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VLADIMIR NIKOLAEVICH IPATIEFF

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A Biographical Memoir by
LEWIS SCHMERLING

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BY LOUIS SCHMERLING

FORTUNATELY FOR BOTH the scientific and the industrial worlds, Vladimir Nikolaevich Ipatieff, who was born in Moscow on November 21, 1867, did not maintain his original intent to have a military career. When he was eleven years old, he was enrolled at the Third Moscow Military Gymnasium after three years in a classical gymnasium. He had no difficulty completing the courses, but his grades were poor until he was promoted to the sixth class at the age of fourteen. His favorite subject was mathematics, which he studied beyond the class requirements. His report card showed steady improvement, particularly in science courses. However, on being graduated at the age of sixteen, his application to the Mikhail Artillery School in St. Petersburg was rejected on the basis of his grades. He entered the Alexander Military School in Moscow, where he received an intense military education. He ranked near the top of his class and, rather than accept rank as sergeant, he decided to transfer in September 1886 to the Mikhail Artillery School, to which he was now admitted, the 450 ruble tuition being waived because he had the highest grades in his class in mechanics, artillery, and chemistry. He became an officer (lieu-

* The author gratefully acknowledges his particular indebtedness to Dr. Vladimir Haensel for suggesting that he write this biography and for his helpful advice and comments throughout.

tenant) * on August 7, 1887, a day that he considered memorable because of the solar eclipse that occurred and the concurrent scientific flight in a balloon made by a famous chemist, Dimitrii I. Mendeleev. Using part of the money he received from the government and from his father for officer's equipment, he furnished a small chemistry laboratory in his home where he could study qualitative analysis (quantitative analysis being beyond his means because a balance was too expensive).

After a four weeks' vacation, Lt. Ipatieff chose to join the Second Reserve Artillery Brigade and became a teacher of arithmetic and artillery at a battery school in Serpukhov (about 60 miles from Moscow). Since his classes were in the morning, he could devote his afternoons to studying chemistry, largely from two Russian language books: Mendeleev's *The Fundamentals of Chemistry* (3d edition, 1884), and Menshutkin's *Analytical Chemistry*, books that he claimed were his real teachers.

After teaching for two years, he passed competitive entrance examinations and, in September 1889 was admitted to the Mikhail Artillery Academy in St. Petersburg, which had been founded to give technical training to officers who were to serve as engineers in government munitions plants, as inspectors of materials furnished by private concerns, or as members of the Artillery Committee of the Chief Artillery Administration.

Unfortunately (from Ipatieff's viewpoint), the supposedly well-equipped chemical laboratory at the Academy was less useful than it could have been: it had equipment for classes in qualitative and quantitative analysis, but not in organic chemistry.

* Graduates of an institution such as the Mikhail Artillery School were given commissions and assigned to (or, if their grades were high, permitted to choose) active duty. Then, after serving in the army for a few years and after passing stiff competitive examinations, they could enter academies (such as the Mikhail Artillery Academy) for specialized training that led to high positions in the army or in military educational institutions.

Ipatieff moved his home laboratory to his apartment in order to carry out experiments while studying for examinations. He found it necessary to get approval from the Governor of St. Petersburg because the police were suspicious of home laboratories, which might be used to prepare explosives.

He received industrial experience in his junior year when he spent June and July working at plants and factories, particularly in steel mills. He spent much time learning analytical methods of metallurgy. He commuted to the plants in order to be able to use his own laboratory in the evening. He was criticized by his supervisor (and his final grade was low) for spending more time in his laboratory than at the plants, but he had no regrets because he felt he learned much there that helped him all his life.

Fellow students found Ipatieff's notes quite useful and persuaded him to prepare manuals of qualitative and quantitative analysis; these were subsequently published in 1891 by the Academy.

Much of Ipatieff's time at the Academy was spent studying the properties and analysis of steel, working with the renowned Russian metallurgist, Professor Dimitrii K. Chernov. This resulted in 1892 in his first publication, "The Chemical Investigation of the Structure of Steel." Largely due to this work and to his manuals, Ipatieff was retained by the Academy as an instructor (with the military rank of captain) after he was graduated on May 30, 1892, third highest in his class. He was granted a short leave of absence, which he used to travel to Moscow to marry Varvara Ermakova, whom he had known for ten years.

His first teaching duties involved a junior class course in qualitative analysis. He decided to devote one hour a week to lectures on the laws of chemistry because he realized the deficiency of his chemical education at the Academy. He published a set of notes entitled, *Principal Laws of Chemistry.*

Academy regulations required that in order to continue teaching all instructors present an approved dissertation three years after their appointment as instructors. Ipatieff asked the advice of Professor A. E. Favorsky of St. Petersburg University, who was lecturing on organic chemistry at the Academy. Favorsky suggested that he study organic chemistry and carry out research in that field. "For," said Favorsky, "it is only in organic chemistry that you will learn to think chemically and to experiment rationally." Ipatieff therefore took a course in organic chemistry from N. A. Menshutkin at the University of St. Petersburg, but found that although he profited from the lectures, he did not find them interesting because Menshutkin presented them chiefly from an analytical and physical chemistry viewpoint. Ipatieff devoted himself to studying A. M. Butlerov's textbook of organic chemistry.

His first practical work in organic chemistry was carried out in Favorsky's laboratory, where he started to study the isomerization of allene hydrocarbons to disubstituted acetylenes, as proposed in Favorsky's master's thesis. He spent much time learning how to prepare dimethylpropylcarbinol by the reaction of dimethylzinc with the butyryl chloride. By the end of the spring of 1893, he had prepared two pounds of the tertiary alcohol. He studied the action of bromine on tertiary alcohols (usually using the commercially available *tert*-butyl alcohol) to obtain a dibromide from which an allene could be prepared. This and subsequent work formed his dissertation, "The Action of Bromine on Tertiary Alcohols and of Hydrogen Bromide Upon Acetylene and Allene Hydrocarbons in Acetic Acid Solutions," which was presented and accepted in 1895. Ipatieff became an assistant professor and taught both inorganic and organic chemistry. He was awarded the first of his many (about twenty-five) awards in 1895—the Order of St. Stanislaus, third class.

In 1896, the Academy, which was entitled to send one of its instructors abroad each year, decided to send Ipatieff to study chemistry and the new explosives in use in other countries. Favorsky suggested that he go to Munich to work in the laboratory of Adolf von Baeyer, to whom Favorsky immediately wrote, enclosing a copy of Ipatieff's dissertation, published in German. This letter and one from a Russian classmate of Baeyer resulted in Baeyer's accepting Ipatieff as an assistant for joint work. Baeyer suggested that Ipatieff study the structure of the terpene derivative, carone. Based largely on the determination of the structure of the caronic acids formed by permanganate oxidation of carone, Ipatieff was able to prove the structure of carone in about four or five months. Baeyer was so pleased by his assistant's work that he told Ipatieff to write up the investigation so they might publish it jointly rather than, as was usually the case, publish in Baeyer's name only with an expression of gratitude to the young co-worker at the end of the paper.

The remainder of Ipatieff's research in Munich was independent work, to which he turned at Baeyer's suggestion. He chose to finish work on a problem he had started at the Academy, the action of hydrogen bromide on allenes and other dienes. He found that addition of hydrogen bromide to 1,1-dimethylallene yielded the same dibromide as did its addition to isoprene. Dehydrobromination of the dibromide prepared from dimethylallene yielded isoprene, and Ipatieff was thus the first chemist to synthesize and then prove the structure of isoprene.

While in Baeyer's laboratory, Ipatieff met Dr. Richard Willstaetter of Germany, who later became noted for organic research, particularly the synthesis of chlorophyll, and Dr. Moses Gomberg of the United States, who would later discover stable free radicals. They remained lifelong friends.

Before returning to St. Petersburg in 1897, Ipatieff visited chemists in Germany and France, including Rudolf Fittig, Pierre Berthelot, and Charles Friedel. He inspected military institutions and discussed ballistics. While in France, he spent four months with Paul Vielle, discoverer of smokeless gunpowder, studying the combustion of ballastite at various charging densities to check the accuracy of the parallel layer combustion theory.

Ipatieff carried out his usual large quantity of research experiments when he returned to the Artillery Academy. He was appointed a member of the Explosives Commission and of the Fifth Section of the Artillery Committee, which dealt with gunpowder and chemical questions. He also accepted appointment as assistant professor at the Institute of Civil Engineers to teach chemistry and to supervise student experiments. Despite all these interests, he found time to attend the Second International Congress on Pure and Applied Chemistry in Vienna in the spring of 1898 and to write his dissertation on allene hydrocarbons, on the action of nitrosyl chloride and nitrogen oxide on unsaturated compounds, and on the synthesis of isoprene. Acceptance of his dissertation at a public examination resulted in his being given the title Professor of Chemistry and Explosives.

As the first chemistry teacher to hold the rank of professor at the Artillery Academy, Ipatieff redesigned and refurnished the laboratories and wrote textbooks on inorganic (seven revised editions) and organic chemistry (six revised editions).

