
> It has thus added to the power and performance of over 50 million automobiles.
>
> It has contributed to the constant improvements in quality and the steadily decreasing price of billions of gallons of gasoline annually.
>
> It has strengthened our national defense.
>
> It has made possible the present peaks in performance of airplanes.
>
> It has lowered costs in power farming and truck transport.
>
> It has caused the construction of millions of dollars worth of factories, laboratories, transportation and blending facil-

ities, for its manufacture, distribution and use.

It has given temporary and permanent employment to many.

It has uncovered fresh sources of mineral wealth by "mining" the waters of the ocean successfully.

It has aided oil companies in the conservation of petroleum in their gasoline refining processes.

It has paid taxes toward the support of the government.

It has made a profit for those corporations that had the courage to go through a long and difficult "shirt-losing period" because they believed that antiknock gasoline would eventually succeed.

# CHAPTER V

## "Ethyl" Goes To Market

With discovery of the antiknock agent so direly needed for automotive transportation advancement, it might seem that all that remained was to put the product on the market and let it sell itself. It was not so easy or simple as all that. At least five thorny and immediate problems had to be ironed out before the compound could be considered a saleable product:

1. The most efficient formula for employing the antiknock fluid in gasoline had to be prepared. This meant, for one thing, putting automobiles to road tests covering thousands of miles, and operating engines on dynamometer stands for hundreds of hours. Such exhaustive tests were necessary to determine what type and quality of fuel would operate the automotive engines of the day most efficiently.

2. Certain measures had to be taken to overcome the engine deposits that would be built up through long and continued use of fuels which contained the antiknock compound. It was known that a bromine compound could be mixed with tetraethyl lead to accomplish the desired result, but 10 to 20 times the prevailing total of world production of bromine would be needed if any substantial portion of the nation's motor fuel was to be improved by the antiknock compound.

3. A practical and economical method of manufacturing the product had to be evolved.

4. Tetraethyl lead was a success in the laboratory, but it had yet to show that it could perform equally as well or better in cars on the road.

5. Motorists, not to mention the automotive and petroleum industries, had to be convinced of the advantages of gasoline containing the tetraethyl lead compound.

Despite these problems, it was only slightly more than a year after the discovery of the antiknock qualities of tetraethyl lead that "Ethyl" gasoline was offered to the public. (One of the reasons for the decision to market the product at that time undoubtedly was an encouraging letter received in September 1922 from Harry Spears, of the Spears and Riddle Company, West Virginia jobbers. Mr. Spears pointed out that he had read of the new antiknock development in the August 1922 issue of Motor, and asked that his company be allowed to market the compound in its sales area once tetraethyl lead was commercialized. This request was honored in 1923, when Spears and Riddle became one of three companies that distributed the product in its first year).

"Ethyl" gasoline was initially sold at a Refiners Oil Company station located at the corner of Main and Sixth Streets in downtown Dayton. The first public purchase was made on the wintry morning of February 2, 1923, by a Dayton motorist, F. M. (Mike) Redelle. To advertise the new product, the service station hung out a wooden sign which read:

| | |
|---|---|
| ETHYL GAS | ANTI-KNOCK GASOLINE |
| Product of the General Motors Research Corporation | |

On the face of the globe atop the vending pump were the words "ETHYL GASOLINE" in the center, with "The General Motors Research Corporation" arranged in a circle around the outer rim of the illuminated face.



ETC 36619

As new as it was then, "Ethyl" gasoline was no stranger to Mr. Redelle. He was recreation manager for General Motors in Dayton, and often had discussed the new product with friends at the General Motors Research Corporation laboratory. Mr. Redelle also had been among the few adventurous Daytonians who loaned their automobiles as wheeled "guinea pigs" to test gasoline treated with the various antiknock combinations formulated in the laboratory.

Sales moved slowly the first day, but on the second day, following the appearance of a news item about the new product in the Dayton newspapers, more than 400 gallons of "Ethyl" gasoline were dispensed from the single pump at the single service station where it was then available. In all, some 8,375 gallons were publicly sold during February 1923. The following month's sales fell off to 4,175 gallons, but an increase to 6,187 gallons was recorded in April.

With "Ethyl" thus formally on the market, it was decided that a special company should be formed to direct the manufacture and distribution of the product, since this was not a normal function of the General Motors Research Corporation. This was accomplished on March 7, 1923, when the General Motors Chemical Company was organized as a wholly-owned subsidiary of General Motors Corporation. Mr. Kettering was named president and Mr. Midgley general manager of the new company.

It is interesting to note that the very first "Ethyl" gasoline sold contained an antiknock mixture of seven grams of lead triethylbromide and 1.5 grams of carbon tetrachloride. This additive had been made by dissolving in benzol enough lead triethylbromide and carbon tetrachloride to treat 1,000 gallons of gasoline. The first of seven "Ethyl" antiknock compound formula improvements that have been effected through the years occured during the second month of "Ethyl" gasoline sales.

Late in February 1923, Mr. Midgley, then vacationing in Miami Beach, sent this telegram to Mr. Boyd at the General Motors research laboratory: "Suggest you try three cubic centimeters tetraethyl lead and two cubic centimeters carbon tetrachloride per gallon in the Buick for 2,000 miles." Mr. Midgley explained in another wire the next day that his reason for making this suggestion was "to replace the bromide in it (the antiknock compound) if humanly possible to do so and as quickly as possible. This would mean quick production and reduced cost, both of which are needed."

The test car was run not for 2,000 miles, but for 8,500 miles. Results indicated that Mr. Midgley's suggested mixture of three parts by volume of tetraethyl lead and two parts by volume of carbon tetrachloride would prove a more effective knock-reducer than the original lead triethylbromide and carbon tetrachloride compound. The effort to improve the tetraethyl lead antiknock compound ever since its discovery has been continuous, and is still one of the prime objectives of Ethyl Corporation research.

Not long after Mr. Redelle made the first purchase of "Ethyl" gasoline, another motorist of note in Ethyl Corporation annals drove into the same Dayton service station at Main and Sixth Streets and asked for a tankful of the new fuel. His Model T had knocked like the seven furies driving down Main Street, but the noise vanished when he drove away on "Ethyl" gasoline.

The duly-impressed motorist was Fred Lewis, garage superintendent of the Dayton Power and Light Company. He was supervisor of a fleet of 65 vehicles.

When Mr. Lewis told O. B. Reemelin, general superintendent of the utility, about the new antiknock compound, Mr. Reemelin wanted to know who made "this stuff." Mr. Lewis replied: "Tom Midgley and Charley Kettering are behind it. It's sold by the General Motors Chemical Company."

"Must be all right then," Mr. Reemelin remarked. "I know Midgley. I'll call him up."

Messrs. Reemelin and Midgley had lunch together the next day. By the time dessert was served, Mr. Reemelin had agreed to the use of his company's fleet as a "proving ground" for the new and various antiknock mixes as they came out of the laboratory. Both sides enjoyed obvious benefits from this arrangement. The utility received an assured supply of superior gasoline, while the new antiknock company acquired a "test fleet." Too, the use of the additive by a major concern caused oil companies to take a deeper interest in the newborn product.

Today, the Dayton Power and Light Company is the world's oldest fleet user of high octane gasoline. It began using "Ethyl" gasoline on June 1, 1923 and has run its vehicles on lead-treated fuels ever since.

As other service stations started selling the new fuel the advantages of "Ethyl" gasoline were discussed and passed along from motorist to motorist. "It stops knock." "More power on hills." "Doesn't heat up the engine." These were the comments of enthused car owners.

By mid-summer 1923, "Ethyl" gasoline was on sale at a number of Refiners Oil Company stations throughout Ohio, principally in Dayton and Cincinnati. A few months later, Standard Oil Company (Indiana) entered into a contract with the General Motors Chemical Company for the exclusive sale of "Ethyl" gasoline throughout Standard's 10-state marketing territory. This contract, the first with a major oil company, was executed September 29, 1923. In addition to

Refiners and Standard of Indiana, a third company, Spears and Riddle, also distributed "Ethyl" gasoline in 1923, as has been noted.

The summer 1923 sales were supported by the first advertising ever placed on behalf of "Ethyl" gasoline. A series of advertisements, issued in the name of the General Motors Chemical Company, appeared in the Cincinnati and Dayton newspapers beginning in May of that year. In addition to describing "Ethyl" gasoline and its advantages, the ads also featured a reproduction of the Ethyl emblem, or trade-mark design, similar to that used today. The original emblem was conceived and sketched by Henry Ewald of the Campbell-Ewald Company in Detroit, the advertising agency which handled the initial "Ethyl" gasoline advertising campaign.

Gasoline containing "Ethyl" antiknock compound was subjected to its first spectacular demonstration before the general public during the famous Indianapolis 500-mile automobile race on Memorial Day 1924. Seven of the 20 drivers competed in racers powered by "Ethyl" gasoline. When the hours of gruelling pounding around the brick oval were finished, the first three places had been won by cars that had extra-strength "Ethyl" gasoline in their tanks.

The tetraethyl lead which went into "Ethyl" antiknock compound for the early sales tests and demonstrations was manufactured by the so-called ethyl bromide process developed by tetraethyl lead research men at the M. I. T. laboratory. Under this method, tetraethyl lead was produced by reacting an alloy of metallic lead and sodium with ethyl bromide at atmospheric pressure.

A license to E. I. duPont de Nemours to manufacture tetraethyl lead for General Motors by this process was signed, providing for the construction at Deepwater, New Jersey, of a plant capable of manufacturing 1, 300 pounds of tetraethyl lead per day. (For a number of years, until 1937, all tetraethyl lead used in "Ethyl" antiknock compound was manufactured at Deepwater. By that time, additional capacity was needed. Baton Rouge, Louisiana, was selected as the site of the new Ethyl Corporation plant, which since has grown into the largest of its kind in the world).

At the outset, the tetraethyl lead was shipped from Deepwater to the General Motors Chemical Company at Moraine City, where it was blended with other ingredients to form "Ethyl" antiknock compound. The blending and canning plant at the Moraine City laboratory went into service about August 1, 1923 with a capacity of 160 gallons of "Ethyl" fluid per day. Later, the blending and packaging activities were transferred to the manufacturing plant at Deepwater.

Unlike now, when it is blended with gasoline at the refinery, "Ethyl" fluid in the early days was shipped directly to service stations in small metal containers. These were called methyliters and held one liter of the compound. The methyliters were attached to the service station pump and the additive then was introduced in the fuel as the gasoline flowed into the tank of a vehicle. If a motorist wanted regular gasoline, the service station attendant merely pumped out the straight fuel. For customers who specified "Ethyl" gasoline, the dispenser was operated so that drops of the antiknock compound were mixed with the fuel as it was delivered. There were about 17,000 methyliters or similar devices in use when this method of adding the antiknock compound to gasoline was discontinued early in 1925.

## CHAPTER VI

### Ethyl Corporation Is Born

The price of the first tetraethyl lead manufactured under contract for General Motors was $2.00 per pound. The antiknock compound was sold to oil companies at one cent per cubic centimeter of tetraethyl lead content. Nothing was charged for the other ingredients, which comprised one-third of the finished product. Hope for reasonable profit was placed in the expectation of lower manufacturing costs.

Through the years, manufacturing costs did decline sufficiently to bring about a profit and at the same time allow a series of reductions in the selling price of "Ethyl" antiknock compound. (At the end of 1950, oil companies were purchasing "Ethyl" antiknock compound for less than a fourth of the original price.)

It was, in fact, the discovery of a process by which tetraethyl lead could be made less expensively that led directly to formation of the Ethyl Corporation.

Among other groups which, along with General Motors, had been active in tetraethyl lead production research was the Standard Oil Company of New Jersey. The Jersey company entered into a contract on January 7, 1924, with the General Motors Chemical Company for addition of "Ethyl" antiknock compound to its best grade of gasoline for initial distribution in the District of Columbia-Baltimore area. Before then, however, Standard's consulting chemists had found a cheaper way to produce tetraethyl lead. This was by reacting the lead-sodium alloy with ethyl chloride at high pressure, rather than with ethyl bromide at atmospheric pressure. Dr. C. A. Kraus and Dr. Conrall C. Callis evolved the new method of manufacture, which is referred to interchangeably as the Kraus-Callis process or the ethyl chloride process.

Dr. Kraus had been a Standard of Jersey consultant in chemistry since 1921 and still serves in that capacity. Presently, he also is emeritus professor of chemistry at Brown University. Dr. Callis had studied under Dr. Kraus while earning his degree at Clark University in Worcester, Mass.

The research that led to their discovery was conducted at Clark. The university, however, had no connection with the research beyond the loan of its laboratory facilities. Drs. Kraus and Callis made their own test apparatus.

Following announcement by Standard that it had discovered a cheaper way of producing tetraethyl lead, a merger of ideas was discussed by General Motors and Standard Oil Company of New Jersey as the logical means of conveying the full advantages of both discoveries to the general public. General Motors and Standard decided not to market the antiknock compound directly but to form a jointly-owned company for this purpose.

The company thus born was the Ethyl Gasoline Corporation. It was incorporated August 18, 1924, in the State of Delaware, with authorized stock of five million dollars, divided into 50,000 shares of $100 par value each. General Motors and Standard Oil Company (N.J.) each subscribed to and now own 7,500 shares of common stock at par, the only common stock issued. The new company was assigned the rights to the General Motors and Standard of Jersey patents in the field of antiknocks and also acquired all assets of General Motors Chemical Company. The purchase of the Chemical Company, for $407,000, included full rights to the trade-mark established by General Motors for the antiknock compound and "Ethyl" gasoline, and to the trade name "Ethyl." Use of "Ethyl" as a trade name had been granted General Motors Chemical Company by the U. S. Patent Office on August 5, 1924.

(While the word "ethyl" is a common prefix and suffix in chemistry, standing for the radical $C_2H_5$, there is no use of "ethyl" as the name of any substance alone in chemistry, since $C_2H_5$ does not exist except as attached to some other chemical radical to designate such compounds as ethyl alcohol, ethyl ether, tetraethyl lead, triethylamine, etc. Thus, the legal basis for securing trademarks was that "ethyl" is not a whole substance or complete chemical compound, nor a definitive or descriptive word when standing alone, except as it is given meaning by its use as a trade name by the Ethyl Corporation).

Within 10 days after its incorporation, the Ethyl Gasoline Corporation had chosen a 10-man board of directors and the company's first officers. It was decided that the board would consist of an even number of persons, and that each of the parent companies would elect half of the members. The original board, selected August 20, 1924, was composed of Messrs, Donaldson Brown, Kettering, Midgley, Alfred P. Sloan, Jr., and John Thomas Smith, for General Motors; and Messrs. E. M. Clark, Frank A. Howard, Arch M. Maxwell, James A. Moffett, Jr., and Walter C. Teagle, for Standard.

Corporation officers were named on August 28. Mr. Kettering was elected president. Mr. Howard was chosen first vice president; Mr. Midgley, second vice president and general manager; Mr. Maxwell, third vice president and sales manager; Arthur Mittnacht, secretary and treasurer; and Chester O. Swain, general counsel.

Executive offices of the Ethyl Gasoline Corporation were set up in the Cunard Building, 25 Broadway, New York City, and were maintained there until quarters were leased in the Chrysler Building in May 1930. The Corporation was the second tenant of the midtown Manhattan skyscraper office building. (In April 1950, the company moved its executive offices to 100 Park Avenue.)

One of the first acts of the new Corporation was to license DuPont to construct and operate new tetraethyl lead manufacturing facilities at Deepwater, employing the ethyl chloride process. The manufacture by this process began early in January 1925. Plants which had been built for the production of tetraethyl lead by the original ethyl bromide method were scrapped.

For its principal trade-mark, the Corporation secured approval of a design of a black triangle inside a circle with yellow rays emanating from the three sides of the triangle to the circle. It is estimated that during the first 25 years of Ethyl's existence this trade-mark was reproduced more than 20 billion times in such promotional media as advertisements, desk calendars, window displays, exhibits, motion pictures, slide films and the like.

The "Ethyl" trade-mark and trade-mark name have been used to identify numerous articles distributed by the Corporation in the course of its business. Many of these were not articles for sale but were various regulations and services where the trade-mark or the trade-mark name have been used to identify the source or origin.

When the company name was shortened to Ethyl Corporation* on April 9, 1942, the wording of the trade-mark was changed from "Ethyl Gasoline Corporation, New York" to merely "Ethyl Corporation." The appearance of the emblem itself, however, remained virtually the same. The word "Gasoline" was dropped from the Corporation's name at that time since it was then envisioned that the company might choose to market future products not incidental to the manufacture of antiknock compounds. Such became the case two years later when Ethyl Corporation offered its first direct-to-consumer product, a detergent called "Ethyl" Cleaner, for general public sale. This product, incidentally, was removed from the market in 1947.

* For the sake of earlier reading, the company almost always is referred to herein as Ethyl Corporation, regardless of whether reference is made to events before April 9, 1942.

[redacted]

The stumbling block of how to manufacture tetraethyl lead at a reasonable cost had been surmounted with discovery of the ethyl chloride process by Standard of Jersey chemist consultants. But there still remained the pressing question of where to obtain the vast volume of bromine that would be needed to make sufficient "Ethyl" antiknock compound to meet anticipated future demand.

Bromine, of course, was needed in large quantities since it is one of the component parts of ethylene dibromide, which, together with tetraethyl lead and ethylene dichloride, forms "Ethyl" antiknock compound. Bromine is a halogen. So is chlorine, a chemical element contained in ethylene dichloride. Halogens act as scavengers during engine combustion by combining with lead after it has done its work of stopping knock.

To say that the lack of bromine presented a grim situation is to state it mildly. So serious was that prospect that trips were made to the far corners of the globe in efforts to establish a sufficient source of supply. All these proved futile, however.

Late in the fall of 1922, Mr. Kettering left Europe, where he was on a business trip, and went to Tunis in northern Africa to inspect a bromine plant built by French interests in Ain-es-Serah during the first World War. The plant was inoperative at the time. The owners proposed either to reopen it and operate it themselves on a cost-plus basis, or else to permit it to be operated by the DuPont company on behalf of Ethyl Corporation. But, it is recorded, "after a great deal of consideration, conferences, and correspondence, this proposal came to naught."

ETC 36630

About the same time that Mr. Kettering was visiting the Tunis plant, H.G.M. Fischer of Standard Oil Company of New Jersey was in Palestine to inspect the Dead Sea from a bromine content standpoint, and also to see if he could obtain concessions for extraction operations. The trip to Palestine was made in the light of a United States Geographical Survey study which had led Mr. Midgley and his associates to compute that "there is enough bromine in the water of the Dead Sea to treat all the gasoline consumed in the United States (1923 rate of consumption) for over 15,000 years." Nothing came of this venture.

Still another considered source of supply was Mexico. Two Standard of Jersey representatives were dispatched to that country to explore the possibility of deriving bromine from the salt water of oil wells. However, it developed that this propect was not at all promising. In all cases, one of the factors that discouraged commitments abroad was an import duty of 10 cents per pound on bromine.

Virtually all of America's bromine was being produced, at the time, by the Dow Chemical Company from the salt brine wells of Michigan. Its principal uses were for pharmaceutical and photographic chemicals. A contract signed late in 1924 called for Dow to supply ethylene dibromide at the rate of 100,000 pounds monthly for five years. (Ethyl Corporation presently uses about 5 million pounds monthly.) The cost of the ethylene dibromide was 55 cents per pound the first year, after which it was to drop a few pennies annually until the cost to Ethyl Corporation was 49 cents a pound.

When it became apparent that tremendous amounts of bromine would be required, if the corporation were ever to reach a profitable volume of business, the research team turned to the world's largest deposits--the oceans.

No one ever before had released this element--or any other, for that matter, except crude salt--from the ocean. Even if it was found possible to "mine" the ocean successfully, there was the risk that the extraction process might prove a commercial failure since there are only 67 parts of bromine in every million parts of sea water, or about one pound of bromine in 7.5 tons of sea water. The process then in use by the Dow Chemical Company to extract bromine from salt brine was such that the waste effluent contained about the same concentration of bromine as the 67 parts of sea water. Thus a commercially feasible process with sea water would have to begin where the natural brine method left off.

Messrs. Midgley, Kettering and Fischer had been in Midland, Mich., in the summer of 1924, just before Ethyl Corporation was formed, to talk bromine with Dr. Herbert H. Dow. On the train ride back to Dayton Mr. Midgley suddenly turned to Mr. Fischer and said: "Why try for bromine as bromine?" Since a bromine compound was really what was wanted anyhow, he explained, it might be feasible to extract a compound from sea water even if elemental bromine could not be separated from the ocean--or at least not at a reasonable cost.

The rush to explore Mr. Midgley's theory was described by Mr. Boyd this way: "We did not even wait to have water shipped in from the ocean to work on, but used instead a synthetic sea water made up in the laboratory."

Suggestion followed suggestion during the experimental period until finally Dr. Graham Edgar, now a vice president of Ethyl Corporation, proposed that sea water might give up its minute quantity of bromine if phenol were reacted with the bromine. This line of thought led the chemists to an aniline compound, and they produced tribromoaniline as the compound that could be extracted.

(Dr. Edgar had gone to Dayton from a University of Virginia professorship in June 1924 to assume the position of director of research of the General Motors Chemical Company, which did not have a separate laboratory. Two months later, he was placed in charge of the first Ethyl Corporation research laboratory--a laboratory that was established even before the company was formally organized. The separate laboratory for the soon-to-be formed Ethyl Corporation was set up in the northeast corner of the General Motors Research Corporation building in Moraine City about August 1, 1924. Among the first men added to the research staff there were Charles A. Thomas, Carroll A. Hochwalt, Fred Thamann, and B. B. Owen.)

It was soon discovered that half the bromine being extracted by the Edgar method in the laboratory was being lost in a reaction with hydrogen. James P. Andrew, a chemist who had taken part in the research on tetraethyl lead, solved that problem by doubling the amount of chlorine theoretically needed. The result was that the chlorine mated with the troublesome hydrogen, thereby eliminating the latter's tendency to "steal" 50 percent of the bromine with which it came in contact.

Some six months after Mr. Midgley had asked "Why try for bromine as bromine?" Dr. Edgar and Mr. Andrew "went to the sea" to check their test tube theories through the use of actual sea water. They established a semi-experimental pilot plant at Ocean City, Md., during the winter of 1924-25. The experiments there bore out what the earlier laboratory work indicated: a bromine compound could be separated from the sea water.

To establish further the feasibility of working the ocean for the bromine compound, the infant Ethyl Corporation decided upon a bold $360,000 ven-



ETC 36633

ture at the source of supply itself. A 4,200-ton war-built cargo vessel, the Lake Harminia was purchased from the U.S. Government, re-christened the S.S. Ethyl, and committed to the Bethlehem shipyards at Wilmington, Dela., for conversion into a floating chemical factory. After 10 weeks of refitting, she put out to sea on April 27, 1925, with the now-familiar "Ethyl" trade-mark painted on the sides of her hull.

The 254-foot ship, designed for Great Lakes duty, looked sorely out of place meandering along in Gulf Stream waters some 100 miles off the coast of the Carolinas on her unusual mission. As she followed her unchartered course, the S. S. Ethyl floated too high--about 10 feet above the waterline; her pumps discharged water in the wrong places--out of the forward cargo holds; and her masts were rigged with three small staysails--to steady her in a wind.

But if the crews of passing ships thought the good ship Ethyl appeared unorthodox from the outside, they would have been even more perplexed could they have viewed the maze of heavy tanks, pumps, drums, fans, valve wheels, blowers and twisting pipes in her hold. Yet, all this intricate equipment was necessary for the job at hand. Someone later likened the Ethyl to "a big whale straining her dinner out of the ocean she swims in."

The first and only voyage ever made by the vessel as a seagoing bromine extraction laboratory lasted seven days. The costly machinery aboard her operated only six hours or so all told--a few hours on May 2 and a few hours on May 3, 1925. The $60,000-an-hour experiment was not a business success in itself, but it did prove beyond doubt that bromine in a usable form could be recovered from sea water on a commercial basis. The then "usable form" was bromine compound tribromoaniline.

It is a coincidence of the first degree that the <u>Ethyl</u> should have made its turnabout for the return voyage to its Delaware River pier at the latitude of Wilmington, N. C. For, it was near that Southern city, less than a decade later, there arose a permanent on-shore plant for carrying out the sea "mining" process proved practicable by the <u>S. S. Ethyl.</u>

(Although no longer under the Ethyl Corporation flag, the <u>S. S. Ethyl</u> was seaworthy enough to be used as a dollar-a-year auxiliary vessel by the U.S. Coast Guard during World War II. As such, she completed numerous wartime assignments about New York harbor. One of these was to escort the fire-gutted <u>Normandie</u> from her Manhattan pier to a Staten Island shipyard.)

Again a principle had been proved, but the cost was high and the prospects for lower costs were not bright. Bromine from the sea, as extracted by the <u>S. S. Ethyl</u>, would cost about $1.00 a pound, compared to a current market price of only one-fourth that amount. Some other application of the principal was needed. The vessel had demonstrated that bromine could be separated from ocean water. But was there a cheaper way to do it?

Once more laboratory groups tackled a problem connected with the development of "Ethyl" antiknock compound. This time, it was the Dow Chemical Company which came up with the right answer after a long period of experimentation. The Dow company was using an electrolytic process to liberate bromine directly from brine. Its chemists succeeded in modifying and refining this process into a similar electrolytic method for producing the element from sea water.

Accordingly on May 5, 1931, almost six years to the day after the steamship <u>Ethyl</u> drew water from the Atlantic, Ethyl Corporation entered into a contract with Dow Chemical Company for construction of a pilot plant along the coast of North Carolina. This test plant, designed to extract 500 pounds of bromine per day by the electrolytic liberation process, was built among the sand dunes and scrub oaks at Kure Beach, 17 miles southeast of Wilmington, and was so successful that the Ethyl and Dow companies formed the jointly-owned Ethyl-Dow Chemical Company on August 4, 1933. Six months later, a permanent plant with a capacity of 15,000 pounds of bromine per day was operating at Kure Beach, on a 90-acre strip of land between the Atlantic Ocean and the Cape Fear River. Before long, North Carolina had displaced Michigan as the nation's leading bromine producing state.

Construction of the plant was started August 15, 1933, and operations began the following January 10th. Capacity soon was increased from the original 15,000 pounds of bromine per day to 29,000 pounds. That was sufficient for an annual production of 10 million pounds of ethylene dibromide. The production rate of 29,000 pounds of bromine daily meant pumping 40,000 gallons of water a minute. It also meant producing 10 times as much bromine as had been marketed in the United States annually only a decade before.

In 1937 the Kure Beach installation underwent a one million dollar expansion, doubling its annual ethylene dibromide production capacity to 20 million pounds. As a result, the plant was able to draw 137,000 gallons from the sea each minute.

With the outbreak of war in Europe, even this capacity was considered insufficient for the future. So, a second Ethyl-Dow sea water plant was built at Freeport, Texas. This was completed in March 1941. An addition and then a duplicate plant soon became necessary as the wartime forecasts for 100-octane aviation fuel production soared to new levels. The addition went "on stream" in

April 1944. The duplicate plant of the original Freeport unit started operating in December 1944, in time to meet the peak demand for aviation fuel in World War II.

All in all, the Freeport installation represents an investment of more than $10,000,000. Its capacity is more than 84 million pounds of ethylene dibromide a year. Freeport can treat as much as 550 million gallons of sea water a day. That is roughly equivalent to the daily fresh water consumption of Boston, Cleveland, and St. Louis combined.

After the end of the war, the Kure Beach plant was deactivated. The Freeport plant is newer, employs the most modern methods of deriving bromine from sea water, and is more accessible to Ethyl's manufacturing plant at Baton Rouge. Ethylene dibromide is shipped to Baton Rouge from Freeport by tank car.

Removing bromine from the ocean at Freeport represents an interesting chemical operation. After the sea water is pumped into a receiving canal outside the extraction plant and passed through several steel screens, it is discharged into a brine pumping basin. Pumps then lift the brine to the plant itself, where, following an acid treatment, chlorine is added to the brine in order to liberate the bromine.

The liberated bromine, dissolved in the brine. is removed from the solution in a stripping tower. This is done by forcing a blast of air upward through the tower while the brine is flowing down. The bromine "mist" that results is reduced to a concentrated solution, and this bromine is combined with ethylene to form ethylene dibromide.

## CHAPTER VIII

### Public Health Examination

In the spring of 1925, a change in the management of the young Ethyl Corporation occurred.

Mr. Kettering, anxious to return to research activities, resigned as president, although keeping his seat on the board of directors. At the same time, Mr. Midgley, retaining the office of vice president, relinquished his membership on the board to make room for the election of Earle W. Webb. Following his election as a director, Mr. Webb was named president of the Corporation. These changes took place at the board meeting of April 21, 1925.

Mr. Webb had been a director of the General Motors Chemical Company and was general attorney for General Motors Corporation at the time of his election as successor to Mr. Kettering. He served as president of Ethyl for 22 years until August 9, 1947, when, nearing retirement age, he was succeeded by Edward L. Shea. Mr. Webb was then named to the new office of chairman of the board of directors. He resigned from this position February 9, 1948, upon reaching the age of 65.

As president, Mr. Webb's first major responsibility was to guide Ethyl Corporation through a critical period in 1925 and 1926 when the sale of "Ethyl" antiknock compound was suspended for 13 months, partly as a result of the occurrence of five deaths in the experimental manufacture of tetraethyl lead. The fatalities occurred late in October 1924 and involved men employed at a Standard of Jersey pilot plant in Bayway, N. J. Several other workers suffered severe cases of lead poisoning. A cloud had thus been cast over the future of "Ethyl" gasoline, and many outsiders freely predicted that the tragedy meant the end of the company. The New York World conducted a campaign of publicity against the public sale of gasoline containing the company's antiknock compound and labeled such motor fuel "looney gas."

Corporation officials, however, reaffirmed their faith in the antiknock agent and in their ability to manufacture it safely. They decided upon a series of steps to insure greater safety in the handling of the new product. The distribution of "Ethyl" fluid by means of the gasoline pump dispenser was discontinued, and a program was effected under which service station employees would have no direct contact whatsoever with the additive. This arrangement called for mixing the compound with gasoline at bulk stations, after which the blended fuel was delivered in tank wagons to service stations and there placed in underground storage tanks.

On May 5, 1925, the Ethyl Corporation board of directors voted unanimously to discontinue the sale of the antiknock compound to customer companies until such time as a comprehensive investigation could be carried out to determine whether use of the product was in any way a threat to public health and safety. During the two years "Ethyl" had been on the market more than 300 million gallons of gasoline were blended and used without any reported ill effects. The Ethyl directors, nevertheless, recognized that the unfortunate occurrence at the Bayway plant pointed up the need for an investigation that would settle the "Ethyl" gasoline discussion, one way or the other.

The decision to suspend sales also was taken in view of the fact that scientists and medical men differed widely amongst themselves as to the potential hazard associated with the distribution and use of the product, even in a 1 to 1,300 dilution in gasoline.

Those associated with the tetraethyl lead research program and the early marketing of "Ethyl" gasoline had appreciated the potential public health hazard almost from the start, and had taken steps to evaluate the hazards long before any difficulties had presented themselves. As early as February 1922 the opinions of medical men were sought to establish what possible poisonous effects the use of the tetraethyl lead compound in the dilute solution in gasoline might offer.

A thorough-going study of the problem presented by the discharge of lead-containing exhaust gases by motor vehicles was initiated by the U.S. Bureau of Mines under a contract from the General Motors Chemical Company. This agreement became effective on October 19, 1923, and by December of that year highly significant experimental work was under way. An investigating medical committee, consisting of physicians representing General Motors Corporation, Standard of Jersey, and DuPont, was appointed. This group was given responsibility for gathering all available information and for initiating and coordinating further hygenic investigation.

Less than a month after its formation, Ethyl Corporation contracted with the Bureau of Mines to continue and extend the scope of the experimental work it had been conducting. At the same time the company arranged for further studies to be carried out at Columbia University and the University of Cincinnati. The Corporation meanwhile assured the Surgeon General of the U. S. Public Health Service that it would recall the antiknock compound from the market if there was the slightest indication that its use was hazardous. This it did, as noted, on May 5, 1925.