In 1900 he began to prepare a large quantity of butadiene by the only method then known—the passage of isopentyl alcohol vapors through a heated tube at about 600°C. However, he obtained isovaleraldehyde and hydrogen instead of the expected butadiene, methane, and water. He found that when he used a glass or quartz tube instead of the iron tube he had used in his earlier experiments, there was no reaction unless the temperature was raised to 700°C. Similar experiments showed that passage of other primary alcohols through the hot iron tube (but not the quartz tube) produced aldehyde and hydrogen, secondary alcohols yielded ketones and hydrogen, and tertiary alcohols underwent no reaction other than dehydration. Ipatieff concluded that the iron wall of the tube caused the dehydrogenation of the alcohols without undergoing any change; in other words, there occurred a new phenomenon, which Russian chemists called a contact reaction and other European chemists called a catalytic reaction. The significance of Ipatieff's work was that he showed that such reactions could occur at high temperatures; it had been assumed that under such conditions there would be complete breakdown of the alcohol and no clean reaction would occur. It had been believed that the conversion of an organic compound could not be directed at temperatures above 250°C, certainly not at 500–600°C. Ipatieff also showed for the first time the influence of reaction vessel walls on a reaction. He became so interested in this subject that he dropped all other investigations and spent all his research time on catalysis, a field in which he made many outstanding contributions during the next fifty-one years.

He showed that easily reducible oxides and the metals (for example, zinc, cupric oxide, and copper) catalyzed the dehydrogenation of alcohols to ketones and aldehydes. On the other hand, when he used a graphite tube to investigate the effect of carbon, he was astonished to find that a different type of reaction occurred and at a lower temperature; ethyl alcohol was dehydrated to ethylene. Further investigation proved that the effect was due not to the graphite but to the clay binder used in the tube. Finally, Ipatieff showed that the difficult-to-reduce alumina in the clay was the dehydration catalyst.

In 1902 he was appointed Professor Ordinary at the Artillery Academy, a considerable promotion both in salary and rank. He also became a lecturer at the University of St. Petersburg, with which he was connected until 1916, taking over a course in general chemistry in 1906.

Because the chief function of the Academy was to train officers, Ipatieff found it difficult to find assistants for research. Nevertheless, he was able to discover new catalytic reactions, such as (in 1903) the isomerization of olefins over alumina or zinc chloride and the conversion of ethyl alcohol to butadiene in the presence of powdered aluminum at 600°C. Moreover, in order to study the effect of high pressure on catalytic reactions, he designed a rotating autoclave (or "bomb") having a closure consisting of a disk gasket of heat-treated copper or other metal between two knife edges, one on the autoclave top and the other on the bottom of the cover. The usefulness and safety of this piece of apparatus was proved by the many tens of thousands of experiments that were, and are still, carried out in it.

During the war between Russia and Japan (1904–1905), Ipatieff and other officers who had been graduated from the Artillery Academy and continued to work in technical institutions received promotions to the same ranks as men who had been graduated at the same time but had gone into active service. He became a colonel.

Despite the war and the political unrest that followed, Ipatieff's scientific research continued with little interruption. He investigated the effect of high pressures on such chemical processes as the addition of hydrogen to unsaturated hydrocarbons (olefins and aromatics), the destructive hydrogenation of organic compounds, and the polymerization of ethylene. These researches were destined to play an important role in the chemical industry. Ipatieff showed that the liquid phase hydrogenation of organic compounds is a more rapid reaction and in many cases proceeds farther than the vapor phase hydrogenation at atmospheric pressure, a reaction then being studied in France by Paul Sabatier and J. B. Senderens.

In 1906 the Russian Academy of Sciences awarded Ipatieff the 4000-ruble Ivanov Prize in recognition of his scientific work. This increased his prestige and resulted in his being permitted to submit a dissertation, "Catalytic Reactions Under High Pressures and Temperatures," to the University of St. Petersburg for the Doctor of Chemistry degree. Such permission was necessary because he had never been graduated from a classical gymnasium. A university regulation of 1884 made it possible to admit to public examination for higher degrees scientists whose achievements had made them famous; permission from the Minister of Education was necessary. Ipatieff received the permission, presented his dissertation, was examined publicly in February 1908, and was named a Doctor of Chemistry.

In 1909 Ipatieff discovered an important phenomenon, the "promoter effect" of additives on catalysts. He noticed that the high-pressure hydrogenation of olefins in the presence of copper oxide was slow when carried out in a bronze-lined autoclave, but rapid and complete when an iron autoclave was employed. He concluded that the iron wall of the autoclave was a promoter for the hydrogenation. Similarly, he found that complete hydrogenation occurred in the bronze-lined autoclave, if the added copper oxide was mixed with iron filings. Incorporation of promoters in catalysts is, of course, now widely used.

Having taught for twenty-five years, as an "ordinary professor" for ten, Ipatieff in 1912 was named emeritus professor, a position that permitted him to continue teaching for ten more years at the Academy and to draw a yearly pension of 1500 rubles.

His scientific life did not interfere with his military life. In 1910 he was promoted to the rank of major general; in 1914, lieutenant general. However, military factors did interrupt his research. During World War I, he was chairman of the Commission for the Preparation of Explosives, which by the end of the war controlled almost the entire chemical industry. In 1916 he was named chairman of the Chemical Committee of the Chief Artillery Administration, formed largely because of the German's use of poison gas. The Committee had five branches: poison gases, gas masks, explosives, incendiaries and flame throwers, and acids. It was concerned with developing the production of these items as well as deciding the best types to manufacture.*

The personnel of the Chemical Committee remained largely unchanged, even after the Russian Revolution in 1917, because most of its members were nonpartisan and worked only for the good of the country while sincerely regretting the mistakes of the old regime. The Chemical Committee was disbanded when it had relatively little to do after the war was almost over. The Bolshevik leaders asked Ipatieff to help convert the chemical industry from a wartime to a peacetime basis. He was appointed chairman of both the Chemical Committee of the Chief Artillery Administration and the Technical Section of the War Council, positions from which he was relieved in June 1918 when he pointed out that he would be more useful if his scientific ability were used. He served as chairman of the Chemical Administration of the Supreme Council of National Economy (S.C.N.E.) during 1921–1926.

He found life in St. Petersburg (now renamed Petrograd) quite unpleasant in 1919–1920. Malnutrition and fuel shortage led to epidemics; typhoid fever raged through the city. Food was rationed. Work in the laboratory ceased in 1918 because water pipes froze and there was no gas supply or heating fuel. About all he did was attend meetings of the Academy of Sciences (to which he had been elected as one of the three chemist members in January 1916) twice each month and give a weekly two-hour lecture at the Artillery Academy to about seven students, who wore overcoats in the unheated classroom.

Ipatieff and his family survived the Revolution largely because some of the leaders realized that the country had to make good use of a man with his scientific ability and because he was friendly with all people, whether revolutionists or peasants.

* The work and political affairs of the Commission and the Committee are discussed in a most interesting and detailed manner in Ipatieff's memoirs, *The Life of a Chemist*, pp. 190–236.

In 1920 Ipatieff was chosen to direct the Central Chemical Laboratory (previously the Centeral Laboratory of the Ministry of War) in Petrograd, since he had done so well in reorganizing the chemical industry as chairman of the special commission of the Chemical Committee of the S.C.N.E. Unfortunately, he had difficulty obtaining chemicals and apparatus, particularly because foreign purchases were not approved. One advantage of his connection with the laboratory (renamed the National Institute of Scientific and Technical Investigation) was its food research department, the investigations of which were paid for in food that was distributed to the hungry research workers and their families. Ipatieff was able to resume research in high-pressure catalysis using equipment he moved from the laboratory in the Artillery Academy. His chief areas of study were destructive hydrogenation of polynuclear aromatic hydrocarbons into mononuclear aromatic hydrocarbons and conversion of carbonic acid into formic acid.

However, much of his time was spent making trips to Germany, England, France, and other European countries to negotiate for chemical supplies for his laboratory in Russia. He was also very busy on his return to Russia with committees concerned with the development of the chemical industry. He became chairman of the Scientific Technical Administration, which had jurisdiction over fourteen institutes, ranging from The Institute of Fertilizers to The Aerodynamic Institute and The Chief Bureau of Weights and Measures. The Administration also subsidized many scientists working in other laboratories on problems of interest to industry.

Ipatieff was considered a government official even though he never became a Communist Party member. He gave many personal reports to Lenin and, after 1924, to Trotsky. Early in 1926, Trotsky became the chairman (in name only) of the Scientific Technical Administration, while Ipatieff remained on the board as vice-chairman. In 1926 both were removed from the Administration, chiefly as a result of disputes over development of one or another branch of the chemical industry, particularly nitrogen fixation and dyes, but Ipatieff remained chairman of a special Technical Council of the Chemical Administration.

Ipatieff's interest in scientific chemistry remained high, and in 1926 he resumed annual publication of a large number of papers. In January 1927 he signed a contract, with Soviet approval, to establish research on high pressure and catalysis in the Bayerische Stickstoff Werke in Berlin, agreeing to devote three periods of one and one-half months each in Germany. The government approval was probably granted to "atone" for Ipatieff's incomprehensible removal from the technical committees and because it had been agreed that the USSR would share in any discoveries or inventions that resulted. Ipatieff worked very happily in the new surroundings; the laboratory personnel were friendly and, best of all, he was free to concentrate on purely experimental work.

The Soviet government recognized Ipatieff's scientific ability. In 1927 he was awarded the Lenin Prize for his work on catalysis and high pressure. In May a banquet in his honor celebrated the thirty-fifth anniversary of the publication of his first paper.

A month later he spoke on his latest achievements at a meeting sponsored by German scientific societies, to which were invited about twenty prominent Russian scientists to discuss their researches. At a dinner during this "Scientific Week," he was asked why he did not leave Russia and live in a country where his scientific work would find a more favorable environment. Without hesitation, he replied as he had on other occasions to similar questions; he felt it his patriotic duty to remain in his country for the remainder of his life and to devote all his ability to meeting its needs. Professor Albert Einstein, who overheard the question and answer, remarked that he agreed. However, within six years both men left their respective countries on grounds that fully justified their actions. Nevertheless, Ipatieff, and also probably Einstein, long felt that he had betrayed his beliefs and deserted his country.

In 1927 Ipatieff founded and directed the Institute of High Pressures in the Artillery Academy. Work developed efficiently and smoothly, with his son, Vladimir, one of the twelve men working under his direction. The research included the precipitation of metals and oxides from aqueous solutions by hydrogen and the oxidation of phosphorus by water under pressure. As consultant to Bayerische Stickstoff Werke, he developed the latter reaction into an industrial process for the manufacture of phosphoric acid for use in the manufacture of fertilizers.

Although Ipatieff's research projects were extremely successful and resulted in many publications; although the government sent him as its delegate to many international meetings, including the International Bureau of Pure and Applied Chemistry in The Hague (1928), the Congress on Industrial Chemistry in Strasbourg (1928), and the International Engineering Congress in Tokyo (1929); and although he was appointed chairman of the chemical committee of the Russian Academy of Sciences (1928), he could not keep from worrying about the future. Many chemists were arrested by the G.P.U. (State Political Administration), and rumors, confirmed by friends close to the G.P.U., suggested that Ipatieff's name was fourth on a list of chemists being considered for arrest, largely because of the government's dissatisfaction with his work in Germany (despite its earlier approval). Therefore, when he was appointed to replace a professor of electricity who was to be one of ten delegates to the International Power Congress in Berlin, but who could not go because the G.P.U. had arrested him, Ipatieff was pleased to accept. While wives were usually not permitted to go abroad with their husbands, Ipatieff succeeded in getting his wife's passport in only three days by saying he would be a delegate only if she could accompany him, because she needed medical treatment abroad. They crossed the Russian border at Negorloe on June 12, 1930. Most of their personal possessions were left behind; Ipatieff had not told even his wife (until they had left the country) that he did not expect to return to his beloved Russia, to Leningrad (formerly Petrograd), or to the laboratories.

At the Berlin meeting, Ipatieff met many chemists prominent in the chemical industries of various countries. One of these was Dr. Gustav Egloff of the Universal Oil Products Company (UOP) in Chicago, with whom Ipatieff conversed in German because he did not speak English. He mentioned his interest in visiting laboratories in the United States. Egloff helped him get the necessary visa from the American Consul and in September the Ipatieffs arrived in New York City. Ipatieff met with Hiram Halle, president of UOP; after a visit to the company's research laboratories in Riverside, Illinois, he accepted Halle's invitation to become Director of Chemical Research. It was agreed that he would spend six months a year, for the first three years, in Germany, where he was under contract to the Bayerische Stickstoff Werke. He returned to Berlin, where his work was concerned chiefly with the precipitation of pure aluminum oxide and of various metals and their oxides by the action of hydrogen on solutions of salts.

In May 1931 Ipatieff and his wife returned to the United States, where he was permitted to remain as lecturer on catalysis in organic chemistry at Northwestern University, a position offered to him by Professor Ward V. Evans.* For several years Ipatieff gave one lecture a week at the University (a task that made him practice the English he was studying intensively with

* In a speech made at a dinner held in celebration of Ipatieff's seventy-fifth birthday, Evans said, "When I cash in, and they see fit to enumerate the little things I have been able to do, I hope they say, 'He brought Ipatieff to Northwestern University.' This will be glory enough for me."

a private tutor); he spent the remainder of the week supervising research at UOP. Subsequently, he spent Wednesdays and Saturdays at the University and the remainder of the week at UOP. He Americanized his appearance by shaving off his beard. Thus, at sixty-four, the age at which most men are getting ready to retire, Ipatieff began to study a difficult new language and to carry out research with the objective of applying catalysis to petroleum technology. The Professor (the name by which Ipatieff was known at UOP) and his co-workers developed several catalysts and processes, at the same time adding to the fundamental knowledge of hydrocarbon reactions.

It was found that, unlike sulfuric acid, which catalyzed the polymerization of olefins to produce not only olefins but also paraffins and dienes (a reaction the Professor named "conjunct polymerization"), phosphoric acid resulted in only olefinic polymers ("true polymerization"). A solid catalyst (kieselguhr impregnated with phosphoric acid) was developed and was already used industrially by 1935 for the conversion of gaseous olefins (formerly waste matter) to liquid gasoline having a high octane number, especially after hydrogenation. This was the first of many catalysts employed in continuous flow petroleum refining processes. It is still in worldwide use.

Other reactions discovered and applied industrially included the catalytic alkylation of olefins by isoparaffins, previously believed to be the most inert of all organic substances, and the isomerization of saturated hydrocarbons, for example, of *n*-butane to isobutane. Processes based on these reactions produced high-octane aviation gasoline and played an important role in the winning of World War II. The processes are still used in the production of motor fuel.

Many other chemical advances, a number of which found practical application, were made by Ipatieff and his research group during his UOP career. These included the development of hydrogenation and dehydrogenation catalysts, the alkylation of aromatic compounds, the demethylation of paraffins, and other reactions. (See the titles of the almost 160 papers published in 1933–1954, listed in the appended bibliography.) His name appeared as inventor or co-inventor on more than two hundred U.S. patents.

Early in this writer's career at UOP, the Professor mentioned that he wanted each chemist working under his supervision to have two problems, one for the company and one for the chemist's chemical soul. The chemical soul problem, which occupied 10–15 percent of the chemist's time, often became a company problem. A most important example of such a problem was the isomerization of *n*-butane, studied by Herman Pines despite the fact that the higher boiling *n*-butane could be sold as a component of gasoline (at least in cold weather) and was more valuable than isobutane; it was not then fully appreciated that only isobutane undergoes catalytic alkylation to yield high-octane gasoline and would be used in an important commercial process.

Another research principle that the Professor emphasized at UOP was that new reactions being investigated, even in an industrial organization, should be studied first with pure compounds and then applied to commercial mixtures. He felt it was easier and quicker to understand the results and reach conclusions when relatively simple products, rather than complex mixtures, were obtained.

Soon after his arrival in the United States, the Professor began work on his chemical autobiography, *Catalytic Reactions at High Temperatures and Pressures.* This was a well-organized review of all the catalytic work he and his collaborators carried out from the time he first showed (in 1901) that inorganic substances induce organic reactions until 1936. He wrote the book because many chemists pointed out the desirability of a work that would coordinate his isolated papers, many of which had been published in various Russian and other foreign journals.

Furthermore, he was extremely irritated by the treatment his work had received by authors of books on catalysis; he was annoyed by the fact that his contributions were ignored and credit for the reactions he had discovered was given to others. His book was published in Russian in April 1936 by the Russian Academy of Sciences, which asked his son, Vladimir, to edit it. Several months later, the English translation appeared.

The writing of this chemical autobiography and of his memoirs, *The Life of a Chemist,* illustrates one of the outstanding characteristics of the Professor—his strict self-discipline, which was probably a result of his military training. He was able to write the books by making sure that he wrote at least three pages each morning before leaving his Chicago residence for the UOP laboratory in suburban Riverside. He took advantage of the time spent on the train (about forty minutes round trip) to study English, by reading novels.

Occasionally, when excited over an idea he was anxious to impart to his assistants, the Professor would burst into the laboratory and start talking rapidly in Russian. The blank look on his assistants' faces quickly let him know what was wrong; with a smile and an "excuse me," he would start over again, just as excited, but now in English.

He had a most gracious personality: considerate, courteous, and charming. He never regarded the people working with him as his subordinates. He often asked about their families and was genuinely sorry to hear of illnesses and misfortunes. He did not reprimand, but suggested and taught in a most unobtrusive manner. It was never necessary for him to assert his authority; he inspired cooperation and encouraged independent thought.

While in the United States, the Professor was repeatedly visited by Troyanovsky, Soviet ambassador to the United States and a former chemistry pupil, who tried to persuade him to return to Russia. He was asked to come back to help solve the many problems of the Russian industry. The Professor explained that this was impossible because of his contract with UOP, and suggested that Russia would benefit by licensing processes for which he was responsible, such as polymerization of gaseous olefins. His refusal to return resulted in his being expelled from the Russian Academy of Sciences in January 1937; he was deprived of his Soviet citizenship and forbidden to return to the USSR. The Professor took the expulsions quite philosophically; he was convinced that the Soviet government could not deprive him of honors given by the Tsarist regime for scientific work and not for political beliefs. Furthermore, he became a United States citizen on March 11, 1937; his wife became one a month later. On April 26, 1939, he was elected to membership in the National Academy of Sciences.

Ipatieff's attachment to chemistry was obvious to all who knew him. A UOP chemist recalls being surprised soon after beginning work at the company to find the Professor working at a laboratory bench on which there were chemicals, test tubes, flasks, distilling columns, and other glassware. He asked the Professor (in Russian, the mother tongue of both men) whether his assistant was away, thus causing him to be in the laboratory. The Professor drew himself up and replied, "I am doing some of my own research because I love intimacy with chemistry. I love to carry out experiments with my own hands, to see and smell transformations of matter."

The Professor was deeply religious and completely unprejudiced. When he took the United States citizenship examination, he answered in the affirmative when asked whether he went to church. In answer to the next question, "What church do you attend?", Ipatieff replied, "Any church; this is a free country." This was the final question.