To resolve the entire problem, a conference was called by the Surgeon General in Washington, D.C., on May 20, 1925, to which leading health authorities, physicians, labor representatives, and officials of the companies concerned were invited.

The result of this meeting was the appointment by the Surgeon General of an impartial committee of seven eminent authorities in clinical medicine, physiology, and industrial hygiene to investigate the hazards to the public health which might be associated with the distribution and use of gasoline containing tetraethyl lead. The conference indorsed as "wise" the decision of Ethyl Corporation to discontinue sales temporarily. To the investigating committee, Ethyl pledged and rendered its "full and unreserved" cooperation.

During the remainder of 1925--seven months, in all--representatives of the U. S. Public Health Service, under the direction of the Surgeon General's committee, conducted a broad investigation in which were included examinations of some 252 persons who had been exposed to the various possible hazards associated with the distribution and use of "Ethyl" gasoline. In this group were garage men, service station and bulk handlers of gasoline, as well as the drivers of several cars that had been operated on "Ethyl" gasoline.

Although the sale of its antiknock fluid to oil companies had been discontinued, generally, the Refiners Oil Company and the Spears and Riddle Company kept "Ethyl" gasoline on the market at several of their service stations in Ohio and West Virginia. The continuance of sales by these two distributors was helpful to the Surgeon General's committee in that the group was able to investigate "Ethyl" gasoline in actual usage.

Finally in January 1926, the committee reported publicly its unanimous conclusion that "there are at present no good grounds for prohibiting the use of 'Ethyl' gasoline of the composition specified as a motor fuel (maximum 3 cc. tetraethyl lead per gallon of gasoline), provided that its distribution and use are controlled by proper regulations."

The U. S. Public Health Service, on the advice of the committee, proposed certain regulations for adoption by the various states. No action on the part of the states was required or was taken at that time or since, however, for the reason that Ethyl Corporation agreed to accept and to implement the proposed regulations. This moral obligation has always been borne in good faith by the Corporation throughout its field of operations to the full extent of its abilities and its legal rights.

The findings of the Surgeon General's committee were reiterated by a special British Government Departmental Committee on Ethyl Petrol two years later. This committee had been appointed by the Minister of Health, upon authorization by Parliament, following the introduction of treated gasoline in England in 1928. Reported the British investigating group: "The results of our experiments agree with the results of the experiments carried out in the United States of America . . . and fully confirmed the view we expressed in our Interim Report that the findings of the United States Government Committee were justified."

Although the investigation undertaken by the Surgeon General's committee was completed in seven months, "Ethyl" antiknock compound was withheld from sale six months longer until the recommended safety steps could be put into full effect. When the product finally was offered to oil companies again, commencing June 1, 1926, the sales area for "Ethyl" gasoline consisted of 24 states. A year later, it could be purchased in any section of the country. By the time sales were resumed, Ethyl Corporation had incurred a deficit of approximately three million dollars, not counting the original tetraethyl lead development expense. This was the "shirt losing" period often referred to by Messrs. Kettering and Midgley.

As its business developed in breadth and volume, Ethyl Corporation evolved several types of carefully designed systems for blending the antiknock compound with gasoline at the refineries of customer companies. These types of mixing equipment are adapted for the handling of both large and small quantities of "Ethyl" antiknock compound and gasoline. All operations at these blending plants are controlled by Ethyl Corporation hygienic regulations and by technical and medical supervision, with the result that no member of the mixing personnel ever has been poisoned in the course of this work. Despite this perfect safety record, Ethyl Corporation seeks constantly to improve and simplify the equipment and procedures employed in these operations and has made numerous such improvements through the years.

In safeguarding the public according to the proposed regulations, gasoline containing "Ethyl" antiknock compound is given a distinctive coloring. In addition, a metal "caution" sign is prominently displayed on each service station pump from which such gasoline is sold, in order to familiarize the public with the hazards of the gasoline when improperly used. The sign, with wording in capital letters, black on white background, states that the gasoline dispensed from that pump "CONTAINS LEAD (Tetraethyl)" and is "for use as a motor fuel only." Still more important, the tetraethyl lead content of motor fuel containing "Ethyl" antiknock compound is limited so as not to exceed 3 cc. per gallon.

Among other things, gasoline with "Ethyl" antiknock compound added should not be used for dry cleaning and spot removing purposes. Many of the older metal signs still attached to service station pumps emphasize this fact. These signs state that gasoline from that pump is a motor fuel only and "Not For Cleaning or Any Other Use." Lastly, the old sign warned: "Avoid Spilling."

The Medical Department of Ethyl Corporation has instituted, and the Safety Division of the Sales Department carries out, regulations designed to offer utmost security to personnel of Ethyl Corporation and customer companies in handling concentrated "Ethyl" fluid. The Safety Division, as such, came into existence in 1936. Prior to that time, all Ethyl field representatives were trained in safety practices to handle the erection, maintenance, and inspection of blending facilities. They turned these duties over to the Safety Division specialists with a perfect record of no accidents at any blending plant.

In order to render the most efficient service to customer companies, the work of the Safety Division is divided into two main operations: engineering blending plants and the safe operation of them; and attending and observing tank cleanings, so that the chance of accidents attributable to "Ethyl" antiknock compound will be minimized.

Through the years, Corporation engineers have perfected maximum efficiency systems and methods for the handling of "Ethyl" antiknock fluid at all stages of its manufacture, transportation and blending. In blending, it has been seen, the entire system of handling and mixing "Ethyl" antiknock compound with gasoline at refineries is designed so that no individual will come into contact with it.

Although the antiknock fluid is transferred from shipping container to gasoline under vacuum, blending operators are required to wear special white clothing and to bathe at the end of each operation. The white clothing will show any spill, and the bathing eliminates the possibility of any antiknock fluid remaining unnoticed on the body.

The task of supervising the blending of several hundred millions of pounds of antiknock fluid at nearly 600 plants throughout the United States is one that requires the utmost attention on the part of those charged with this responsibility. Customer oil companies have available to them the services of Ethyl Corporation safety engineers for advice and counsel in this connection.

The Corporation's corps of safety engineers is also available constantly to aid in the cleaning of tanks in which gasoline containing tetraethyl lead has been stored. This service is one which has been utilized by the petroleum industry for many years. The Ethyl men not only act in an advisory capacity, but have special tank cleaning equipment which may be used when needed. Storage tanks, of course, are cleaned for any of several reasons, including repair work, dismantling for removal to another location, and changing the product which the tank is to hold.

From its continuing studies and long experience in this field, the Safety Division has developed a set of precautions for the cleaning of leaded gasoline storage tanks which is generally accepted by the petroleum industry. Beyond that, it has cooperated in bringing about the use of the special protective clothing which is now standard apparel for tank cleaning personnel.

Ethyl Corporation's staff of safety engineers sometimes attends as many as 300 tank cleanings a month. The tanks vary in size from the large 150,000-barrel vertical type at refineries to the small 250-barrel horizontal compartment tanks at bulk stations.

In addition to cooperating at actual tank cleanings, the Safety Division devotes part of its efforts to assisting in the design of tanks, and offering to the petroleum industry, upon request, structural drawings of any improvements that are perfected.

While continuing their normal services on behalf of the petroleum industry, Corporation safety engineers, during World War II, served in direct cooperation with the armed forces. Many Corporation men who went into uniform filled Army, Navy and Air Forces jobs concerned with the use and distribution of petroleum products for war. The experience and training of others were "loaned" to several essential wartime agencies, such as the Petroleum Administration for War.

Ethyl Corporation safety engineers explained the gasoline safety story to thousands of armed forces personnel, both in the United States and overseas. The Safety Division, at the request of the Air Transport Command, prepared a demonstration that familiarized countless ATC personnel with oil industry techniques for handling and storing fuels.

This presentation so impressed oil company executives who witnessed it that Ethyl Corporation altered the show for offering to refinery personnel, as one of its first special postwar projects on behalf of customer companies. Five mobile units of the "Safe Handling of Gasoline" show began touring the country in December 1946 and presented 562 performances at refineries and other meeting places during the ensuing two years. (In January 1949 the show, revised for service station personnel, began a new tour under the name "Fire Power.")

In peace or war, the operations of the Safety Division and the Medical Department are geared to help the petroleum industry maintain and better its outstanding safety record in the handling of gasoline. To this end, the services of Ethyl's skilled personnel are constantly available.

# CHAPTER IX

## Octane Numbers

Progress in gasoline technology has been continuous through the years, but prior to 1926 there existed no stable yardstick by which the antiknock quality of motor fuels could be measured. In that year Dr. Graham Edgar of Ethyl Corporation sought--and found--such an index. His creation of what is now known as the "octane scale" provided, in effect, a standard for measuring the antiknock value of a gasoline during the process of combustion. The octane scale was adopted for general use by the Cooperative Fuel Research Committee in 1930.

In devising his scale, Dr. Edgar selected two pure chemicals, both hydrocarbons in the gasoline boiling range. The first was iso-octane, a once-rare laboratory hydrocarbon that would not knock in the highest compression ratio engines then in existence. The other chemical was normal heptane, a "knocker" of the first degree.

To the iso-octane Dr. Edgar assigned the arbitrary value of 100. His arbitrary rating for the heptane was zero. Thus, a blend of 60 percent iso-octane and 40 percent heptane was said to have an octane number of 60, a mixture of 67 percent iso-octane and 33 percent heptane had an octane value of 67, and so on. By running an unknown test fuel through a special engine used for the purpose, and by switching over to "reference" blends of varying percentages of iso-octane and heptane, the equivalent octane number of the test fuel could be determined. Research men at last had a yardstick by which they could compare the knocking of any gasoline, and thus select an appropriate fuel for any given motor.

The Edgar octane scale permitted the oil industry to discard such cumbersome methods as "Benzol Equivalent" and "Highest Useful Compression Ratios" for determining the antiknock quality of gasoline. Through the years, it has also contributed greatly to the increased uniformity of the antiknock value of fuels; provided a basis for the gradual but certain improvement in antiknock value; and enabled the automotive industry to design engines that would take advantage of the higher antiknock fuels as they became available.

To give the octane scale wider use, Ethyl perfected a precision-built engine for knock-testing purposes. This special motor was hand-fashioned in the machine shop of the company's research laboratories, and was sold to oil companies and automotive manufacturers so that they might conduct their own studies relating to the joint development of fuels and engines. The U. S. Army also adopted the engine as a means of testing fuels used by military vehicles and equipment.

Various improvements were made on the engine, leading to development of the well-remembered Ethyl Series 30 knock test unit. Among innovations to be found on the Series 30 was the knockmeter, which is still widely used on knock-test engines. The knockmeter, devised and perfected by Ethyl research, proved a vast improvement over the previous method of gauging the degree of knock by means of an electrolytic cell.

From February 26, 1930, to May 13, 1932, when the first and last Series 30 engines were shipped, the machine shop of the Ethyl laboratories produced 159 of these units. These were sent not only to oil and automotive company laboratories all over the United States, but to many foreign lands as well.

The Series 30 and earlier engines developed by Ethyl Corporation are credited with successfully filling the gap until a standard laboratory engine -- the CFR (Coordinating Fuel Research) engine -- was perfected and generally accepted by the oil and automotive industries. The CFR engine included most of the major technical details that were incorporated in the Ethyl engines.

Although it no longer machines knock-test engines for sale, Ethyl Corporation has continued to cooperate closely and actively in research in the methods and instrumentation of knock-rating equipment.

Not too long after Dr. Edgar perfected the octane scale the first modern high compression engine appeared on the market. This was Chrysler's famous "Red Head" engine, which demonstrated the additional power that automobile engines could develop when designed specifically for better fuels. In introducing the new engine as optional, Chrysler stamped the words "USE ETHYL GAS" on the cap of the gasoline tank of each car powered by a "Red Head."

Meanwhile, Ethyl's research and sales staffs had been continuing their exploratory studies--and seeking to spread more widely the message of better fuels. Most people still had to be convinced to what extent the further possibilities of the internal combustion engine could then be realized.

To demonstrate, Ethyl engineers arranged an epic 1928 test in Dayton for what later was to be commonly called "high octane" fuel.

On one of two new cars to be used in the demonstration, the engineers stepped up the compression ratio and then filled the tank with high octane gasoline produced in the laboratory. They predicted that their entry in the Dayton "contest" would perform 20 percent better than the competing new model of low compression engine. But a representative of the automobile company, for one, had to be shown.

"If that figure means anything," he said, "it must mean that if you add 20 percent to the total load of this (the high compression) car and then race the two cars uphill, they'll come out even."

Earl Bartholomew, then as now head of the Ethyl Corporation Research Laboratories in Detroit, had not anticipated such a challenge, but he had faith in his company's claim. To give the high compression vehicle the extra load, he ushered four passengers, weighing a total of 660 pounds, into the car and the uphill spurt was on. With their throttles jammed to the floorboards, both vehicles reached the top of the incline at the same instant. The forecast that the car equipped with the high compression engine and powered by high octane fuel would perform at least one-fifth better than the other automobile was proved true.

The skeptical automotive company engineer shook his head in amazement and uttered something about never having seen "mathematics work like that before."

The exhibition in Dayton was so convincing that Ethyl had built 150 of these experimental cars for use by oil companies as a means of demonstrating the advantages of high octane gasoline in high compression engines. Corporation field representatives also drove the vehicles to automobile showrooms and took dealers out riding to prove to them the superiority of better fuels. They became known as "mystery cars" to the public, but what made them tick was no mystery to the automotive industry. Numerous manufacturers soon began introducing high compression models, and the public responded more than enthusiastically.

Aided by "Ethyl" antiknock compound, the year-after-year development of more powerful fuels has resulted in a steady increase in the power and performance of automotive engines. The improvement in the quality of gasoline naturally reflected the continuing increase in octane rating. In case of "Ethyl" gasoline, the climb was from 70 octane number ASTM (American Society for Testing Materials) Motor method in 1930 to 80 octane ASTM in 1941.

The octane rating of civilian gasoline was limited by govenment decree during World War II due to the record amount of the antiknock additive and high octane base stocks that were needed in the manufacture of military and aviation grades of gasoline. Soon after the end of the war, however, the octane number of civilian motor fuels was restored to prewar levels. It reached 85 octane ASTM in the case of some premium fuels in certain sections of the country before the Civilian Production Administration in Washington established a temporary maximum octane number of 78.5 ASTM for leaded premium gasolines. This standard was set in June 1946 in view of a shortage of metallic lead, which is essential in the manufacture of tetraethyl lead. The octane ceiling ordered by CPA was removed on December 31, 1946, as supplies of mined lead increased.

Accompanying the increase of premium fuels from 70 octane number ASTM to 80 ASTM from 1930 to 1941, the octane rating of regular grade gasoline advanced from 60 octane ASTM to the range of 75 ASTM during this same period.

As with premium fuels, the increase in octane number of regular grade fuels can be attributed, in part, to the addition of antiknock compound to gasoline. Ethyl Corporation made its "Q" brand of antiknock compound available to the petroleum industry on June 1, 1933, for adding to regular grade fuel. During depression years, oil companies were loathe to invest capital sums in new refinery equipment to improve the quality of their "house brands," and at the same time sales of premium gasoline were declining with the shrinking purses of motorists. With tetraethyl lead added, regular grade gasoline offered motorists more automotive power and better performance at no extra charge. During the years 1933-34 alone, the octane number of regular grade gasoline increased from 63.5 ASTM to 69 ASTM.

Today, the antiknock compound sold for regular grade gasoline is the same as that used by the oil industry in making "Ethyl" gasoline.

By 1947, as a result of this change in policy--selling "Ethyl" antiknock compound for use in other than premium fuels--over 80 percent of all gasoline sold in the United States and Canada was so treated. And practically every gallon of aviation fuel of 87 octane number or better contained an "Ethyl" fluid made in special mixture for use in aircraft. (By 1951, nearly all automotive gasoline sold in these two countries contained a tetraethyl lead antiknock compound.)

## CHAPTER X

### Better Fuels for Better Engines

It can be said that June 1926, which was the date that sale of "Ethyl" antiknock compound was resumed following the voluntary withdrawal of the product from the market, also marked the real beginning of Ethyl research.