Once, when the Professor and the writer were having a lengthy discussion as to why an unexpected result had been obtained in an experiment, the writer remarked in exasperation, "Only God knows!" The Professor answered, "Yes, but He doesn't care."

The Professor had a favorite phrase that he used to keep the chemists working with him from leaping to unwarranted conclusions based on the unexpected results of an experiment. "Remember," he would warn, *"ein Experiment ist kein Experiment."*

In 1939 he deposited $35,000 with Northwestern University to establish the Ipatieff Prize ($3000) to be awarded triennially by the American Chemical Society for outstanding chemical experimental work performed in the field of catalysis and high pressures by a chemist not yet 40 years old. When asked why he limited the prize to chemists under 40, he replied that honors were for old men; young men needed money.

The Professor also established a fund at Northwestern in 1939 to institute a high-pressure catalytic labortaory, which the University named the Ipatieff High Pressure and Catalytic Laboratory and which UOP insisted on equipping because the company appreciated Ipatieff's scientific and technical work. The Professor not only kept financing the laboratory while he was its director, but also named it principal beneficiary of his will.

Work carried out in the laboratory included catalytic condensation of alcohols with ketones and other reactions of alcohols. Most work was concerned with terpenes, for example their polymerization, alkylation, and isomerization; this was done chiefly because reactions of these hydrocarbons were not being studied in the UOP laboratories.

The Professor's fortitude is illustrated by his preparations for a throat operation he underwent in December 1939. His throat had been inflamed and his voice hoarse for some months. He carefully kept the matter secret from his associates, and told everyone he was taking a month's vacation. He and his assistants laid out a program of research work to be carried out in his absence and made other plans, just as they had done before his other vacations. He said his goodbyes and left with no hint that he might soon undergo a serious operation. On December 2 he had a minor but torturous operation for the removal of tissue for examination purposes. On December 8 he learned it was cancerous. The operation, performed on December 18, was successful; but for the remainder of his life, the Professor spoke in a hoarse whisper. When he received the Willard Gibbs Medal of the Chicago Section of the American Chemical Society on May 24, 1940, his acceptance speech had to be read for him because he was forbidden by his physician to deliver any public speeches. However, it was not long before he was again able to speak at meetings.

In 1951 the Professor flew to The Hague to attend the Third World Petroleum Congress. Though 84, he had never flown before. Dr. Vladimir Haensel, who accompanied him, remembers the event: "I would not say he was apprehensive, but, for reassurance, after he got into his seat and put on the belt, he crossed himself and from there on really enjoyed the trip. He had faith in God and faith in experienced personnel, and felt that this was a pretty good combination. We came back on the *Queen Mary* with Ipatieff strolling the deck while the ship was rolling and pitching violently, and most passengers were staying in their cabins. The flight back was not needed—he *had* done it once."

Still actively engaged in research, Ipatieff died in Chicago on November 29, 1952. His wife died only ten days later. They were survived by two of their four children: their youngest son, Vladimir, a professor of chemistry in Leningrad, and their daughter, Anna. Their other two sons had passed away earlier—his first son, Dimitrii, was killed in action on the Vilna front during World War I, and his next son, Nicolai, died of yellow fever in 1934 in the Belgian Congo, where he was working as a government food inspector.

THIS BIOGRAPHY could not have been written without the aid of Ipatieff's autobiography, *The Life of a Chemist,* which presents in

520 pages a detailed description of the Professor's schooldays, his scientific life, and his relations with the Russian governments, ending with his emigration to the United States in 1930. His shorter memoir, *My Life in the United States* (two hundred pages), covers the succeeding years until February 1941. I also depended on my own memories as well as those of many of my colleagues.

HONORS AND DISTINCTIONS

AWARDS AND MEDALS

1895 Order of St. Stanislaus, 3d Class
1896 Minor Butlerov Prize, Russian Physical–Chemical Society
1898 Order of St. Anna, 3d Class
1902 Order of St. Stanislaus, 2d Class
1904 Order of St. Anna, 2d Class
1904 Order of St. Vladimir, 4th Class
1906 Ivanov Prize, Russian Academy of Sciences
1907 Order of St. Vladimir, 3d Class
1913 Moshnin Prize, University of Moscow
1913 Order of St. Stanislaus, 1st Class with Star
1913 Order of St. Alexander (awarded by the King of Bulgaria)
1915 Order of St. Anna, 1st Class with Star
1916 Commander of the French Legion of Honor
1916 Order of St. Vladimir, 2d Class with Star
1920 Major Butlerov Prize
1927 Lenin Prize, Soviet Government
1928 Berthelot Medal
1939 Lavoisier Medal
1939 Medal presented by King Boris of Bulgaria
1940 Willard Gibbs Medal, Chicago Section, American Chemical Society
1940 Modern Pioneer Award, National Association of Manufacturers
1942 Honor Scroll, American Institute of Chemists
1943 Fawcett Aviation Award
1952 Chevalier of the Cross of Lorraine and Companion of the Resistance
1952 Order of the French Association of the Knights of Cyprus and Jerusalem

HONORARY DEGREES

1927 Sc.D., University of Munich
1928 Sc.D., University of Strasbourg
1938 Sc.D., Northwestern University
1939 Sc.D., University of Sofia, Bulgaria

HONORARY MEMBERSHIPS

1916 Russian Academy of Sciences
1922 Goettingen Academy of Sciences
1930 German Chemical Society
1938 Russian Institute of Science, Belgrade, Yugoslavia
1939 National Academy of Sciences, USA
1939 Officier de l'Academie de la France

BIBLIOGRAPHY

KEY TO ABBREVIATIONS

Artilleriiskii Zh. = Artilleriiskii Zhurnal
Ber. Dtsch. chem. Ges. = Berichte der Deutschen chemischen Gesellschaft
Bull. Acad. Sci. USSR = Bulletin of the Academy of Sciences of the USSR (Izvestiya Akademii Nauk SSSR)
Bull. Soc. chim. France = Bulletin de la Société chimique de France
Chim. Ind. = Chimie et Industrie
C. R. hebd. seances Acad. sci. = Comptes Rendus hebdomadaires des seances de l'Academie des sciences
Div. Pet. Chem., A.C.S. Mtg. = Division of Petroleum Chemistry, American Chemical Society (General papers presented before meetings of the division)
Dokl. Akad. Nauk SSSR = Doklady Akademii Nauk SSSR (Proceedings of the Academy of Sciences of the USSR)
Ind. Eng. Chem. = Industrial and Engineering Chemistry
Ind. Eng. Chem. Anal. Ed. = Industrial and Engineering Chemistry, Analytical Edition
J. Am. Chem. Soc. = Journal of the American Chemical Society
J. Appl. Chem. USSR = Journal of Applied Chemistry of the USSR (Zhurnal Prikladnoi Khimii)
J. Chem. Educ. = Journal of Chemical Education
J. Chem. Ind. USSR = Journal of Chemical Industry, USSR (Zhurnal Khimicheskaya Promyshlennost)
J. Org. Chem. = Journal of Organic Chemistry
J. Phys. Chem. = Journal of Physical Chemistry
J. prakt. Chem. = Journal fuer praktische Chemie
J. Russ. Phys.–Chem. Soc. = Journal of the Russian Physical–Chemical Society (Zhurnal Russkago Fiziko–Khimicheskago Obshchestva)
Khim. Prom. (Berlin) = Khimicheskaya Promyshlennost (Chemical Industry, published in Berlin)
Khim. Tverd. Topl. = Khimiia Tverdogo Topliva (Chemistry of Solid Fuels)
Natl. Pet. News = National Petroleum News
Oil Gas J. = Oil Gas Journal

1891

Quantitative Analysis. St. Petersburg.

Qualitative Analysis. St. Petersburg.

1892

Chemical investigation of the structure of steel. Artilleriiskii Zh., p. 1059.

Principal Laws of Chemistry. St. Petersburg.

1895

Action of bromine on saturated tertiary alcohols of the paraffin series. J. Russ. Phys.–Chem. Soc., 27:347; J. prakt. Chem., 53:257 (1896).

Action of bromine on saturated alcohols and the action of hydrogen bromide on acetylene and allene hydrocarbons. (Dissertation) St. Petersburg.

Action of hydrogen bromide on hydrocarbons of the C_nH_{2n-2} series. J. Russ. Phys.–Chem. Soc., 27:388; J. prakt. Chem., 53:145 (1896).

1896

With A. von Baeyer. Caronic acid. Ber. Dtsch. chem. Ges., 29:2796.

1897

Combustion of nitroglycerin in parallel layers. Artilleriiskii Zh.

With N. Wittorf. Structure of isoprene. J. prakt. Chem., 55:1.

Structure and synthesis of isoprene. J. prakt. Chem., 55:4.

1898

Action of zinc dust on dibromides in alcoholic solution. J. Russ. Phys.–Chem. Soc., 30:292.

Action of ethyl sodium malonate on dibromides of the $C_nH_{2n}Br$ series. J. Russ. Phys.–Chem. Soc., 30:391.

Determination of Elementary Velocities of Combustion and of the Pressure Index for Gun Powder Burning in Parallel Layers. St. Petersburg.

Preparation and Explosive Properties of Tri-nitro-cresol and Tri-nitro-naphthalene. St. Petersburg.

Allene Hydrocarbons, the Reaction of Nitrosyl Chloride on Organic Compounds with a Double Bond and Nitrosates. St. Petersburg.