Research activities had gone forward as usual during the period of sales suspension. It was during that time, in fact, that the new engineering laboratory at Yonkers was established. But the first several months of 1926 were spent in outlining research projects, planning long-range programs, and carrying out the many other details that always attend the establishment of any new phase of a business.

From the outset, Ethyl Corporation's philosophy of research has been based upon recognition of the interdependence of engines and their fuels, lubricants, and fuel additives. Just as the power that may be developed by a fuel is limited by the power possibilities of the engine, so the maximum power of an engine is obtainable only with a satisfactory fuel. Whatever progress is achieved in the one inevitably affects the other.

The growth of the company's research facilities from the temporary headquarters in Moraine City and then the small engineering laboratory in Yonkers to major research centers in Detroit and San Bernardino was but a natural course. Having itself been born in a test tube, so to speak, Ethyl Corporation has, quite understandably, recognized the supreme importance of research to continued automotive, aviation and farm machinery progress.

In support of that fact, Ethyl sponsors coordinated research activities in the closely related fields of fuels and engines. Being a child of both the petroleum and automotive industries, the Corporation occupies a singularly fortunate position. It is able to undertake cooperative research programs of mutual benefit to oil companies and automotive manufacturers, and, consequently, to the public at large.

The major emphasis in Ethyl research is placed on developing ever-better means of utilizing fuels containing "Ethyl" antiknock compound, and the possible development of more efficient antiknock mixtures.

The success of this exacting research in the past is best typified by three notable examples--"Ethyl" fluid formula changes; work with halogens, and pioneer studies of triptane, one of the first pure hydrocarbons to be engine-tested.

Seven times since 1923, as engine designs and base fuels have been improved and operating conditions of automotive equipment have changed, research has produced new mixtures of the antiknock compound to meet current needs. Thus, eight different mixes, not including those developed for aviation fuels, have been sold under the "Ethyl" trade-mark.

For one change in composition of the compound for motor fuels, eight years of comparative testing of one compound against the other required more than nine million miles of driving and more than 17,000 hours of laboratory engine operation.

The work with halogens was significant enough to lead to a U. S. patent. Both bromine and chlorine, which are halogens, serve as scavangers during engine combustion. In the heat of combustion, the halogens combine with the lead atoms in the combustion gases to form lead halides; lead bromides and lead chlorides. These then are carried off with the other exhaust gases. However, there are maximum and minimum limits to the amounts of the halogens that can be used satisfactorily with tetraethyl lead. The use of too little of each results in excessive engine deposits of lead oxide, lead sulfate, and other lead compounds. Too great an amount of each encourages corrosion of engine parts. But in proper proportions, the halogens provide adequate scavenging action without introducing these problems.

Years of research in the Ethyl laboratories established the underlying principles upon which satisfactory proportions may be determined, and in 1945 the company was granted a patent covering the halogen range for best results in motor fuel operation. This range, per cubic centimeter of tetraethyl lead, is from one-tenth to six-tenths of a theory of bromine, and from 15/100th to eight and one-tenth theories of chlorine. In the case of "Ethyl" antiknock compound, a theory is the amount of a specified material theoretically required to form a chemical compound with tetreathyl lead.

Triptane, today's so-called fuel of tomorrow, was first produced in this country by the Ethyl laboratories in 1926, four years after it had been made as an individual chemical by the French chemist, Chavanne. The name "triptane" was coined by Dr. George Calingaert, then an Ethyl research chemist and later associate director of research. Its actual chemical designation is trimethylbutane.

Triptane is still in the laboratory stage, but, in respect to antiknock quality, is definitely known to rate among the highest of any pure hydrocarbon yet discovered. Even so, triptane becomes even more powerful when it contains "Ethyl" antiknock compound. There is evidence in the laboratory that, with "Ethyl" fluid added, its Performance Number may be as much as 500 under some

ETC 36656

engine conditions, as compared with 100 for iso-octane

From the beginning, triptane has suffered from the limitation that it could not be made cheaply in quantity. In 1938, however, the Ethyl laboratories were able to prepare two gallons and successfully test it in a supercharged laboratory engine. As a result, U. S. Army aviation scientists at Wright Field, Ohio, became interested and later conducted tests in a full-scale airplane engine. Those experiments--using 125 of 300 gallons of triptane prepared for Ethyl Corporation by the Dow Chemical Company at a cost of about $35 a gallon--were conducted in February and March 1941. The unleaded triptane tested by the Air Materiel Command rated (rich) 165 Performance Number by reference fuel comparisons.

During the World War II years, following a long series of researches in its laboratories, General Motors evolved a "relatively simple procedure" for making pure triptane. This discovery, coupled with successful experimental usage of the fuel component, forms the basis of the prospect that triptane someday will be available in quantity at reasonable cost.

Beyond the effort to produce better antiknock compounds and better fuels, the Ethyl laboratories also strive to assist in the coordinated improvements that have characterized the advancement of engines and fuels toward the goal of greater efficiency.

To this end, they have developed a vast fund of basic information relating to high compression and the supercharging of all types of automotive engines, and to their fuel and antiknock compound requirements. These data are available to the automotive and petroleum industries for use in their development work.

Cooperative research with farm machinery manufacturers conducted by the Ethyl laboratories greatly aided in development of the modern gasoline-powered tractor.

New instruments have been devised to aid automotive and petroleum research. An instance of such instruments is the automatic equipment for the control of engines on dynamometers in programs of varying speed and load, more nearly duplicating the conditions of vehicular engine operation on the highway than previous types of equipment.

As a result of cooperative research in metallurgy and design with the manufacturers of valves and associated engine parts, engine durability has greatly increased. Continuing studies on ceramics, gap geometry, and electrode materials have aided manufacturers of aircraft and automotive spark plugs in improving their products.

Such a comprehensive research program is of benefit to all concerned. Oil companies are aided in the development and testing of improved fuels, and kept abreast of the latest improvements in engine design. Engine manufacturers are able to take advantage of the improved fuels as they come along. Finally, the buying public benefits through the better engine performance, additional power, and greater fuel economy which these endeavors stimulate. Operators of fleets of buses, trucks, and other commercial equipment receive the added benefit of having experienced Ethyl fleet engineers work with them in improving their operations.

The present Ethyl Corporation research facilities incorporate the experience gained in 27 years of intensive effort devoted to the development and application of antiknocks. The laboratories are designed specifically for thorough studies of the complex problems of automotive engines and their fuels and lubricants, and are planned for easy adaptability to virtually all types of engines. The facilities are comprehensive also with respect to the methods of investigation which can be utilized.

Included in the equipment of the Detroit laboratories are 17 engine dynamometers with power absorption capacities ranging from 25 to 400 horsepower and speeds as high as 6,000 revolutions per minute. Also, there are two chassis dynamometers, each located in a temperature-controlled room. Temperatures as low as minus 50 degrees Fahrenheit for cold starting research, and as high as plus 150 degrees for studies of vapor lock, cooling, and other related subjects are available.

The laboratories also house some 29 engines upon which single-cylinder engine research covering motor deposits, wear of automotive parts, and other projects requiring long operation can be conducted. Two standard CFR engines are set up in individual rooms for studies requiring isolation, while knock-ratings on experimental fuels are made on motors in still another room.

In two other rooms, CFR engines are mounted so that they may be connected either to inductor motors or to direct current dynamometers. This arrangement allows the engines to be run at either variable or constant speed, as needed, for special studies of preignition, combustion chamber design, ignition timing, flame propagation, research fuels, and antiknock compounds.

It has been mentioned that Ethyl Corporation research had its beginning at Moraine City, Ohio, in August 1924. On January 2, 1926, this activity was shifted to Yonkers, where a converted garage served as the laboratory. Six men formed the staff and a lone single-cylinder engine represented all the test equipment immediately available. The scope of activities widened quickly, however, and soon a separate chemical research department was created to function with the original engineering department.

Then, in November 1927, the Ethyl laboratories were transferred again. This time the move was to Detroit so that activities could be carried on in the heart of the automobile industry and at a more central geographical point for the petroleum industry. Originally situated at 723 East Milwaukee Avenue in midtown Detroit, the laboratories, as a whole, were transplanted to their present location on West Eight Mile Road in January 1942. The chemical research department, however, had occupied its accomodations at the new site in 1939, and a chemical pilot plant for research on manufacturing matters had been in operation since 1936. The pilot plant was the first structure completed on the 26-acre property.

From the time the new buildings were put into use until the capitulation of Germany and Japan, the laboratories were engaged almost exclusively in endeavors on behalf of the armed forces. At the time of the Pearl Harbor attack, construction of the laboratories at the new location was nearly completed. Work on the project was accelerated, and many facilities which had never yet been put to use were converted for application to research on problems of military equipment.

Engines on which research was accomplished during the war included those for airplanes, tanks, trucks, motorcycles, landing craft, and auxiliary power plants for a wide variety of military equipment. The conditions under which equipment was operated ranged from those representative of winter in

Alaska at 50 degrees below zero to summer in the African desert at 145 degrees above zero.

Because of the urgency of wartime and reconversion operations, formal public showing of the laboratories was delayed until the fall of 1946. On November 14, 15, and 16 of that year, Open House was held for citizens of the community and for personnel of the automotive and petroleum industries.

A feature of the Open House was the unveiling and dedication of a bronze plaque in honor of Thomas Midgley, Jr. The plaque, showing a likeness of Mr. Midgley in bas relief, was placed in the main entrance lobby of the laboratories "that all who enter may be inspired by the memory of his achievements." Says the legend on the plaque: "His contributions to scientific knowledge were outstanding. This company owes its existence to his genius."

Under a reorganization of the laboratories on a unified line-and-staff basis effected in August 1947, the five major groupings are Automotive Products, Aviation Products, Manufacturing and Chemical Products, Technical Service, and Laboratory Operations. The engineering, chemical and aeronautical laboratories, which had functioned as separate operating units prior to that time, thus were blended into a single organization. Technical Service is the liaison group between the Ethyl laboratories and the automotive, petroleum, and related industries. Its individual sections are Passenger Car and Accessory, Commercial Engine and Fleet, Agricultural, Engine Development, and Laboratory Contact Representatives.

In order to apply laboratory fuels to road conditions, the laboratories at both Detroit and San Bernardino maintain fleets of different make and model vehicles for this purpose. Most of the actual road testing, however, is carried on at San Bernardino, since weather conditions there facilitate the operation of vehicles in many different types of service throughout the entire year.

From the doors of the Southern California laboratory, facing U.S. Highway 66, stretches a great natural proving ground which simulates most of the road conditions to be found in the United States.

The Mojave Desert and the San Jacinto, San Gabriel, Santa Ana, and San Bernardino mountains are included in this area. They afford an opportunity to test fuels and engines on roads that drop to 200 feet below sea level and rise to 7,000 feet above, and which vary from the billiard table flatness of a dry lake bed to 12 percent grades encountered in a 36-mile climb. Temperatures range from blistering desert heat as high as 115 degrees Fahrenheit to sub-zero cold at mountain top altitudes.

During 1948, a typical year, the Corporation's test fleets operated approximately six million miles. This figure added to the mileage totals of previous years meant that the road test units had traveled about 47 million miles since this phase of the research program began. Of this grand total, the Detroit fleet operated nearly 3.2 million miles, the San Bernardino fleet 6.7 million miles, and cooperative test fleets 37 million miles.

Although the present building was not opened until October 1938, the laboratory at San Bernardino actually came into being on March 9, 1935. On that day, a caravan of trucks and cars carrying test equipment and nine engineers, test drivers, and mechanics arrived from the Detroit laboratories to establish Ethyl in Southern California.

In all of its many and varied operations, the research program of Ethyl Corporation is designed to reach one objective. That aim is the improvement of present products and the possible development of new antiknock compounds for future use. In the past, Ethyl Corporation research has aided in the development of better fuels and better engines. In the future, it will continue to serve the petroleum, automotive, and allied industries in the mutual undertaking of providing for the better and more economical use of gasoline-powered vehicles and equipment.

# CHAPTER XI

## Sales Through Service

Ever since its formation, Ethyl Corporation has built sales through service to customer oil companies and by direct appeal to the consumers of gasoline containing "Ethyl" antiknock compound.

Ethyl Corporation, in one sense, has only about 220 customers. They are the oil companies which purchase "Ethyl" antiknock fluid to improve the antiknock quality of their own brands of motor and aviation gasolines. These companies, in turn, sell the finished product to the ultimate consumer through their own distributing units and those of thousands of independent jobbers.

Although no sales are made directly to the public, Ethyl Corporation helps to increase the use of gasoline containing "Ethyl" antiknock fluid by advertising the improved quality of such fuel.

The services to customer companies around which most activities of the company's Sales Department revolve take many forms, but the goal is always the same. These services are designed to help customer companies realize the best utilization of gasoline containing "Ethyl" antiknock fluid, and to contribute to the industry-wide stimulation of gasoline sales at times when petroleum is in long supply.

As now constituted, under a reorganization plan that became effective January 1, 1947 the Sales Department field organization is divided into four marketing areas, each having a regional manager, assistant regional manager and an office manager. Headquarters of the Eastern region are in New York, the Central region in Chicago, the Southern region in Tulsa, and the Western region in Los Angeles. Sub-offices are located in Philadelphia, Pittsburgh, Dayton, Kansas City, Dallas, Houston, San Francisco, and Seattle.

Each regional organization includes account representatives, resident managers, field engineers, fleet engineers, tractor engineers, safety engineers, and fuel technologists. Supplementing the activities of these specialists is the Technical Service Division of the Research Laboratories.

In 1923, the Refiners Oil Company, Spears and Riddle, and Standard Oil Company (Indiana) were the sole distributors of "Ethyl" gasoline. Then, in 1924 the list of companies purchasing "Ethyl" antiknock compound for addition to their best gasoline more than doubled as Gulf Refining Company, Standard Oil Company (Kentucky), Standard Oil Company of Louisiana, and Standard Oil Company of New Jersey signed contracts. By late summer 1924, at the time of formation of Ethyl Corporation, these companies were distributing "Ethyl" gasoline from thousands of service station pumps.

In 1926, the year "Ethyl" antiknock fluid sales to the industry were resumed, a dozen more oil companies joined the Corporation's customer group. These were Associated Oil Company, Atlantic Refining Company, Colonial Beacon Oil Company, Continental Oil Company, Humble Oil & Refining Company, Imperial Oil Ltd., Pennzoil Company, Standard Oil Company of Cuba, Standard Oil Company (Nebraska), Sterling Oil Company, Union Oil Company of California, and Waverly Oil Works Company

By the end of 1931, most of the major oil companies and many smaller ones were adding "Ethyl" antiknock compound to their base stocks. Today some 220 refining companies purchase "Ethyl" antiknock fluid. The result of this widespread distribution meant that by 1947 four of every five gallons of motor fuel sold in the United States were either premium fuels or regular grade gasolines containing "Ethyl" antiknock fluid.

In addition to antiknock compounds, Ethyl Corporation sells the following chemicals to its customers and other industrial users: ethyl chloride, salt cake, oil soluble dyes, metallic sodium, chlorine, ethylene dichloride, and benzene hexachloride. The company also has sold in the past such other items as soapless detergents, tank trucks and tank cars, steel drums, automotive parts, knock test engines, mixing installations, and mixing installation parts.

Service to customers is rendered in many different ways.

It may be the advice given by a company safety engineer during a storage tank cleaning operation, the field solution of an engine complaint, or assistance in a sales training program. It may be an analysis of a fuel sample by one of the Corporation's gasoline testing laboratories. It may be a cooperative undertaking in the research laboratories at Detroit. It may be a road test at the San Bernardino laboratory. Or it may be as simple a matter as an answer given over the telephone. It may be, and is, a number of things.

From the time "Ethyl" antiknock compound leaves the manufacturing plant until it reaches the consumer, Ethyl men work hand in hand with personnel of the various branches of the petroleum industry to give counsel on its proper handling, distribution, and utilization.

In the early days--and, in a sense, even now--Ethyl sales personnel were more missionaries of an idea than salesmen of a product. It took extraordinary efforts indeed to convince the petroleum and automotive industries and the public at large of the need for a product such as "Ethyl" fluid. It has been said of the pioneer Ethyl field representatives that "their text book was a knock-



ETC 36666

ing engine and their pulpit was any handy street corner".