1899

Allene hydrocarbons. J. Russ. Phys.–Chem. Soc., 31:323; J. prakt. Chem., 59:577.

Action of ethyl sodium malonate on dibromides of the $C_nH_{2n}Br$ series. J. Russ. Phys.–Chem. Soc., 31:349; J. prakt. Chem., 59:542.

Action of nitrosyl chloride on organic compounds containing a double bond. J. Russ. Phys.–Chem. Soc., 31:426.

With A. Solonina. Nitrosates. J. Russ. Phys.–Chem. Soc., 31:441.

Melts of explosive compounds. Artilleriiskii Zh.

1901

Pyrolytic reactions with organic compounds. J. Russ. Phys.–Chem. Soc., 33:143; Ber. Dtsch. chem. Ges., 34:596.

Synthesis of methylheptenone. J. Russ. Phys.–Chem. Soc., 33:148; Ber. Dtsch. chem. Ges., 34:594.

Action of zinc duct on dibromides of the $C_nH_{2n}Br$ series. J. Russ. Phys.–Chem. Soc., 33:151.

With A. Solonina. The nitrosyl chloride reaction and the nitrosates. J. Russ. Phys.–Chem. Soc., 33:496.

Pyrogenetic Contact Reactions. St. Petersburg, 1901/1902.

With Grawe. Synthesis of dimethylpentadecyl carbinol and the action of bromine on the same. J. Russ. Phys.–Chem. Soc., 33: 502.

With W. Sviderskii. Action of ethyl sodium malonate on tribromides. J. Russ. Phys.–Chem. Soc., 33:532.

Isoprenic acid. J. Russ. Phys.–Chem. Soc., 33:540.

Pyrolytic contact reactions with organic compounds. J. Russ. Phys.–Chem. Soc., 33:632.

Decomposition of ethyl alcohol. Ber. Dtsch. chem. Ges., 34:3579.

1902

Pyrolytic contact reactions. II. J. Russ. Phys.–Chem. Soc., 34:152.

With S. Bordelius and W. Mikeladze. Action of ethyl sodium malonate on dibromides of the $C_nH_{2n}Br_2$ series. J. Russ. Phys.–Chem. Soc., 34:351.

Pyrolytic contact reactions with organic compounds. Ber. Dtsch. chem. Ges., 35:1047.

Pyrolytic contact reactions with organic compounds. III. Ber. Dtsch. chem. Ges., 35:1057.

With A. Sapozhnikov. *Course in Inorganic Chemistry,* 1902–1913 (8 editions).

1903

A new method for preparing ethylene hydrocarbons. J. Russ. Phys.–Chem. Soc., 35:577; Ber. Dtsch. chem. Ges., 36:1990.

Catalytic isomeric transformation. J. Russ. Phys.–Chem. Soc., 35:592.

With W. Huhn. Catalytic isomeric transformation with cyclic hydrocarbons. J. Russ. Phys.–Chem. Soc., 35:603.

Decomposition of ethyl alcohol in the presence of various catalysts. J. prakt. Chem., 67:420.
With B. Ogonovskii. Addition of hydrogen halides to olefins. Ber. Dtsch. chem. Ges., 36:1988.
Contact isomery. Ber. Dtsch. chem. Ges., 36:2003.
With W. Huhn. Contact reactions with organic compounds. Ber. Dtsch. chem. Ges., 36:2014.
With Leontovich. Contact metamery. Ber. Dtsch. chem. Ges., 36: 2016.
Course in Organic Chemistry, 1903– (7 editions).

1904

With W. N. Dekhanov. The mechanism of the addition of hydrogen halide to olefins in acetic acid and aqueous media. J. Russ. Phys.–Chem. Soc., 36:659.
With Tikhotzkii. Catalytic isomerization of vinyltrimethylene. J. Russ. Phys.–Chem. Soc., 36:760.
With Leibin. Catalytic isomerization of butylenes. J. Russ. Phys.–Chem. Soc., 36:760, 762; Bull. Soc. chim. France, 34:1103.
With Chernyavskii. Formation of acetaldehyde by the Schutzenberger method. J. Russ. Phys.–Chem. Soc., 36:763.
Manual for Experimental Chemistry. St. Petersburg.
With G. G. Schulmann. Catalytic decomposition of organic acids. J. Russ. Phys.–Chem. Soc., 36:764; Bull. Soc. chim. France, 34(3): 1105.
Catalytic reactions at elevated temperatures and pressures. J. Russ. Phys.–Chem. Soc., 36:786.
Dissociation in the phenomenon of catalysis. J. Russ. Phys.–Chem. Soc., 36:813.
Pyrolytic decomposition of alcohols. Ber. Dtsch. chem. Ges., 37:2961.
Conversion of alcohols into ethers. Ber. Dtsch. chem. Ges., 37:2986.

1906

Influence of pressure on catalytic action. J. Russ. Phys.–Chem. Soc., 38:63.
Reduction catalysis. J. Russ. Phys.–Chem. Soc., 38:75.
Dehydration in the presence of alumina catalyst. J. Russ. Phys.–Chem. Soc., 38:92.
Purification of melinit. Zhurnal Artilleriiskago Komiteta.

1907

Catalytic reactions at elevated temperatures and pressures. J. Russ. Phys.–Chem. Soc., 39:681.
Catalytic reductions in the presence of metals. Ber. Dtsch. chem. Ges., 40:1270.
Catalytic reductions in the presence of metal ozides. Ber. Dtsch. chem. Ges., 40:1281.
With Zdzitovetzkii. Catalytic isomerization of butylene. Ber. Dtsch. chem. Ges., 40:1827.

1908

With G. G. Filippov. Hydrogenation of aromatic ethers and acids in the presence of nickel. J. Russ. Phys.–Chem. Soc., 40:502.
Decomposition of alcohols in the presence of metal oxides. J. Russ. Phys.–Chem. Soc., 40:508.
Catalytic decomposition of acids. J. Russ. Phys.–Chem. Soc., 40:514.
Hydrogenation of aromatic amines and quinoline in the presence of nickel oxide. Ber. Dtsch. chem. Ges., 41:991.
Hydrogenation of benzaldehyde and benzyl alcohol in the presence of iron. Ber. Dtsch. chem. Ges., 41:993.
With I. Yakovlev and L. Rakitin. Hydrogenation of anthracene and phenanthrene. Ber. Dtsch. chem. Ges., 41:996.
With G. G. Filippov. Hydrogenation of aromatic esters, ethers and acids in the presence of nickel. Ber. Dtsch. chem. Ges., 41:1001.
Reduction and oxidation of nickel oxides at atmospheric and elevated pressure. J. prakt. Chem., 77:513.
Catalytic Reactions at Elevated Temperatures and Pressures. St. Petersburg.

1909

With A. Sapozhnikov. *Condensed Course in Chemistry.* St. Petersburg.
With V. Verkhovskii. Precipitation of metals from the aqueous solutions of their salts by hydrogen at elevated temperature and pressure. Ber. Dtsch. chem. Ges., 42:2078.
Hydrogenation of aliphatic compounds with ethylene double bond in the presence of copper oxide. Ber. Dtsch. chem. Ges., 42:2089.

Hydrogenation of fluorene, acenaphthene and retene in the presence of nickel oxide. Ber. Dtsch. chem. Ges., 42:2092.

Hydrogenation of aromatic acids in the presence of nickel and copper oxide. Ber. Dtsch. chem. Ges., 42:2097.

1910

Dehydration of cyclic alcohols. Ber. Dtsch. chem. Ges., 43:3383.

Action of admixtures on the activity of catalysts. Ber. Dtsch. chem. Ges., 43:3387.

Hydrogenation of terpenes. Ber. Dtsch. chem. Ges., 43:3646.

1911

With N. Dovgolevich. Decomposition of hexane and hexamethylene. J. Russ. Phys.–Chem. Soc., 43:1229; Ber. Dtsch. chem. Ges., 44: 2987.

The origin of crude oil. J. Russ. Phys.–Chem. Soc., 43:1229, 1437.

Hydrogen at elevated temperatures and pressures. J. Russ. Phys.–Chem. Soc., 43:1746.

With V. Verkhovskii. Precipitation of metals from the aqueous solutions of their salts by hydrogen at elevated temperatures and pressures. Ber. Dtsch. chem. Ges., 44:1755.

Polymerization of ethylene hydrocarbons at elevated temperatures and pressures. Ber. Dtsch. chem. Ges., 44:2978.

Precipitation of metals from the aqueous solutions of their salts by hydrogen at elevated temperatures and pressures. Ber. Dtsch. chem. Ges., 44:3452.

With G. Balachinskii. Hydrogenation of acetone in the presence of copper oxide and zinc. Ber. Dtsch. chem. Ges., 44:3459.

With G. Balachinskii. Hydrogenation of terpenes. Ber. Dtsch. chem. Ges., 44:3461.

The origin of crude oil. J. prakt. Chem., 84:800.

1912

Simultaneous action of catalysts. Catalytic reduction and oxidation. J. Russ. Phys.–Chem. Soc., 44: 1675.

With O. Rutala. Dehydration of *o*-hexahydrocresol in the presence of alumina and copper oxide. J. Russ. Phys.–Chem. Soc., 44:1692.

With N. Matov. Simultaneous action of catalysts. Hydrogenation of terpenes. J. Russ. Phys.–Chem. Soc., 44:1695.