When an Ethyl man left home in the fabulous early days, he kissed his wife and children goodbye with added fervor because he knew it might be weeks, perhaps months, before he saw them again. One representative actually was away from home for 21 months, living out of a suitcase in hotel rooms. Territories covering a dozen states were not uncommon for these "missionaries." Fifteen meetings in twelve towns in six days was a usual week's work.

The Ethyl representatives, then as now, were trained in engineering, and were well versed in the technical phases of their subject. But besides being technical men, they also had to be traveling showmen, moving from town to town and promoting their own show. They lectured and they instructed. But what is more important, they sold the oil industry and the public on the merits of "Ethyl" gasoline. Theirs was a vital role in starting Ethyl Corporation on the road to success.

At the outset, their job was primarily to assist in the installation of "Ethyl" fluid mixing plants at refineries, to advise on the standard safety precautions, and to talk before groups of oil company employees and service station dealers. Later, almost always in cooperation with an oil company, they gave vivid demonstrations of "Ethyl" gasoline at local service stations, and cordially invited the general public to attend.

Special single-cylinder engines of high compression ratio were the backbone of the demonstration. The 600-pound engines were transported around the country-side in the back of red Chevrolet coupes to church suppers, Rotary meetings, street corners, service station gatherings--in fact, wherever the Ethyl representative could collect a crowd and go into action. Since the demonstration engines, as well as the automobiles driven by the Ethyl field men, were painted red it isn't hard to understand how the engines won the nickname of "Red Devils." Eventually, the "Red Devils" were streamlined to such compactness that they are now transported in car trunk compartments. Each Corporation sales office was supplied several of the engines of the new design, and they were easily routed to whatever community might be the scene of a demonstration.

The demonstration itself had overtones of magic, even as it does today whenever it is presented. Using a commercial fuel, probably purchased that day at a local service station, the Ethyl "missionary" would start the one-cylinder job. As the engine warmed up, the knock became apparent. The audience could hear the noise. It could see the electric bulb connected with the bouncing pin start flashing like a Roman candle. The flashes indicated the severity of the detonation. It could also see the needle on the volt meter falter, indicating that the engine's power output was low and sluggish. The demonstrator called attention to all this in a running commentary.

Then came the magic. Using a medicine dropper, he put two or three drops of "Ethyl" antiknock compound into the gasoline. The audible knock ceased almost immediately. The bulb stopped flashing. The needle on the volt meter came to life with a jerk, as the engine speeded up. Before it became stationary again, it indicated a substantial increase in power output.

There was no trick to it. It was a demonstration based on a sound scientific principle--the principle that better fuels make possible better engines, and that better engines give more power and better performance.

Each audience watched the demonstration with interested and thoughtful eyes. Drivers remembered how the family car had knocked the day before going up hill, and they determined to try this new fuel the next time they bought gasoline. Slowly but surely, public demand for "Ethyl" gasoline mounted.

Meanwhile, the demonstrations went on--at club luncheons, in town halls, in engineering and chemical society meetings, and at schools and colleges. Automobile distributors and dealers arranged for demonstrations for their own personnel. Exhibits were set up at state and county fairs. One Ethyl representative even gave his talk from a church pulpit with minister, choir, and parishioners present.

Then, about 1930, the missionary aspects of the Ethyl meetings began to give way to more formalized activities. Field men concentrated their efforts entirely with the sales forces of customer oil companies, and this work increased rapidly as more and more oil companies began selling "Ethyl" gasoline. Some marketers purchased demonstrating engines from Ethyl and trained their personnel on the merits of their own individual gasolines containing "Ethyl" antiknock compound.

As its activities have intensified, the Sales Department has employed many special feature presentations through the years to stimulate the sale of better gasoline. One of the more ambitious of these undertakings was the Ethyl Motor Clinic, which made its debut in a garage in Glendale, California, on June 1, 1936. So enthusiastic was the response to the Motor Clinic that it soon was restyled into a mobile demonstration that could be transported city to city. At one time, 11 such units were traveling throughout the country, presenting demonstrations in any type of suitable gathering place. During the three years the Clinic was on the road, demonstrations were held in every important city of 50, 000 or more population.

The Motor Clinic consisted of a chassis dynamometer, on which vehicles could be demonstrated using three grades of fuel of varying power and efficiency. The purpose of the Clinic was to point out to oil and automotive service people and to fleet operators the importance of tuning-up automotive engines at regular intervals, so that owners might realize the utmost performance from the gasoline they used. Starting January 12, 1939, Ethyl sponsored a coast-to-coast-broadcast entitled "Tune-Up-Time" to make the motoring public even more tune-up conscious. This was discontinued in 1941.

Educational programs were conducted in the farm tractor field. It was, in fact, a handful of Ethyl sales engineers who started and carried on a movement which practically revolutionized the farm tractor. In 1930, this small group undertook to bring about the development of the high compression gasoline tractor engine. Almost alone then, these men realized that the low compression distillate-burning tractors then in use did not offer the farmer the economy, power, all-around better performance that high compression tractor motors could make possible.

Efforts in this direction bore their first fruit one hot Summer's day in 1934 on a farm near the Illinois community of Kaneville. With the encouragement of Ethyl Corporation engineer George Krieger, the owner of the farm, Clarence L. Dauberman, agreed to convert his nine-year-old tractor from low compression to high compression ratio. There was no fuss or fanfare that July 31, 1934, when Mr. Dauberman's tractor was converted as a practical experiment, but seven years to the day later, in 1941, he was the central figure of a "Dauberman Day" celebration on his farm. The proceedings were broadcast nationally, and many prominent agriculturists and farm machinery manufacturers attended. As part of the program, Mr. Dauberman presented his now-famous tractor to the museum of the University of Illinois as a permanent display piece.

Mr. Dauberman reaped unexpected benefits from the conversion of his tractor. His more powerful machine gained such attention that interested farmers flocked to his farm to try it out for themselves. "My son Mac and I just sat around and watched while our neighbors drove the tractor," Mr. Dauberman recalled, "and the first thing we knew they had plowed all our fields for us."

The first commercial high compression tractor, The Oliver "70", designed for 70-octane gasoline, made its appearance on the market in 1935. Today, every farm machinery manufacturer markets tractors with high compression engines.

The receptiveness of farmers to high compression is clearly demonstrated by the fact that 95% of all tractors now sold in the U. S. have high compression gasoline-burning engines.

Countless farmers possessing low compression tractors changed them to high compression. Converting tractors to high compression was relatively simple. For the most part, the operation consisted of replacing the pistons with high compression, or "high altitude," pistons or a high compression cylinder head; installing "cold" (gasoline) spark plugs; adjusting the heat control on the manifold; and adjusting the carburetor for gasoline.

Following the introduction of high compression tractors to the public, Ethyl Corporation conducted a "traveling tractor school", which was designed to acquaint as many customer company personnel as possible with the construction, operation, and maintenance of tractors. The school, held during the first two weeks of August 1936, opened with meetings in a Chicago hotel and closed with a series of lectures in Minneapolis. Leading authorities discussed every related topic from tractor fuels to rubber tires for farm equipment. One of the highlights of the school was a visit to the University of Illinois, where the Ethyl "students" had to start and operate all 17 different models of tractors then on the market.

Through the years, as the use of high-compression gasoline tractors has helped the farmer to realize greater performance, efficiency and economy, Ethyl Corporation has never diminished its interest in this field. Sales Department, Technical Service Division, and research efforts, with more efficient farm machinery operation as the goal, go on continuously.

Still another type of service to customer companies is the work of Ethyl's five gasoline testing laboratories in key cities from coast to coast. These laboratories are operated by the Sales Department.

It is their function to sample fuel collected from two principal sources--oil refineries in the territory served by the particular testing laboratory, and service stations in scattered points all over the country. The refinery samples are checked primarily to determine the amount of "Ethyl" antiknock compound to be added to make the resultant gasoline conform to the standards established for it. The field samples, collected by Ethyl Corporation field representatives, provide a spot-check against any contamination of the gasoline after it leaves the refinery. The sampling aids the refiner further in that it provides an independent check on his own laboratory findings.

As many as 25,000 samples have been tested in a single year by Ethyl's five service laboratories, but the normal average figure is many thousands lower. As many as 11 standard tests may be performed on each fuel sample. These take in determination of Motor and Research octane numbers, tetraethyl lead content, color, gravity, gum content, oxidation stability, sulfur content, corrosion, vapor pressure, and distillation.

Since 1942 the company has prepared for use by the petroleum industry a quarterly survey of gasoline quality throughout the United States, based on refinery samples submitted from all sections. These surveys provide a prompt report on prevailing gasoline and trends in quality, both for premium and regular grade motor fuels.

The first Ethyl Corporation gasoline testing laboratory was established in Yonkers as part of the research laboratory there. On October 8, 1928, other gasoline testing facilities were opened in New Orleans and Omaha, and less than a year later--April 16, 1929--a new laboratory at Detroit tested its first sample of gasoline. (The Detroit unit was discontinued in 1946 and the space occupied by it at the Research Laboratories was converted into additional accommodations for chemical research).

Two more gasoline testing laboratories began operations in 1930, one in Kansas City on May 23 and the other in Tulsa on July 7. The Kansas City unit replaced the laboratory that had been established in Omaha. On November 9, 1931, the New Orleans laboratory was transferred to Baton Rouge. Finally, a gasoline testing facility was created in San Bernardino on November 29, 1938.

Thus, the Sales Department today maintains gasoline testing laboratories in Yonkers, Baton Rouge, Kansas City, Tulsa, and San Bernardino. Headquarters of the Gasoline Testing Division is at Yonkers.

More than considering physical growth as a hallmark of success, Ethyl Corporation rather looks to the nature and scope of the services it has offered to the oil and automotive industries since the days when the now-familiar "Ethyl" trade-mark became a recognized emblem. The growth of these services has paralleled the company's progress in supplying antiknock chemicals to help the oil industry give the nation the best gasoline in the world. In truth, the achievements of the past quarter-century are achievements in service as well as in product.

# CHAPTER XII

## Sales Policies

Three policies adopted by the stockholders and directors of Ethyl are fundamental to the business. These are:

(a) "It is recognized that the business of the Ethyl Corporation cannot be successfully conducted except for each of the two stockholders to forego any attempt to dominate its policies. This is particularly true because of the relations which the tw stockholders bear to the oil and automotive industries."

(b) "No exclusive contracts shall be made with any oil company in the United States." (This policy was put into effect upon the termination of the exclusive contract which Ethyl's predecessor had made.)

(c) No terms with respect to the purchase of tetraethyl lead, its mixture with gasoline and conditions of resale, shall be more favorable to one customer company than to another. In carrying out this policy, no quantity discounts have been made and, except for minor differences in the costs of packaging, the smallest purchaser gets the product at the same price as the largest. By absorbing freight costs even the geographical disadvantage which resulted to those purchasers who are most distant from the location of Ethyl plants has been avoided.

Among Ethyl's customers are the smallest as well as the largest refiners, some of the customer oil companies sell as little as 1/100 of 1% of the total gasoline used in the United States.

Constituting, as it does, only one of the methods by which a refiner is free to increase the antiknock quality of gasolines the price of tetraethyl lead is a major factor in determining how much a given refiner will add to his gasoline and, therefore, each reduction made in the price of tetraethyl lead has increased the volume used. Barring other changes in the economics of the cost of the antiknock value to a refiner, it may be assumed that larger quantities of tetraethyl lead may be used should the Ethyl Corporation succeed in further efforts to reduce the price of its product.

The record of price changes is as follows:

| | Effective Date | Per cc. tetraethyl lead content |
|---|---|---|
| | Original price | .01 per cc. |
| | October 1, 1928 | .0050 per cc. (gallonage charge of .007 added) |
| | August 15, 1929 | .0040 " " (gallonage charge reduced to .006) |
| | January 1, 1930 | .0035 " " |
| | July 1, 1930 | .0035 " " (gallonage charge reduced to .005) |
| | March 1, 1932 | .0035 " " (gallonage charge reduced to .00425) |
| | July 15, 1933 | .0035 " " (gallonage charge reduced to .002) |
| (1) | January 1, 1934 | .0033 " " |
| | December 1, 1934 | .0030 " " |
| | November 1, 1935 | .0028 " " |
| | July 1, 1936 | .0026 " " |
| (2) | January 1, 1938 | .0026 " " |
| | July 1, 1939 | .0025 " " |
| | May 15, 1940 | .0023 " " |
| | April 1, 1941 | .0020 " " |
| | April 1, 1942 | .0018 " " |
| (3) | June 1, 1942 | .0018 " " |
| (4) | January 1, 1948 | .0018 " " |
| | July 1, 1948 | .0020 " " (Motor)<br>.0022 " " (Aviation) |
| | October 16, 1948 | .00215 " " (Motor)<br>.00235 " " (Aviation) |

(1) Gallonage charge eliminated.

(2) Freight allowed on tank car and tank truck shipments.

(3) Packaging charges reduced.

(4) All freight absorbed.

| Effective Date | Per cc. tetraethyl lead content | |
|---|---|---|
| February 1, 1949 | .0023 per cc. | (Motor) |
| | .0025 per cc. | (Aviation) |
| March 14, 1949 | .00215 " " | (Motor) |
| | .00235 " " | (Aviation) |
| April 5, 1949 | .0021 " " | (Motor) |
| | .0023 " " | (Aviation) |
| May 9, 1949 | .002073 " " | (Motor) |
| | .002273 " " | (Aviation) |
| May 27, 1949 | .002028 " " | (Motor) |
| | .002228 " " | (Aviation) |
| October 1, 1949 | .0021 " " | (Motor) |
| | .0023 " " | (Aviation) |
| October 25, 1949 | .002063 " " | (Motor) |
| | .002263 " " | (Aviation) |
| March 10, 1950 | .002015 " " | (Motor) |
| | .002215 " " | (Aviation) |
| November 1, 1950 | .0021 " " | (Motor) |
| | .0023 " " | (Aviation) |
| December 11, 1950 | .002237 " " | (Motor) |
| | .002437 " " | (Aviation) |

On July 1, 1948, higher costs of metallic lead (up 250% in the post-war period) and other materials and labor used in the manufacture of "Ethyl" antiknock compound forced the company to announce the first increase ever in the "Ethyl" fluid selling price. Additional increases and decreases were announced later, as manufacturing costs varied with the costs of men and materials. (Even so, the selling price after the last price change was only .002237 cents per cubic centimeter and 61.5¢ per pound of tetraethyl lead content. Aviation Mix, under the price change of December 11, 1950, sells for approximately .002437 cents per cubic centimeter and 67 cents per pound of TEL content.)

Licenses originally were granted to all refiners and jobbers who pledged to handle the antiknock fluid in accordance with the Corporation's hygienic program. The license issued to refiners, who bought the antiknock compound for blending with their own gasoline, provided that the oil company would not sell the blended fuel to any jobber who was not licensed by Ethyl Corporation.

In the case of jobbers, the two main stipulations were that they abide by the regulations concerning the safe handling of "Ethyl" antiknock compound, and that they not dilute or adulterate "Ethyl" gasoline in any way. Approximately 12,000 oil jobbers in the United States were granted licenses by the Corporation.

The jobber licensing system, however, was ruled illegal by the Federal Court for the Southern District of New York in 1939, and that decision was upheld by the U.S. Supreme Court in a ruling handed down on March 25, 1940.

The court action was in the form of a civil suit instituted by the U.S. Department of Justice, charging Ethyl Corporation with violation of the anti-trust laws. It was alleged that the Corporation used the licenses "as a means of excluding from the market the unlicensed jobbers who do not conform to the market policies and posted gasoline prices adopted by the major oil companies or the market leaders among them."

The company's reply to the charges pointed out that its jobber licenses contained no clauses relating to the question of price at which "Ethyl" gasoline was to be sold, and that licenses were refused only to jobbers who were deemed unlikely to live up to those provisions of the agreement that were concerned with matters of health and safety.

The court, in ruling against the company, enjoined Ethyl Corporation from "enforcing or attempting to enforce, or including in any subsequent agreement provisions that refiners shall sell lead-treated gasoline only to licensed jobbers, and from requiring or attempting to require jobbers to secure licenses..."