Catalytic reactions at elevated temperatures and pressures. Catalytic reduction of unsaturated aldehydes, ketones, alcohols and diketones. J. Russ. Phys.–Chem. Soc., 44:1703.

Catalytic reduction of carbohydrates. J. Russ. Phys.–Chem. Soc., 44:1710.

Displacement of acetic acid from solutions of its salts by carbon dioxide under high pressure. J. Russ. Phys.–Chem. Soc., 45:992.

Combined action of catalysts. Ber. Dtsch. chem. Ges., 45:3205.

Catalytic reactions at high temperatures and pressures. Ber. Dtsch. chem. Ges., 45:3218.

With B. Zvyagin. Precipitation of metals from the aqueous solutions of their salts by hydrogen at elevated temperatures and pressures. Ber. Dtsch. chem. Ges., 45:3226.

Catalytic synthesis of methane. J. prakt. Chem., 87:479.

1913

Catalytic reactions at elevated temperatures and pressures. J. Russ. Phys.–Chem. Soc., 45:994.

Hydrogenation of fats in the presence of nickel oxide. J. Russ. Phys.–Chem. Soc., 45:1464.

With O. Rutala. Polymerization of ethylene at elevated temperatures and pressures in the presence of a catalyst. Ber. Dtsch. chem. Ges., 46:1748.

Hydrogenation of phenols with unsaturated side chains. Ber. Dtsch. chem. Ges., 46:3589.

1914

With. A. N. Starunkevich. Precipitation of metals of the second group of the odd series of the periodic system from the aqueous solutions of their salts by hydrogen at elevated pressures and temperatures. J. Russ. Phys.–Chem. Soc., 46:172; Bull. Acad. Sci. USSR, 1918:119.

Hydrogenation of fats in the presence of metallic nickel and nickel oxide. J. Russ. Phys.–Chem. Soc., 46:302.

With Lugovoi. Hydrogenation of phenols. J. Russ. Phys.–Chem. Soc., 46:470.

1917

With A. Andryuschenko. Absorption of carbon dioxide by salt solutions under elevated pressure. Bull. Acad. Sci. USSR, 1917:851.

1918

With V. Verkhovskii. The solubility of zinc in hydrochloric acid at elevated pressures. Bull. Acad. Sci. USSR, 1918:1.

1923

With A. N. Starunkevich. The displacement of metals of the second odd group of the periodic system from their salt solutions by hydrogen at high temperature and pressure. Ber. Dtsch. chem. Ges., 56:1663.

1924

With N. Klyukvin. Pyrolysis of naphthalene under the combined action of nickel oxide and alumina catalysts. Bull. Acad. Sci. USSR, 1924:A185; Ber. Dtsch. chem. Ges., 58:1.

With N. Klyukvin. Polymerization phenomena under the combined action of alumina and iron at elevated temperatures and pressures. Bull. Acad. Sci. USSR, 1924:A186; Ber. Dtsch. chem. Ges., 58:4.

The process of cracking. Khim. Prom. (Berlin), vol. 2.

1925

With N. Klyukvin. Simultaneous catalytic action of alumina and iron at high temperatures and pressures. Khim. Prom. (Berlin), 3:5.

With I. Orlov and G. A. Razuvayev. Reactions between methyl alcohol and phenol at elevated temperatures and pressures. Bull. Soc. chim. France, 37(4):1576.

1926

With G. A. Razuvayev. Hydrogenation of aromatic acids and their salts in the absence of solvents but in the presence of nickel oxide and under pressure. J. Russ. Phys.-Chem. Soc., 58:122.

Precipitation of metals, metalloids and their oxides from aqueous solutions of their salts by hydrogen at elevated temperatures and pressures. J. Russ. Phys.-Chem. Soc., 58:664; Ber. Dtsch. chem. Ges., 59:1412.

With G. A. Razuvayev. Hydrogenation of aromatic acids and their salts under pressure. Ber. Dtsch. chem. Ges., 59:306.

With V. Nikolayev. Action of hydrogen and water on phosphorus at high temperatures and under pressure. Ber. Dtsch. chem. Ges., 59:595.

With N. A. Klyukvin. The influence of various factors, such as the presence of salts of metals, upon the separation of copper by hydrogen. Ber. Dtsch. chem. Ges., 59:1412.

With A. Kisselev. The formation of crystalline oxides from compounds of elements of the iron group (chromium, manganese and iron) by hydrogen under pressure and at high temperatures. Ber. Dtsch. chem. Ges., 59:1418.

With N. V. Konduirev. The displacement of metals of the iron group from solutions of their organic salts and their cyanide compounds by hydrogen under pressure. III. Ber. Dtsch. chem. Ges., 59:1421.

With V. Nikolayev. The displacement of phosphorus, arsenic and antimony from solutions of their compounds by hydrogen at high temperature and under pressure. IV. Ber. Dtsch. chem. Ges., 59:1423.

With A. O. Petrov. Hydrolysis of salts of aromatic sulfonic acids at high temperature and pressure. Ber. Dtsch. chem. Ges., 59:1737.

With G. A. Razuvayev. Hydrogenation of aromatic acids and their salts under pressure. Ber. Dtsch. chem. Ges., 59:2028.

With G. A. Razuvayev. Condensation of lactic acid to methyl succinic acid under the influence of the combined action of catalysts at high pressure and temperature. Ber. Dtsch. chem. Ges., 59:2031.

With A. O. Petrov. Catalytic condensation of acetone at high temperatures and pressures. Ber. Dtsch. chem. Ges., 59:2035.

With V. Nikolayev. The allotropic modifications of phosphorus. Chemiker-Zeitung, 50:989.

With A. Andreyevskii. The displacement of platinum by hydrogen at high pressure. C. R. hebd. seances Acad. sci., 183:51; Bull. Soc. chim. France, 39(4):1405.

With B. Dolgov. Hydrogenation of triphenylcarbinol and phenylfluorenecarbinol under pressure. C. R. hebd. seances Acad. sci., 183:304; Bull. Soc. chim. France, 39(4):3456.

With B. A. Muromtzev. Reduction of chromium compounds by hydrogen at elevated pressure and temperature. C. R. hebd. seances Acad. sci., 183:505; Bull. Soc. chim. France, 39(4):1384.

With I. Orlov. Hydrogenation of xanthone and xanthene. C. R.

hebd. seances Acad. sci., 183:973; Bull. Soc. chim. France, 41(4): 208.

With I. Orlov and A. D. Petrov. Action of elevated temperatures and pressures on some benzoic acid derivatives. Bull. Soc. chim. France, 39(4):664.

1927

With I. Orlov and A. D. Petrov. Reaction between phenol and methyl alcohol at high temperatures and pressures. Bull. Acad. Sci. USSR, 1927:A49; Ber. Dtsch. chem. Ges., 60:130.

With A. D. Petrov. Pyrolytic decomposition of ketones at elevated pressure. J. Russ. Phys.-Chem. Soc., 59:93; Ber. Dtsch. chem. Ges., 60:1956.

With A. D. Petrov. Catalytic condensation of acetone at elevated temperatures and pressures. J. Russ. Phys.–Chem. Soc., 59:429; Ber. Dtsch. chem. Ges., 60:753.

With I. Orlov. Hydrogenation of dibenzyl-acetone and dibenzylacetone under pressure. J. Russ. Phys.–Chem. Soc., 59:537; C. R. hebd. seances Acad. sci., 184:751; Bull. Soc. chim. France, 41(4): 862.

With I. Orlov and A. D. Petrov. Reaction between propyl alcohol and phenol at elevated temperatures and pressure. J. Russ. Phys.–Chem. Soc., 59:541; Ber. Dtsch. chem. Ges., 60:1006.

With G. A. Razuvayev. Condensation of polybasic α-hydroxy acids and keto acids under the combined action of catalysts. J. Russ. Phys.–Chem. Soc., 59:1083; Ber. Dtsch. chem. Ges., 60:1971.

With B. Dolgov. Hydrogenation under pressure of tetraphenylmethane and *p*-hydroxytetraphenylmethane. J. Russ. Phys.–Chem. Soc., 59:1087; C. R. hebd. seances Acad. sci., 185:210; Bull. Soc. chim. France, 41(4):1621.

With I. Orlov. Pyrolytic dissociation of some aromatic compounds under hydrogen pressure and the combined action of catalysts. Ber. Dtsch. chem. Ges., 60:1963.

With I. Orlov and A. Petrov. *Aluminum Oxide as Catalyst in Organic Chemistry.* Leningrad, 1927; translated from Russian and edited by Carl Freitag, Leipzig: Academie Verlag, 1929.

With G. A. Razuvayev. Reduction of polybasic α-hydroxy acids under the combined action of catalysts. Ber. Dtsch. chem. Ges., 60:1973.

With B. A. Muromtzev. Displacement of metals or their oxides from solutions by hydrogen under pressure. Ber. Dtsch. chem. Ges., 60:1980.

With V. V. Ipatieff. Effect of concentration of the hydrogen ions on the displacement of copper from solutions at elevated temperatures and pressures. Ber. Dtsch. chem. Ges., 60:1982.

With A. D. Petrov. Pyrolytic decomposition of cyclic ketones. Ber. Dtsch. chem. Ges., 60:2545; J. Russ. Phys.–Chem. Soc., 60:491.

With A. Andreyevskii. Precipitation of iridium from solution by hydrogen under pressure. C. R. hebd. seances Acad. sci., 185:357; Bull. Soc. chim. France, 41(4):1466.