The Corporation later was named a party to another legal action as a result of its licensing system, but was excluded from this suit before it went to trial. This action was the so-called Mother Hubbard anti-trust suit filed in 1940 by the U. S. Department of Justice against the American Petroleum Institute, 368 petroleum companies, and Ethyl Corporation. The case was held in abeyance during World War II. On July 22, 1946, Ethyl Corporation and 140 of the defendant oil companies were dismissed from the action by the Justice Department. (The Justice Department in June 1951, announced dismissal of the entire "Mother Hubbard" suit.)

In marketing their premium grade of motor fuel, oil companies may, if they wish, designate it with a name that includes the word "Ethyl." Many do so. Others employ only such words as "Premium," "Extra," or some other coined brand name. In the beginning days, it was a sales policy of the company that "Ethyl" gasoline had to be sold as just that--with no reference in the trade name to the refining company which manufactured the fuel. Since 1928, however, it has been policy to permit, but not require, display of the "Ethyl" trade-mark name emblem on the service station pump from which such gasoline is dispensed. A separate "trade-mark authorization" agreement is concluded with those customer companies which want to use the "Ethyl" trade-mark.

Although Ethyl Corporation maintains trade-mark registrations and patents in numerous foreign countries, it presently has no customer companies outside continental North America. Associated Ethyl Company, Ltd. is authorized to use the "Ethyl" trade-mark in connection with the marketing of antiknock compounds purchased from Ethyl Corporation.

Associated Ethyl came into being in 1939 as the result of outright sale of the Ethyl Export Corporation, an Ethyl Corporation subsidiary company which was formed in 1930 to supervise the sale of "Ethyl" antiknock fluid abroad, particularly in Europe, South America, Australia, and New Zealand. During its 12-year lifetime, Ethyl Export contracted with chemical companies in three countries to build and operate tetraethyl lead manufacturing plants. These were in England, France, and Germany. (Late in 1949, Ethyl Corporation formed a subsidiary company--Ethyl Antiknock, Ltd.--to handle the sale of "Ethyl" fluid to Canadian oil companies. Headquartered in Toronto, the Ethyl Antiknock company's activities correspond, from an organizational standpoint, to those of the four Ethyl Corporation sales regions in the United States.)

# CHAPTER XIII

## Advertising

From its very beginning, Ethyl advertising has been designed to benefit all segments of the petroleum and automotive industries, through stimulating sales of production and services and through discussing the importance of the two industries to the American economy.

The Corporation has been a regular and steady advertiser in magazines from its earliest days, and on occasion has employed newspapers, radio, billboards, sidewalk signs, booklets, meetings, and various other means to tell the story of better gasoline.

As a result of its long association with magazine advertising, the company is permitted to place its messages on the choice pages of most publications, thus increasing the readership of its ads. The 1946 Safe Driving campaign, for instance, enjoyed a male readership four times above the readership of the average advertisement. This campaign is generally considered to be one of the best of its kind ever sponsored by any advertiser, and won several advertising awards. Employing the quiz technique, the series stressed the need for good car driving habits and observance of safe driving rules.

From a public response standpoint, one of the most successful of all Ethyl advertising campaigns was conducted in 1941-42. Based on the theme of "What's In a Name?," advertisements in this series told the meanings of person's given names, and as a "commercial" explained the meaning of the "Ethyl" name. More than 2.5 million requests for the free booklet, "What's In a Name?" were received--and many still were being received six years later.



ETC 36683

As a matter of policy, the Corporation supports its consumer advertising with regular insertions in oil, automotive, and chemical trade journals. It also sponsors so-called "executive" advertising in the magazines most read by leaders of industry, government, and public affairs.

Ethyl Corporation's first advertising budget, approved by the board of directors on February 11, 1925, was $25,000. The agency of Barton, Durstine & Osborn (now Batten, Barton, Durstine & Osborn) was engaged to prepare and place the advertisements, and has continued as the company's advertising agency ever since.

On November 16, 1928, the board of directors appropriated the Corporation's first one-million dollar advertising budget. By 1939, when Ethyl Corporation sponsored its first and only national radio program, a show called "Tune-Up Time," the budget was $1,400,000. The broadcast made its debut on January 12, 1939, over the coast-to-coast Columbia Broadcasting System network, and remained on the air until 1942. "Tune-Up Time" marked a significant change in Ethyl Corporation advertising policy, inasmuch as it promoted not only the sale of "Ethyl" gasoline but of regular gasoline containing "Ethyl" antiknock compound as well.

The company presently spends more than $2 million a year on advertising. During Ethyl's entire lifetime, something like $100 million has been spent in advertising which carried the "Ethyl" trade-mark name or trade-mark emblem. The major portion of this tremendous advertising volume, of course, was carried out by customer companies in promoting the sale of their own brand of gasoline containing "Ethyl" fluid.

## CHAPTER XIV

### "Ethyl" Fluid on the Move

To transport "Ethyl" antiknock fluid to oil company refineries and blending plants scattered across and up and down the United States, the Corporation maintains a large fleet of railroad tank cars and a fleet of tank trucks and trailers. The rail units are of two sizes. Volume capacity of the larger tank cars is 80,000 pounds of fluid, while the smaller ones carry half that amount.

It was on September 15, 1930, that the first tank car shipment of "Ethyl" antiknock fluid moved out to a customer oil company. On that date, tank car EBAX-302 left Carney's Point, New Jersey, the shipping center for the "Ethyl" fluid manufacturing plant at that time, with a shipment for the Skelly Oil Company, at Eldorado, Kansas. In EBAX, incidentally, the E is for "Ethyl", the B for brand, and the A for antiknock. The X is a railroad designation to show that the rolling stock is privately owned and not the property of the rail line. All "Ethyl" antiknock fluid tank cars and tank trucks and trailers are owned by Ethyl Corporation.

The first delivery of the product by tank truck was made to the Richfield Oil Company, at Schenectady, N. Y., on September 27, 1933.

In the years since then Ethyl Corporation tank cars and tank trucks and trailers have carried millions of pounds of "Ethyl" antiknock fluid billions of miles to every corner of the country. During a normal year, the Corporation's present rail fleet of 283 tank cars rolls up between 10 and 12 million miles, while the fleet of four tractors and seven tank-trailers travels thousands of miles annually in making over-the-road deliveries. For the most part, the tank trucks are used to serve customer companies which do not have adequate railroad connections or are limited in storage facilities.

This modern means of supplying quantities of "Ethyl" antiknock compound to refineries and blending plants is a far cry from the method used when the product first was introduced a quarter-century ago. Then, the fluid was shipped in methyliters, the quart-sized metal containers which were attached to service station gasoline pumps for use in dispensing "Ethyl" fluid along with the gasoline.

Corporation engineers later developed a better and more protective means of shipping the concentrated fluid through the use of metal drums of 10- and 55-gallon capacity. Then, in 1930, came the tank cars.

The EBAX cars are equipped with special safety features and are of sturdy steel construction to guard against the loss of any shipment en route through railroad mechanical failures or other mishaps. Among the safety features of the cars are: double standpipes for loading and unloading, locked dome cover (housing duplicate vent and standpipe valves and safety valve), walkway around the car, safety platform and rail around the dome, and four inches of tank insulation.

Through a series of pre-shipment inspections, Ethyl Corporation assures its customer companies of receiving every ounce of antiknock fluid ordered. Each shipment is weighed on three different occasions during the loading operation, and each outgoing order is chemically analyzed twice to ascertain that the shipment is of the uniform high quality prescribed by Ethyl Corporation standards.

Whether shipped by tank car or tank truck, all freight charges on consignments of "Ethyl" antiknock compound are absorbed by Ethyl Corporation. This, coupled with the fact that all sales of the antiknock fluid in whatever quantity (except cans for laboratory use) are made at the same price, places the product in the hands of customers in every section of the country at the same price.

The policy of absorbing freight charges on tank car shipments of "Ethyl" fluid became effective January 1, 1937, and the fees paid by the Corporation since then total high in the millions of dollars. (The freight charges absorbed by Ethyl Corporation on "Ethyl" antiknock fluid shipments in 1950, for instance, amounted to more than three million dollars.)

To maintain prompt delivery of shipments of "Ethyl" fluid to customer companies at all times, the Corporation has expended more than three million dollars since 1945 to provide for a new and improved system of distribution of the product.

Most of this sum was spent in the construction of two field terminals for storing and shipping fluid. These new facilities, the first of their kind, supplement normal deliveries made from the Corporation's manufacturing plant at Baton Rouge, and are equipped to make interim and emergency shipments to customer companies, whenever and wherever such shipments may be required.

The field terminals have been erected at Edge Moor, Delaware, and Wilmington, California. The nominal storage capacity of these units is 3¼ million pounds each.

Since they are, in effect, alternate sources of supply, the field terminals insure a continuity of supply to refineries and blending plants in each area they serve. Thus is overcome any transportation delays or other contingencies outside the control of Ethyl Corporation that might arise.

Another phase of the improved distribution plan was the erection of a $750, 000 drumming plant at Baton Rouge to facilitate shipments of "Ethyl" antiknock fluid in drums from that point. Construction of this unit began February 15, 1947, and it went into operation in December 1947. With a nominal capacity of 10, 000 drums monthly, it has complete facilities for the inspection, handling, and maintenance of drums, as well as the usual filling equipment.

## CHAPTER XV

### At Home in Baton Rouge

The plant at Baton Rouge where "Ethyl" antiknock compound is manufactured is distinctive not only because it is the largest of its kind in the world. It also is a completely integrated chemical works, which means that it produces virtually every chemical required in the manufacture of the product.

Because of the nature of the company's never-ending efforts to promote fuller engine-fuel compatibility, Ethyl Corporation most often is looked upon as a member of the automotive and petroleum industries. Perhaps not so well appreciated is the fact that Ethyl also is a leading company in the chemical manufacturing field. It is, in fact, one of the seven largest chemical corporations in the United States.

It is the world's largest maker of tetraethyl lead (one billion pounds at Baton Rouge alone from 1937 through April 1948).

It leads the world in the production of ethyl chloride (more than one billion pounds made from 1937 through 1947).

It operates the biggest sodium plant in the world (300 million pounds at Baton Rouge from 1937 through 1947).

It is the South's largest producer of salt cake, which is used in the manufacture of kraft (wrapping) paper.

It is a major producer of chlorine.

It and Dow Chemical Company, through the Ethyl-Dow Chemical Company, are the world's largest producers of bromine and ethylene dibromide.

It is a major producer of benzene hexachloride, which is used by the insecticide industry.

All these, plus the others sold under the "Ethyl" trade-mark, are products or by-products of the "Ethyl" antiknock compound manufacturing operation. In addition to those listed above, Ethyl also produces and markets ethylene dichloride, ethylene, hydrogen chloride, and oil soluble dye.

The need for greater manufacturing capacity than could be provided by the facilities at Deepwater, New Jersey, became apparent in the mid-thirties. As more and more motor vehicles appeared on the road, the oil industry's demand for "Ethyl" fluid increased accordingly. Too, the call for the product was greater now that "Ethyl" antiknock compound was being added to regular brand gasoline. And still further, the swing from low compression distillate-burning tractors to high compression gasoline tractors was getting under way.

New tetraethyl lead manufacturing units had been constructed at Deepwater at an average rate of one every 18 months during the period from 1929 to 1935. But with gasoline sales again on the upswing it was evident that demand for the Ethyl product would outstrip supply in the years ahead.

So it was that Ethyl Corporation sought a suitable location in which to construct an integrated chemical plant for the production of "Ethyl" antiknock compound.

On August 6, 1936, a 200-acre site on the northern outskirts of Baton Rouge, La., was acquired as the home of the proposed new Ethyl plant. Two of the deciding factors in the choice of Baton Rouge were its proximity to the source of supply of several chemicals used in the manufacturing process, and its convenience as a shipping point to the oil industry's major refining centers.

Since the first shovelful of dirt was turned early in the fall of 1936 physical expansion of the Baton Rouge plant has gone forward almost without interruption. At the end of World War II, the investment represented a value of about $50 million. (More than $100 million has been or is being spent since then to expand Baton Rouge and construct the new plant at Houston.)

Clearing of the land and construction of temporary buildings at Baton Rouge started October 6, 1936. The first permanent building was the first of five tetraethyl lead manufacturing units erected at Baton Rouge before the war. The initial tetraethyl lead plant began operations on September 17, 1937, and included such associated buildings as an alloy plant, an ethyl chloride recovery plant, a lead recovery plant, and a blending plant.

Soon after the first tetraethyl lead unit was completed, construction of the second lead plant was well underway. This was put into operation March 1, 1938, the same day that excavation was started for the third and fourth plants. These latter two tetraethyl lead units began operations March 1, 1939, as did a sodium plant, which had been under construction since March 25, 1938. Two ethyl chloride plants were constructed during this period, the first opening on July 16, 1938, and the second on April 25, 1939.

A $4 million expansion program was undertaken in December, 1939. This phase of the continuing growth of the Baton Rouge installation saw a fifth tetraethyl lead plant and a third ethyl chloride plant go up, along with added facilities for the electrolysis of salt for the manufacture of metallic sodium and chlorine gas. The fifth tetraethyl lead unit was completed January 2, 1941, but was maintained as a reserve plant for more than two years. It began production in August, 1943, when the demand for "Ethyl" antiknock compound, due to the war, reached what was then record proportions. The additional ethyl chloride plant went into operation on October 10, 1941, as soon as it was completed.

As the result of expansion at Baton Rouge and readjustments of some manufacutring operations, Ethyl Corporation increased its output of tetraethyl lead during the war by 43 percent. Earlier construction had raised the Baton Rouge production capacity of tetraethyl lead in mid-1941 to a figure 75 percent greater than that of September 1, 1939, when war broke out in Europe.

Throughout the war, new facilities costing more than $12 million were added as their need arose. The last of these wartime additions was a $1.7 million water purification plant which purifies water drawn from the nearby Mississippi River. This unit, which was completed on February 6, 1945, has a capacity of 28 million gallons a day. Water is required for cooling and various other purposes in many of the manufacturing operations.

In addition to $3 million worth of postwar buildings that had already been constructed, a $20 million expansion program for the Baton Rouge plant was announced on June 17, 1947. By the end of 1948, the outlay for Baton Rouge expansion had reached $40 million, either because of additional construction or because of inflated costs. The expansion provided jobs for between 500 and 750 additional men and women. (Baton Rouge plant employment at the end of 1948 was approximately 2,500 persons, by June, 1951, it reached 4,000).

As originally announced, the program called for construction of a sixth tetraethyl lead plant and additions to the manufacturing facilities for the supply of such intermediate chemicals as metallic sodium and ethyl chloride.

Then on November 9, 1948, it was announced that the Baton Rouge plant, already the largest of its kind in the world, would be enlarged still further to assure customer companies of maximum supplies of "Ethyl" antiknock compound and other products sold under the "Ethyl" trade-mark.

The first unit of any kind in the $40 million expansion program to be completed was the nitrogen plant. This unit, which doubled the output of nitrogen at the Baton Rouge plant, began production on October 17, 1948.

The multi-million dollar expansion program is over and above the construction of the following buildings, which were blueprinted earlier in the postwar period: The $750, 000 drumming plant; a $275, 000 cafeteria for employees; a new Development Laboratory and pilot plant, and new headquarters for the Medical and Personnel Departments. The latter two buildings were erected at a cost of $2 million.

Until September 15, 1945, when Ethyl Corporation took over management and operation of the entire Baton Rouge installation, some of the units were operated for the Corporation by DuPont. DuPont operated the tetraethyl lead and sodium plants, while the ethyl chloride units were under Ethyl Corporation direction. Under mutual agreement, Ethyl Corporation gradually assumed supervision of the various departments operated by DuPont. Operation of the sodium plant was taken over by the company on May 1, 1945, and four and a half months later--on September 15--the remainder of the Baton Rouge plant was changed over so that at that time the entire plant became Ethyl Corporation owned, operated, and managed. Nearly all the DuPont employees at the plant were retained on their job and became employees of Ethyl Corporation with full seniority rights from their previous service with DuPont.

From the time of the plant's opening in 1937 through 1950, more than two billion pounds of "Ethyl" antiknock fluid, requiring over a billion and a half pounds of tetraethyl lead, had been produced at Baton Rouge. The billionth pound of tetraethyl lead was made April 22, 1948.