With V. Nikolayev. Separation of metals and their oxides from salt solutions by hydrogen under pressure. Bull. Soc. chim. France, 41(4):1191; C. R. hebd. seances Acad. sci., 185:462.

With B. A. Muromtzev. Formation of crystalline silicates in aqueous medium under pressure and high temperature. C. R. hebd. seances Acad. sci., 185:647; Bull. Soc. chim. France, 41(4):1588.

With V. Nikolayev. Hydrogenation of tin salts at elevated temperatures and pressures. J. Russ. Phys.–Chem. Soc., 60:331.

1928

With V. Nikolayev. Allotropic modifications of phosphorus obtained at elevated temperatures and pressures. J. Russ. Phys.–Chem. Soc., 60:885; Ber. Dtsch. chem. Ges., 61:630.

With G. A. Razuvayev. Condensation of α-hydroxy and keto acids under the combined action of catalysts under elevated hydrogen pressure. J. Russ. Phys.–Chem. Soc., 60:909.

With A. D. Petrov. Pyrolytic decomposition of wood tar in the presence of hydrogen under pressure. J. Appl. Chem. USSR, 1:172.

With V. V. Ipatieff. Displacement of metals or metal oxides from solutions by hydrogen and pressure. Displacement of lead and its oxides. Ber. Dtsch. chem. Ges., 61:624.

With G. A. Razuvayev. Condensation of hydroxy acids by the simultaneous use of a number of catalysts and at elevated hydrogen pressure. α-Hydroxybutyric and α-hydroxyisovaleric acid. Ber. Dtsch. chem. Ges., 61:634.

With I. Orlov and B. Dolgov. Preparation of some diphenylparaffins. Dokl. Akad. Nauk SSSR, Ser. A., 1–4.

With I. Orlov and A. D. Petrov. Hydrogenation of alkyl aryl ketones under pressure. Dokl. Akad. Nauk SSSR, Ser. A, 255.

Displacement of metals and their oxides by hydrogen under pressure at high temperatures. Chim. Ind., special no., April, p. 411.

With B. Dolgov. Catalytic hydrogenation under pressure of *p*-hydroxydiphenylmethane and *p*-hydroxytriphenylcarbinol. C. R. hebd. seances Acad. sci., 185:1484; Bull. Soc. chim. France, 43(4): 242.

1929

With D. G. Zvyagintzev. Action of hydrogen at elevated temperatures and pressures on solutions of ruthenium salts. J. Russ. Phys.–Chem. Soc., 61:823; Ber. Dtsch. chem. Ges., 62:708.

With I. Orlov. Pyrolytic decomposition of aromatic compounds under hydrogen pressure and in the presence of mixed catalysts. J. Russ. Phys.–Chem. Soc., 61:1295; Ber. Dtsch. chem. Ges., 62: 593.

With I. Orlov and N. D. Lukhachev. Cracking of some organic compounds under elevated hydrogen pressure. J. Russ. Phys.–Chem. Soc., 61:1339; Ber. Dtsch. chem. Ges., 63:156 (1930).

With G. A. Razuvayev and I. F. Bogdanov. The action of hydrogen at elevated pressure on metallo-organic compounds. J. Russ. Phys.–Chem. Soc., 61:1791; Ber. Dtsch. chem. Ges., 63:335 (1930).

With G. A. Razuvayev and A. Sizov. Synthesis of α-chlorostyryldichloroarsine. J. Russ. Phys.–Chem. Soc., 61:1869; Ber. Dtsch. chem. Ges., 63:174 (1930).

With A. D. Petrov. Cracking naphthenic acids under elevated pressure. J. Appl Chem. USSR, 2:327.

With A. D. Petrov. Cracking of primary tar from donetz coal under elevated hydrogen pressure. J. Appl. Chem. USSR, 2:429.

With V. Vasilevskii. Preparation of sulfur chloride from pyrites, alkaline earth sulfates and refuse from gas producers. J. Appl. Chem. USSR, 2:689.

Hydrogenation of coal. J. Chem. Ind. USSR, 6:1243.

Pyrolysis of high molecular compounds and cracking of heavy petroleum fractions under hydrogen pressure. J. Chem. Ind. USSR, 6:1563–70.

With V. V. Ipatieff. Displacement of copper from neutral or acid copper sulfate solutions by hydrogen under pressure. Ber. Dtsch. chem. Ges., 62:386.

With G. A. Razuvayev and V. Stromskii. Action of ammonia on halogen-substituted arsines. Ber. Dtsch. chem. Ges., 62:598.

Gasoline substitutes. Chaleur et Industrie, 112:377.
Investigation of liquid fuels. Chim. Ind., special no., February, p. 115.
With B. Dolgov. The rupture of some derivatives of the naphthyl methanes during hydrogenation under pressure. Bull. Soc. chim. France, [4]45:950.

1930

With B. A. Muromtzev. Displacement of metals and their oxides from their salt solutions by hydrogen at elevated pressures and temperatures. Ber. Dtsch. chem. Ges., 63:160.
With G. A. Razuvayev and V. Malinovskii. Displacement of metals from the solutions of their salts by hydrogen at elevated temperatures and pressures. Displacement of arsenic from the solution of its salts by hydrogen. Ber. Dtsch. chem. Ges., 63:166.
With A. D. Petrov. Heating naphthenic acids at elevated temperature and pressure. Ber. Dtsch. chem. Ges., 63:329.
With A. D. Petrov and I. Z. Ivanov. Cracking of a primary tar from donetz coal under elevated hydrogen pressure. Ber. Dtsch. chem. Ges., 63:331.
With A. V. Frost. The chemical equilibrium between phosphine, phosphorus and hydrogen. Ber. Dtsch. chem. Ges., 63:1104.
With G. A. Razuvayev. The displacement of the elements of Group Five from their phenyl derivatives by hydrogen. Ber. Dtsch. chem. Ges., 63:1110.
Correction to the work of Ipatieff and Muromtzev: precipitation of crystalline hydroxide of aluminum and chromium from solutions of their salts at high temperature and pressure. Ber. Dtsch. chem. Ges., 63:2365.
With A. D. Petrov and I. Z. Ivanov. The cracking of acetone under pressure and in the presence of zinc chloride. Ber. Dtsch. chem. Ges., 63:2806.
With G. A. Razuvayev and V. Malinovskii. The displacement of metallic arsenic from an alkaline solution of the arsenic acid by hydrogen pressure at high temperature. Ber. Dtsch. chem. Ges., 63:2812.
Cellulose from sugar. Dokl. Akad. Nauk SSSR, A381.
With B. N. Dolgov and Yu. N. Volnov. A new method for the preparation of mesitylene. Ber. Dtsch. chem. Ges., 63:3072.
Synthetic crude oil. Khim. Tverd. Topl., 1(2):3–12, (3):3–13.

1931

With B. N. Dolgov. Hydrogenation and decomposition of silico-organic compounds at high temperature and pressure. I. Journal of General Chemistry, USSR, 1:5–12.

With B. N. Dolgov. A study of catalysts for the synthesis of methanol. J. Chem. Ind. USSR, 8:825.

With M. A. Belopolskii and M. Nemtzov. Hydrogenation of Grozny mixed-based fuel oil. Reports of the Conference on Cracking Hydrogenation, Grozny, 1:119.

With A. V. Frost and A. A. Vedenskii. The question of the allotropy of phosphorus. Bull. Soc. chim. France, 49(4):670.

Pyrolysis and destructive hydrogenation of heavy crude oil fractions. Natl. Pet. News, 23(12):49.

Hydrogenation developments in Russia. Natl. Pet. News, 23(25):61.

1932

With M. S. Nemtzov. Polymerization of olefins from cracked gases. Khim. Tverd. Topl., 3:707.

1933

With C. Freitag. Oxidation of phosphorus with water at elevated pressures and temperatures. Zeitschrift fuer anorganische und allgemeine Chemie, 215:388.

Hydrogenation of aromatic compounds at temperatures close to their decomposition in the presence of catalyst. J. Am. Chem. Soc., 55: 3696.

1934

With V. I. Komarewsky. The action of aluminum chloride on benzene and cyclohexane. J. Am. Chem. Soc., 56:1926.

With H. Pines and R. C. Wackher. Catalysis in the hydrogen bromide–olefins addition. J. Am. Chem. Soc., 56:2398.

With H. Pines and R. E. Schaad. Isomerization of normal butenes. J. Am. Chem. Soc., 56:2696.

1935

With P. V. Usachev. Oxidation of phosphorus with water at high temperature and pressure in the presence of alkali. The production of phosphorous acid. J. Am. Chem. Soc., 57:300.

With A. V. Grosse. Reaction of paraffins with olefins. J. Am. Chem. Soc., 57:1616.

With V. I. Komarewsky and A. V. Grosse. Reactions of naphthenic hydrocarbons with olefins. J. Am. Chem. Soc., 57:1722.

With G. Egloff. Polymer gasoline from cracked gases. Natl. Pet. News, 27(20):24-G.

With C. Freitag. Double decomposition and oxidation of inorganic compounds under pressure. Transformation of heavy spar into barium carbonate. Ind. Eng. Chem., 27:342.

Catalytic polymerization of gaseous olefins by liquid phosphoric acid. Propylene. Ind. Eng. Chem., 27:1067.

With B. B. Corson. Catalytic polymerization of gaseous olefins by liquid phosphoric acid. Butylene. Ind. Eng. Chem., 27:1069.