(From 1929, when the keeping of sales records was started, through 1947, America had used 60 billion 600 million gallons of "Ethyl" gasoline. That would form a lake ten miles long, two and three-quarters miles wide, and ten feet deep. During that same 19-year period, nearly 12 billion gallons of high octane aviation fuel were produced. Since 1933, when Ethyl Corporation began selling antiknock compounds for use in regular grade gasolines, the sale of such gasoline containing tetraethyl lead exceeded more than 250 billion gallons through 1947.)

The production of "Ethyl" antiknock compound is a complex and highly integrated manufacturing process, involving the use of more than a dozen chemicals and raw materials. No "prior art" in the large scale of production of any organo-metallic compound existed at the time the antiknock compound was ready for marketing, and it was only through experience that the serious problems confronted from the very beginning of the manufacture of the additive were surmounted.

Three principal ingredients make up "Ethyl" antiknock compound-tetraethyl lead, ethylene dibromide, and ethylene dichloride. ("Ethyl" antiknock fluid for use in aviation gasoline contains no ethylene dichloride.) A minute amount of oil soluble dye is added to the finished compound for no other reason than to give it a distinctive coloring. These dyes, which have no chemical effect whatsoever on either the antiknock compound or the gasoline with which it is blended, burn at the time of engine combustion, just as does the gasoline.

As of 1948, the Baton Rouge plant consumed approximately $40 million worth of raw materials and operating and maintenance supplies annually. Raw materials used in the production of "Ethyl" antiknock compound include pig lead, salt, petroleum, sea water, sulfur, and air. These are mixed with other chemicals and elements in a series of chemical operations that produce each of the three basic ingredients. Except for ethylene dibromide, which is made at the Ethyl-Dow Chemical Company sea water plant in Freeport, Texas, the Baton Rouge plant produces all the intermediate chemicals needed in the manufacture of "Ethyl" antiknock compound.

Tetraethyl lead is manufactured by the reaction of ethyl chloride with an alloy of sodium and metallic lead. While metallic lead normally is available in the open market in the quantity required, sodium and ethyl chloride are not, and therefore are made by Ethyl Corporation. The sodium-lead alloy and the ethyl chloride are allowed to react at moderate pressures and temperatures, after which the product is distilled with steam to separate the tetraethyl lead. Only one-fourth of the lead in the alloy is converted to tetraethyl lead, but the other three-fourths is not lost. It is recovered and then re-smelted into pig lead.

In the production of sodium, the raw material is salt brine and the chemical force is electricity. Salt, pumped in from wells 20 miles distant from the Baton Rouge plant, is treated to high purity, evaporated to practically absolute dryness, and then charged to batteries of electrolytic cells, where the salt is decomposed to sodium and chlorine. The Baton Rouge unit produces about half of all the sodium made in the United States. Capacity is more than five million pounds per month.

Ethyl chloride is produced by two processes. The first, the ELA process, is based on the hydrochlorination of ethylene. ELA stood for "Ethyl Louisiana" on the original Baton Rouge construction blueprints, and the abbreviation has stuck as the name for the process.

Under the ELA method, refinery stabilizer gases are fractionated at low temperatures to separate the ethylene formed. The ethylene then is allowed to react with hydrochloric acid gas in the presence of a catalyst to produce ethyl chloride.

A new method of producing ethyl chloride, called the CP process, was developed during the war by Ethyl Corporation. In order to make ethyl chloride by the CP process, a $750, 000 unit was built at Baton Rouge and put into operation October 30, 1945. This process yields ethyl chloride by reacting chlorine with waste products from the ELA ethyl chloride plants. Whether produced by the CP or ELA process, the ethyl chloride is subjected to purification processes before it is ready for final reaction with the lead-sodium alloy to form tetraethyl lead.

Ethyl Corporation is the world's largest producer of ethyl chloride. The Baton Rouge plant turned out its billionth pound of this key chemical in December 1948.

Tetraethyl lead, the active ingredient of "Ethyl" antiknock compound, is a colorless liquid about twice as heavy as gasoline. Being the actual antiknock agent, it controls the rate of combustion of motor fuels, thereby preventing the sharp engine explosions which cause harmful knock, wasted power, and overheating.

Ethylene dibromide, a principal ingredient of "Ethyl" antiknock fluid, is a compound of ethylene and bromine. Like tetraethyl lead, it is a colorless liquid and weighs approximately twice as much as gasoline. Ethylene dichloride, the third basic ingredient, is a compound of ethylene and chlorine.

The "Ethyl" antiknock compound used in motor fuels consists of approximately two-thirds tetraethyl lead, one-sixth ethylene dibromide and one-sixth ethylene dichloride. To make compound containing one pound of tetraethyl lead, it takes 3 1/2 tons of sea water, 1 1/2 pounds of salt, one pound of sulfuric acid, one pound of ethyl chloride and 3/4 pounds of pig lead, plus varying amounts of hydrogen, refinery gas, kerosene, sulphur, soda ash and other chemicals. (As noted earlier, "Ethyl" antiknock compound for aviation fuels contains no ethylene dichloride).

It was this product--made of such varied matter as sea water, salt, and pig lead--that gave our World War II aviation fuels the final decisive lift in octane numbers and thus enabled Allied planes to enjoy superiority in the air. The antiknock compound played a key role in the production of aviation gasoline of 100-octane rating, at one time considered the ultimate in motor fuel perfection. It helped, too, to bring about superfuels of such high knock resistance that they could not be rated by octane number.

Geoffrey Lloyd, Great Britain's watime Joint Parliamentary Secretary to the British Ministry of Fuel, has given American aviation gasoline, with "Ethyl" antiknock compound added, much of the credit for repelling the Nazi air onslaught against the British Isles. Said he: "I think we would not have won the Battle of Britain without 100-octane--but we did have 100-octane."

Ethyl Corporation was called upon repeatedly to increase its output of the vital antiknock compound during the war. As the sole marketer of the product in the United States, the Corporation increased its manufacturing capacity from 165 million pounds of tetraethyl lead annually, as of April 1, 1940 to 315 million pounds in 1945. Four thousand men and women made "Ethyl" antiknock compound under the wartime slogan of "Every Drop of 'Ethyl' Counts."

Because of the all-out war effort of the American petroleum industry, American and Allied airmen held decided advantages over their opponents. Seldom were German bombers powered by gasoline of better than 87 octane number, whereas American and British combat aircraft were standardized on 100/130 grade and some fighter planes even utilized a 100/150 grade fuel.

The extra octane numbers, with engines built to make full use of the increased antiknock value, gave Allied airmen up to one-third more power in the air than their opponents enjoyed in Luftwaffe planes fueled with 87 octane. This added power also meant that take-off distance was cut one-fifth, and rate of climb was increased 40 percent. Further, 100/130 gasoline reduced the fuel load of a bomber so that it could carry 20 to 30 percent more bomb tonnage, or increase its safe flying range in proportion.

Less than a decade before the outbreak of World War II, 100-octane fuel was so rare that laboratory samples cost as much as $30 per gallon. But improved refining equipment and blending methods, plus the addition of "Ethyl" antiknock fluid, enabled the oil industry to produce extra high octane fuel at a wartime rate of about 550,000 barrels a day. The antiknock quality of gasoline reached such high levels during the war that certain aviation fuels "ran-off" the octane scale. These superfuels of better than 100-octane rating could be measured only in "performance numbers."

Although our bombers flew on 100/130 performance number fuel, gasolines rating as high as 115/145 performance number were used during the latter phases of the war. The addition of 4.6 cc. of "Ethyl" antiknock compound per gallon increased the performance number rating of aviation fuels by about 55 numbers. Although U. S. Public Health Service regulations stipulate that no more than 3 cc. tetraethyl lead may be added to a gallon of gasoline, this ceiling was lifted for aviation fuel during the war. The urgency of the times and the fact that "Ethyl" antiknock compound was the easier and most economical way to increase the performance number of fuels dictated this move.

Gasoline of 100-octane number can be made without "Ethyl" antiknock fluid, but the fuel is more expensive and production could not begin to meet the tremendous demand for such gasoline developed by the war. Benzol, among others, is an effective knock-suppressor. However, "Ethyl" fluid is approximately 2,500 times more effective per unit volume. It has been stated that without "Ethyl" antiknock compound it would have been impossible to produce enough 100-octane gasoline to maintain even one squadron of planes in the air.

It is to assure the nation of an even greater supply of "Ethyl" antiknock compound that the current $100 million expansion programs at Baton Rouge and Houston were undertaken. No sum even approaching that figure has ever been spent before in connection with the manufacture of a gasoline antiknock additive.

# CHAPTER XVI

## Ethyl Corporation in World War II

Beyond its primary contribution to the war effort by producing a record volume of "Ethyl" antiknock compound, Ethyl Corporation helped in several other ways to bring about the defeat of the Axis.

When chlorine became one of the scarcest chemicals in the national defense program, the company took steps to solve its own problem of chlorine shortage and then aided in easing the country-wide shortage by producing this vital chemical for other essential users of it. At the outset, the dilemma was that while the supply of chlorine obviously would be extremely short because of heavy wartime demands, the Corporation needed more of this chemical than ever before if it was to produce all the antiknock compound demanded of it.

The first step was to produce far more sodium than was required for current "Ethyl" antiknock fluid manufacture. By so doing, the company was able to produce all the chlorine it needed and thus discontinue its purchase of chlorine on the open market.

Then, shortly before Pearl Harbor, the company turned to the task of supplying chlorine to other users. This was made possible through the construction, both at Baton Rouge and Deepwater, of plants that could produce hydrochloric acid gas as a substitute for chlorine in the manufacture of ethyl chloride. Abundant supplies of sulphuric acid and salt were available for the production of hydrochloric acid.

Ground was broken for the Baton Rouge hydrochloric acid gas unit on October 13, 1941, and it went into operation on August 30, 1942. This new facility represented an investment of $3.4 million. An additional one and one-quarter million dollars was spent to increase facilities for producing, liquefying, and shipping chlorine to other industries throughout the country. A fleet of tank cars for transporting the chlorine cost $200,000 alone. Thus, by erecting at Baton Rouge the nation's then largest single hydrochloric acid gas plant, Ethyl Corporation almost overnight changed from a net consumer to a net producer of the scarce chlorine.

Another wartime activity of Ethyl Corporation was the use of half of one of the ethyl chloride units at Baton Rouge and another at Deepwater for the manufacture of a related chemical--ethylene dichloride--needed in the production of thiokol. Thiokol was one of the special-use synthetic rubbers developed during the war.

The "thiokol half" of the converted ethyl chloride unit at Baton Rouge went "on stream" October 30, 1942, and the manufacture of ethylene dichloride continued until June 1943. At that time, the production of ethylene dichloride was halted due to the curtailment of the thiokol program and the plant was changed back to the production of ethyl chloride for the manufacture of "Ethyl" antiknock compound.

The other half of this ethyl chloride unit--the ethylene section--was used during the war as a pilot plant for testing the workability of a process that had been developed for the manufacture of butadiene, a compound used in making certain types of synthetic rubber. The experimental work on butadiene was carried on by Ethyl Corporation personnel and was undertaken in cooperation with the Standard Oil Development Company, which leased from Ethyl Corporation for the year 1943 the ethylene section of the ethyl chloride unit. Operation of this unit for the manufacture of butadiene began on March 14 and continued until December 13, 1943, when reconversion to the manufacture of ethylene was started.

Until tested in the Baton Rouge pilot plant, this process of making butadiene never had been sampled outside the laboratory. Thus, by using Ethyl Corporation facilities, it was possible to iron out some of the bugs in the method and save many months of possible delay once regular butadiene plants, then under construction, went into operation.

Ethyl Corporation shared in an award for "Chemical Engineering Achievement" in recognition of its "meritorious contribution to the design, construction and operation of the American synthetic rubber industry." The award, presented to the entire American synthetic rubber industry, was made by Chemical Engineering magazine, on December 8, 1943.

Still another project undertaken by Ethyl Corporation in behalf of national defense and the war effort was the Reserve Storage Program of 1941. Under this program, the company agreed to furnish, without compensation, materials for the construction of tanks for the storage of "Ethyl" antiknock compound at refineries making 100-octane aviation fuel. Participating oil companies provided the necessary labor and construction space. Payment for "Ethyl" antiknock compound thus stored was put on a deferred basis.

During the war, too, the Ethyl Corporation research laboratories cooperated in solving many complex problems placed before them by the armed forces. The Detroit laboratories engaged in some 50 major projects of varying scope and magnitude.

The gasoline testing laboratories assumed the sizeable assignment of sampling fuels for the Army after Quartermaster Corps laboratories and available commercial laboratories proved inadequate for this purpose. Between 3, 000 and 3, 500 samples were tested annually from fuel stocks at Army camps in the United States and from shipments earmarked for military use overseas.

The gasoline testing laboratory at Tulsa was utilized further to teach soldiers how to operate knock-testing engines, which are used to establish the octane number of fuels. This training, part of a course sponsored by the Quartermaster Petroleum School at the University of Tulsa, qualified Army personnel for specialized work in QM petroleum field laboratories. These Army laboratories, set up in combat zones conducted spot-checks of the petroleum used by military vehicles and equipment.

The Corporation's field organization and Technical Service Division gave the benefit of their knowledge in the proper maintenance procedures and actual operation of fleets of vehicles. This experience with commercial bus and truck fleet operations was passed on to armed forces personnel during visits by Ethyl Corporation representatives to camps and training centers. Other company engineers collaborated with truck manufacturers, at the request of the Army, in adapting engines to wartime usage in the different climates and under the different conditions where fighting took place.

Corporation safety men traveled throughout the United States and the rest of the world to instruct the armed forces in the safe and proper handling and storage of fuel. Two representatives so engaged gave their lives in an airplane crash while on an 18, 000-mile tour of Army bases. The men, John G. Martin and Philip M. Perry, were killed December 17, 1944, in an airplane crash at Memphis, Tenn.

The manufacturing plants at Baton Rouge and Deepwater and the Ethyl-Dow bromine extraction unit at Kure Beach won seven Army-Navy "E" awards or their equivalent. Deepwater was rewarded three times--on August 2, 1943; December 2, 1944; and June 23, 1945. Baton Rouge received the "E" flag on August 6, 1943, seven years to the day after the plant site had been selected, and was awarded a star for the "E" pennant on December 2, 1944. Kure Beach won the "E" on July 1, 1944, and the star for the "E" flag on February 3, 1945.

Ethyl Corporation was not a free agent in either the manufacture or distribution of "Ethyl" antiknock compound during the war. Some of the raw materials needed in the production of the compound were placed under Government priority control in 1941, and actual distribution of the product was taken over by the Office of Petroleum Coordinator (later the Petroleum Administration for War) early in 1942.

For more than a year after the surrender of Japan, the Government still determined the amount of "Ethyl" antiknock fluid that would be available for civilian use. With a postwar shortage of metallic lead progressively growing worse, the Civilian Production Administration, beginning in April 1946, issued orders which curtailed both Ethyl Corporation's consumption of metallic lead and its deliveries of "Ethyl" antiknock fluid. Further, the CPA in June 1946, established an octane ceiling of 78.5 octane number ASTM over gasoline containing "Ethyl" antiknock compound. This compared with the maximum 76-octane rating permitted for civilian motor fuels throughout the war.

The Civilian Production Administration restrictions continued in effect through December 1946, permitting the company to meet only a part of the requirements of its customer companies for "Ethyl" antiknock fluid. The restrictions also resulted in a severe drain upon the Corporation's plant inventories of metallic lead and tetraethyl lead.

Supplies of metallic lead began to increase early in 1947, however, enabling the Corporation to accomplish the twin objective of increasing deliveries of "Ethyl" antiknock fluid to customer companies and of replenishing its working inventories.

## IMPORTANT DATES IN ETHYL CORPORATION HISTORY

1912

.............Charles F. Kettering undertakes study of the knock problem.

1916

Fall.........Thomas Midgley, Jr., takes up knock experiments begun by Mr. Kettering. Research is conducted under guidance of Mr. Kettering in his laboratory at Dayton, Ohio. T. A. Boyd and Carroll Hochwalt join antiknock research team.

Dec. 2.......Reported date of discovery of iodine as antiknock.

1917

October ......Mr. Midgley interrupts antiknock research to develop first synthetic high octane fuel ever produced.

1918

April 9.......Date of discovery of ethyl iodide as antiknock.

December....Antiknock research resumed.

1919

.............Mr. Midgley perfects optical indicator bearing his name.

January 30....Date of discovery of aniline as antiknock.

1920

February 27...First reported use of an antiknock in an Army aircraft. McCook Field flier sets new altitude record on fuel containing xylidine, an antiknock supplied by Mr. Kettering's laboratory.

March .........Demonstration of detonation in glass tube developed.

March..........General Motors Corporation purchases Mr. Kettering's laboratory.

Names him director of research. Knock research continues under auspices of General Motors Research Corporation.

1921

April 6 .........Date of discovery of selenium oxychloride as an antiknock.

April 8 .........Date of discovery of diethyl telluride as an antiknock.

August ......... Messrs. Midgley and Boyd perfect bouncing pin indicator for use in measuring degree of knock.

December 9......Mr. Midgley discovers tetraethyl lead as an antiknock.

1922

October 6.......General Motors Corporation signs contract with DuPont company to manufacture tetraethyl lead under GM patents by ethyl bromide process at Deepwater, N. J.

1923

February 2......First public sale of "Ethyl" gasoline. Sale made at a Refiners Oil Company service station in Dayton. F.M. Redelle, of Dayton, its first purchaser.

March 7........ General Motors Corporation forms General Motors Chemical Company to market "Ethyl" antiknock compound.

May............ First "Ethyl" gasoline advertising. General Motors Chemical Company sponsors ads in Dayton and Cincinnati newspapers.



ETC 36707

June 1. . . . . . . . . . . Dayton Power and Light Company becomes first fleet user of "Ethyl" gasoline.

September 29. . . . Sales agreement for "Ethyl" antiknock compound signed with Standard Oil Company (Indiana). Contract granted sole distribution rights to sell "Ethyl" gasoline in Midwest states.

<u>1924</u>

Spring. . . . . . . . . . Negotiations under way between General Motors Corporation and Standard Oil Company of New Jersey for merging respective discoveries of tetraethyl lead antiknock compound and cheaper method of manufacturing tetraethyl lead. Discovery of less expensive production method was made sometime before by Standard consulting chemists.

May 30. . . . . . . . . First spectacular public demonstration of "Ethyl" gasoline. First three cars to finish Indianapolis 500-mile race have fuel containing "Ethyl" antiknock compound in their tanks.

August 1 . . . . . . . . First Ethyl Corporation laboratory established. Research facilities set up at Moraine City, Ohio, two weeks before incorporation of the company.

August 5 . . . . . . . . U. S. Patent Office assigns "Ethyl" trade-mark to General Motors Chemical Company.

August 18. . . . . . . .General Motors Corporation and Standard Oil Company (N. J.) form jointly-owned Ethyl (Gasoline) Corporation. All assets of General Motors Chemical Company acquired by new company, as well as rights to patents in antiknock field held by General Motors and Standard of Jersey.

ETC 36708

August 20....... First board of directors of Ethyl Corporation named.

August 28....... Mr. Kettering elected first president of Ethyl Corporation.

December 25.... First plant for manufacture of tetraethyl lead by ethyl chloride process completed at Deepwater.

1924-25

Winter.......... Pilot plant established at Ocean City, Maryland, for testing possibility of extracting bromine from sea.

1925

February 11..... First Ethyl Corporation advertising budget ($25, 000) approved. Batten, Barton, Durstine & Osborn named advertising agency.

April 21........ Mr. Kettering resigns as president of Ethyl Corporation. Earle W. Webb named his successor.

April 27......... S. S. Ethyl sails from Wilmington, Delaware, to test practicability of removing bromine from ocean water. Voyage lasts one week.

May 5.......... "Ethyl" antiknock compound withdrawn from market, pending investigation of possibilities of lead intoxication in its distribution and use.

May 20.......... U. S. Surgeon General appoints committee to study hazard involved in distribution and sale of gasoline containing "Ethyl" antiknock compound.

July............ First "Ethyl" antiknock compound advertisement, under Ethyl Corporation sponsorship, appears. Initial "ad" runs in Saturday Evening Post.

August 6........ First shipment of "Ethyl" fluid to the Navy. Shipment made to the Naval Aircraft Factory in Philadelphia.

1926

................ Dr. Graham Edgar of Ethyl Corporation creates octane scale.

January 2....... Ethyl Corporation research laboratory, transferred from Moraine City begins operations in converted garage in Yonkers, N.Y. First gasoline testing laboratory soon established.

January........ Surgeon General's committee reports use of "Ethyl" antiknock compound in motor fuels not a health hazard; recommends controls and safeguards of distribution and use to insure protection of oil company employees.

February 23 .... Patent for use of tetraethyl lead in motor fuels granted Ethyl Corporation.

June 1.......... Sale of "Ethyl" antiknock compound to oil companies and "Ethyl" gasoline to public is resumed.

November 23.... First triptane made in U.S. produced at Ethyl Corporation Research Laboratories.

1927

November....... Transfer of research departments from Yonkers to Detroit started. Engineering research laboratories established at 723 East Milwaukee Avenue, Detroit.

1928

October 8....... Gasoline testing laboratories established in New Orleans and Omaha.

November 16 . . . . Board of directors approves million dollar advertising budget.

1929

April 16 . . . . . . . . Gasoline testing laboratory established in Detroit.

July 15 . . . . . . . . . Second plant for manufacture of tetraethyl lead completed at Deepwater.

October 19. . . . . . Successful development of knockmeter for knock-testing engine announced. Knockmeter was conceived and designed by Ethyl research engineers.

1930

. . . . . . . . . . . . . . . . Ethyl Corporation and AC Spark Plug Company enter agree- for marketing of carbon remover (REMO).

February 26 . . . . . First Series 30 Ethyl Corporation knock testing engine shipped from Detroit laboratories. Recipient is Standard Oil Develop- ment Company.

March 3. . . . . . . . . Third plant for manufacture of tetraethyl lead completed at Deepwater.

April. . . . . . . . . . . Administrative offices of Ethyl Corporation moved from Cunard Building, New York City, to Chrysler Building, New York City.

May 23 . . . . . . . . . First tetraethyl lead manufacturing plant to be erected at Deep- water closed down permanently.

July 7. . . . . . . . . . . Gasoline testing laboratory established in Tulsa.

September 17. . . . . First tank car shipment of "Ethyl" antiknock compound leaves Carney's Point, N. J. Shipment consigned to Skelly Oil Com- pany at Eldorado, Kansas.

October 20 ...... Ethyl Export Corporation formed to market "Ethyl" antiknock compound in foreign countries.

1931

May 5 .......... Contract executed with Dow Chemical Company for construction at Kure Beach, N. C., of an experimental plant for extraction of bromine from the sea.

November 9 ..... Gasoline testing laboratory moved from New Orleans to Baton Rouge.

1932

November ....... Chemical research department transferred from Yonkers to 723 East Milwaukee Avenue, Detroit.

1933

June 1 .......... "Q" brand of antiknock compound offered for sale to oil companies for adding to regular grade gasoline.

August 3 ........ Fourth plant for manufacture of tetraethyl lead completed at Deepwater.

August 4 ....... Ethyl Corporation and Dow Chemical Company form jointly owned Ethyl-Dow Chemical Company for commercial extraction of bromine from sea.

September 27 .... First tank truck shipment of "Ethyl" antiknock compound. Shipment consigned to Richfield Oil Company at Schenectady, N. Y.

1934

January 10 ...... Ethyl-Dow Chemical Company plant for extracting bromine from sea water opened at Küre Beach, N. C.

July 13. . . . . . . . . . Ethyl Corporation engineers successfully test farm tractor converted from low compression ratio to high compression ratio.

October. . . . . . . . . First issue of ETHYL NEWS.

1935

March 9 . . . . . . . . Vehicles and personnel from Detroit laboratories arrive at San Bernardino, California, to open new road research laboratory.

June 14 . . . . . . . . . Fifth plant for manufacture of tetraethyl lead completed at Deepwater.

1936

June 1 . . . . . . . . . . First showing of Motor Clinic, at Glendale, California.

August 6 . . . . . . . Site in Baton Rouge selected for proposed new plant for manufacture of "Ethyl" antiknock compound.

September 1 . . . . . Safety Division formed.

1936

October 6 . . . . . . . Construction of Baton Rouge plant started.

December. . . . . . . Chemical research pilot plant opened at present location of Detroit laboratories at 1600 West Eight Mile Road.

1937

. . . . . . . . . . . . . . . . Expansion at Kure Beach bromine extraction plant doubles capacity for production of ethylene dibromide.

January 1 . . . . . . . Ethyl Corporation adopts policy of absorbing freight charges on tank car and tank truck shipments of "Ethyl" antiknock compound.

1937

September 17.... First tetraethyl lead manufacturing unit at Baton Rouge plant begins operations.

1938

January 1....... Deepwater plant facilities leased from DuPont. Operation under Manufacturing Service Agreement begins.

March 1........ Second tetraethyl lead manufacturing unit at Baton Rouge plant begins operations.

July 16.......... First ethyl chloride unit at Baton Rouge plant begins operations.

October........ Present laboratory building at San Bernardino opened.

November 29.... Gasoline testing laboratory established at San Bernardino.

1939

January 12....... First broadcast of Ethyl radio show entitled "Tune-Up Time."

March 1......... Third and fourth tetraethyl lead manufacturing units at Baton Rouge plant begin operations. Sodium unit at Baton Rouge plant begins operations.

April 25........ Second ethyl chloride unit at Baton Rouge plant begins operations.

May 1.......... Ethyl Export Corporation sold to stockholders of Associated Ethyl Company, Ltd.

July............ Graduate's Training School inaugurated at Detroit laboratories.

August 1........ First issue of THE ANTI-KNOCK.

December....... Chemical research department moved from 723 East Milwaukee Avenue to 1600 West Eight Mile Road Detroit.

1940

March 25....... U. S. Supreme Court upholds ruling by Federal Court of Southern District of New York that Ethyl Corporation jobber licensing system is illegal.

1941

January.........First issue of ETHYL BULLETIN BOARD.

January 2....... Fifth tetraethyl lead manufacturing unit at Baton Rouge plant completed. (This unit did not begin operations until August 1943).

February 26.... General Motors Parade of Progress, including an Ethyl Futurliner, begins nationwide tour at Miami, Florida. Ethyl Futurliner carries "The Story of Gasoline" and "The Story of Power" exhibits.

March 9........ Ethyl-Dow Chemical Company bromine extraction plant at Freeport, Texas, completed.

October 10.......Third ethyl chloride unit at Baton Rouge plant begins operations.

November 15.... Allocation of "Ethyl" antiknock compound taken over by Office of Petroleum Coordinator.

December....... Aeronautical and Engineering Research Departments moved from 723 E. Milwaukee Avenue to 1600 W. Eight Mile Road, Detroit.

1942

April 9......... Name of company changed to Ethyl Corporation.

August 30.......Hydrochloric acid unit at Baton Rouge plant for easing war-time chlorine shortage starts production.

October 1....... First sale of "Ethyl" brand salt cake. Shipment goes to International Paper Company.

October 30...... One half of one of the ethyl chloride units at Baton Rouge plant converted into unit for manufacturing ethylene dichloride for use in production of thiokol, a synthetic rubber.

<u>1943</u>

February 2......Twentieth anniversary of first sale of "Ethyl" gasoline observed at home of Mr. Midgley in Worthington, Ohio.

March 14........Pilot plant established at Baton Rouge plant for testing process for making butadiene, compound used in manufacture of synthetic rubber.

August 2........Army-Navy "E" awarded Deepwater plant.

August 6........Army-Navy "E" awarded Baton Rouge plant.

December 8.....Ethyl Corporation cited for "meritorious contribution to the design, construction, and operation of the American synthetic rubber industry." Award made by <u>Chemical Engineering</u> magazine.

<u>1944</u>

March 19........First sale of "Ethyl" Cleaner.

April 11..........Addition to Freeport bromine extraction plant goes "on stream."

July 1.......... Army-Navy "E" awarded Kure Beach plant.

November 2.....Death of Mr. Midgley at Worthington, Ohio.

December 2.....Army-Navy "E" star awarded Baton Rouge plant.

Army-Navy "E" star awarded Deepwater plant.

December 22....Duplicate plant of original Freeport bromine extraction plant completed at Freeport.

1945

February 3 . . . . . Army-Navy "E" star awarded Kure Beach plant.

February 6. . . . . .New water purification unit at Baton Rouge plant begins operations.

May 1 . . . . . . . . . . .Ethyl Corporation takes over operation of sodium unit from DuPont at Baton Rouge plant.

June 23. . . . . . . . . Second Army-Navy "E" star awarded Deepwater plant.

September 1. . . . . Research laboratories at 1600 West Eight Mile Road, Detroit. consolidated.

September 15 . . . .Contract with DuPont for operation of certain units at Baton Rouge plant ended. Ethyl Corporation takes over management of entire installation.

October 30. . . . . . Unit for making ethyl chloride by new CP process at Baton Rouge begins operations.

November 30. . . . Kure Beach bromine extraction plant closed and placed on "stand-by" status.

1946

January 2. . . . . . . Ethyl Specialties Corporation, subsidiary of Ethyl Corporation, formed.

April 2 . . . . . . . . .Order by Civilian Production Administration curtails Ethyl Corporation's consumption of metallic lead and deliveries of "Ethyl" antiknock compound. Ceiling of 80 octane (motor method) set for premium gasoline.

April 18. . . . . . . . .Employee cafeteria at Baton Rouge plant opened.

June 1. . . . . . . . . . New order by Civilian Production Administration sets temporary 78.5 (Motor Method) octane ceiling on premium gasoline.

1946

July 22......... U.S. Department of Justice dismisses Ethyl Corporation from "Mother Hubbard" anti-trust suit before case goes to trial.

November 14-16.. First formal public showing of Detroit Research Laboratories at 1600 West Eight Mile Road.

December 26.....Civilian Production Administration lifts orders of April and June, which restricted Ethyl Corporation's consumption of metallic lead and deliveries of finished product and set octane maximum on gasoline containing "Ethyl" antiknock compound.

1947

January 1....... Sales Department reorganized on regional basis.

February 1......Reorganized employee security plan put into effect. Former AIS plan and General Motors Group Insurance Plan replaced by Ethyl Retirement Income Plan, Ethyl Group Life Insurance and Hospitalization Plan, and Ethyl Accident and Sickness Benefit Plan.

February 1...... Product Development Department formed.

June 17..........First announcement of multi-million dollar expansion of Baton Rouge plant.

July 1.......... Ethyl Specialties Corporation dissolved.

August 9........ Edward L. Shea elected president of Ethyl Corporation. Earle W. Webb elected Chairman of the Board.

December 10.... Ceremonies held at Detroit to mark 20th anniversary of transfer of the Research Laboratories from Yonkers.

December 20 .... Baton Rouge plant produces one billionth pound of ethyl chloride.

1948

January 2....... Field terminal at Edge Moor, Delaware, begins operations.

February........ Twenty-fifth anniversary of first sale of "Ethyl" gasoline marked by special issue of ETHYL NEWS.

February........ First Ethyl 25-year service pins awarded to Charles (Pat) Harding, Robert Jordan, and Harry Mack.

February 9...... Earle Webb, reaching retirement age, resigns as Chairman of Board.

February 10..... New drumming plant at Baton Rouge begins operations.

April........... New Chemical Workshop building at Detroit begins operations.

April 22........ Baton Rouge plant produces one billionth pound of tetraethyl lead.

May 1........... Industrial Relations Department formed. Former Employee and Public Relations Department divided into separate departments.

May 11.......... Field terminal at Wilmington, California, begins operations.

July 1.......... First increase in selling price of "Ethyl" antiknock compound effective. New price set at .20 cents per cc for Motor Mix and .22 cents per cc for Aviation Mix.

October 17...... New nitrogen plant, first completed unit of Baton Rouge post-war expansion program, begins operations.

November....... Chemical Sales Division formed to market salt cake and other chemical products.

1987

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T-Bone

Nat'l R. [illegible]

Nat'l Real Estate - $500,000

Dow $\frac{50}{30}$