With B. B. Corson and G. Egloff. Polymerization—a new source of gasoline. Ind. Eng. Chem., 27:1077.

1936

With H. Pines and V. I. Komarewsky. Alkylation of aromatic hydrocarbons and phenols in the presence of phosphoric acid. Ind. Eng. Chem., 28:222.

With A. V. Grosse. Action of aluminum chloride on paraffins. Autodestructive alkylation. Ind. Eng. Chem., 28:461.

With H. Pines. Propylene polymerization. Ind. Eng. Chem., 28:684.

With B. B. Corson. Gasoline from ethylene by catalytic polymerization. Ind. Eng. Chem., 28:860.

With A. V. Grosse, H. Pines, and V. I. Komarewski. Alkylation of paraffins by olefins in the presence of aluminum chloride. J. Am. Chem. Soc., 58:913.

With A. V. Grosse. Polymerization of ethylene with aluminum chloride. J. Am. Chem. Soc., 58:915.

With H. Pines and V. I. Komarewsky. Destructive alkylation in the presence of phosphoric acid. J. Am. Chem. Soc., 58:918.

Catalytic Reactions at High Pressures and Temperatures. New York: Macmillan Publishing Co., Inc.

With B. B. Corson and H. Pines. Influence of sulfuric acid concentration upon the reaction between olefins and benzene. J. Am. Chem. Soc., 58:919.

With V. I. Komarewsky. Destructive alkylation in the presence of a hydrogenating catalyst. J. Am. Chem. Soc., 58:922.

With H. Pines. Alkylation accompanying depolymerization. J. Am. Chem. Soc., 58:1056.

With H. Pines. Conjunct polymerization—the influence of temperature, concentration, and quantity of sulfuric acid on polymerization of olefins. J. Org. Chem., 1:464.

The problem of the rational utilization of crude oil and its distillates. Oil Gas J., 35(26):171.

1937

With H. Pines. The cleavage of side chains in aromatic hydrocarbons in the form of paraffins by means of aluminum chloride. J. Am. Chem. Soc., 59:56.

With B. B. Corson. Influence of cyclohexene concentration in the alkylation of benzene by cyclohexene. Dealkylation of cyclohexylbenzenes. J. Am. Chem. Soc., 59:645.

With V. I. Komarewsky. Hydro-polymerization. J. Am. Chem. Soc., 59:720.

With L. Schmerling. Identification of alkylbenzenes. I. Identification of monoalkylbenzenes by means of the acetamino derivative. J. Am. Chem. Soc., 59:1056.

With B. B. Corson. Dealkylation of dialkylbenzenes. J. Am. Chem. Soc., 59:1417.

With A. V. Grosse. New metal halide catalysts for hydrocarbon reactions. J. Org. Chem., 2:559.

With V. I. Komarewsky. Iso-octane production by simultaneous polymerization and hydrogenation. Ind. Eng. Chem., 29:958.

Cracking of some distillates of crude oil under high pressure and destructive hydrogenation of different tars. Booklet. Chicago: Universal Oil Products Company.

With H. Pines and A. V. Grosse. Reaction of paraffins with cycloparaffins in the presence of metal halide catalysts. Div. Pet. Chem., A.C.S. Mtg., Rochester, September.

1938

With H. Pines and L. Schmerling. Isomerization accompanying alkylation. Alkylation of benzene with isopropylethylene in the presence of sulfuric acid. J. Am. Chem. Soc., 60:353.

With H. Pines and B. B. Corson. Alkylation of benzene with cycloparaffins in the presence of sulfuric acid. J. Am. Chem. Soc., 60:577.

With H. Pines. Destructive hydrogenation of alkylated monocyclic aromatic hydrocarbons. Div. Pet. Chem., A.C.S. Mtg., Dallas, April.

With B. B. Corson. Action of aluminum chloride on cyclohexylbenzene. J. Am. Chem. Soc., 60:747.

With H. Pines and L. Schmerling. Phosphoric acid as catalyst in the ethylation of phenol. J. Am. Chem. Soc., 60:1161.

With L. Schmerling. Identification of alkylbenzenes. II. Identification of the eight amylbenzenes and cyclopentylbenzene by means of their mono- and diacetamino and monobenzamino derivatives. J. Am. Chem. Soc., 60:1476.

With H. Pines and B. S. Friedman. Reaction of isobutene and diisobutene with phenol, with and without scission of C-C linkages. J. Am. Chem. Soc., 60:2495.

With H. Pines and B. S. Friedman. Reaction of aliphatic olefins with thiophenol. J. Am. Chem. Soc., 60:2731.

With A. V. Grosse and J. M. Mavity. Reaction of paraffins with aromatic hydrocarbons. I, II. Various aromatic hydrocarbons and 2,2,4-trimethylpentane. J. Org. Chem., 3:137, 448.

With R. E. Schaad. Mixed polymerization of butenes by solid phosphoric acid catalyst. Ind. Eng. Chem., 30:596.

With B. B. Corson. Olefin hydrogenation. Ind. Eng. Chem., 30:1039.

With B. B. Corson. Refining gasoline with solid phosphoric acid catalyst. Ind. Eng. Chem., 30:1316.

1939

With B. S. Friedman. Reaction of thiol compounds with aliphatic olefins. J. Am. Chem. Soc., 61:71.

With H. Pines and A. V. Grosse. Reaction of paraffins with hexahydroaromatic hydrocarbons in the presence of aluminum halides. J. Am. Chem. Soc., 61:640.

With B. S. Friedman. Identification of alkyl phenyl sulfides, sulfoxides and sulfones. J. Am. Chem. Soc., 61:684.

With B. B. Corson. Simultaneous dehydrogenation–hydrogenation of cyclohexene in the presence of nickel. J. Am. Chem. Soc., 61: 1056.

With H. Pines. Isomerization of alkylcyclopentanes. J. Am. Chem. Soc., 61:1076.

With H. Pines and L. Schmerling. Reaction of propene with isoolefins in the presence of sulfuric acid. J. Am. Chem. Soc., 61:1825.

With H. Pines. Synthesis of *t*-butyl and *t*-amylcyclopentane and of their intermediate products. J. Am. Chem. Soc., 61:2728.

With B. B. Corson. Hydrogenation of acetophenone to cyclohexylmethylcarbinol in the presence of solvent. J. Am. Chem. Soc., 61:3292.

With H. Pines. Reaction of benzene with methylcyclobutene and methylenecyclobutane in the presence of sulfuric acid. J. Am. Chem. Soc., 61:3374.

With B. B. Corson and J. D. Kurbatov. Copper as catalyst for the hydrogenation of benzene. J. Phys. Chem., 43:589.

Catalytic refining methods. Oil Gas J., 37(46):86.

1940

With R. E. Schaad. Catalytic hydration of acetylene and of some alkylacetylenes. J. Am. Chem. Soc., 62:178.

With L. Schmerling and B. S. Friedman. Notes on the preparation and properties of some aliphatic hydrocarbons. J. Am. Chem. Soc., 62:2446.

With H. Pines and L. Schmerling. Isomerization accompanying alkylation. II. The alkylation of benzene with olefins, naphthenes, alcohols and alkyl halides. J. Org. Chem., 5:252.

With H. Pines and L. Schmerling. Isomerization accompanying alkylation. III. The alkylation of benzene with neopentyl chloride and neopentyl alcohol. J. Am. Chem. Soc., 62:2901.

With B. B. Corson and J. D. Kurbatov. Mixed copper–chromium oxide hydrogenation catalysts. J. Phys. Chem., 44:670.

With A. V. Grosse. Catalytic dehydrogenation of gaseous paraffins. Ind. Eng. Chem., 32:268.

1941

With R. L. Burwell. The catalytic preparation and interconversion of simple and mixed ethers. J. Am. Chem. Soc., 63:969.

With B. B. Corson. Activation and poisoning of copper hydrogenation catalysts. J. Phys. Chem., 45:431.

With B. B. Corson. Mixed copper hydrogenation catalysts. J. Phys. Chem., 45:440.

With H. Pines. Reaction of hexahydroaromatics with olefins in the presence of aluminum chloride. J. Org. Chem., 6:242.

1942

With H. Pines and A. V. Grosse. Alkylation of paraffins at low temperatures in the presence of aluminum choloride. J. Am. Chem. Soc., 64:33.

With V. Haensel. Hydrogenation of alkyl phenyl ketones in the presence of copper alumina catalysts. J. Am. Chem. Soc., 64:520.

With V. Haensel. Condensation of ketones with alcohols in the presence of mixed catalysts. J. Org. Chem., 7:189.

With G. S. Monroe. Determination of solubilities of gases at high temperatures and high pressures by rotating bomb. Ind. Eng. Chem. Anal. Ed., 14:166.

With G. S. Monroe. Determination of critical temperatures by rotating bomb. Ind. Eng. Chem. Anal. Ed., 14:171.

Aviation gasoline by polymerization and alkylation of cracking gases. Chemical and Engineering News, 20(21):1367.

1943

Modern science in Russia. J. Chem. Educ., 20:159.

With V. Haensel. Cracking cyclohexane. Thermal and catalytic decomposition at high pressures. Ind. Eng. Chem., 35:632.

With A. V. Grosse. The alkylation of paraffins with olefins. The identification of the paraffins formed. J. Org. Chem., 8:438.

With R. C. Olberg and H. Pines. Synthesis of 1,4-epoxycyclohexane. J. Am. Chem. Soc., 65:2260.

With L. Schmerling. Identification of alkylbenzenes. III. The acetamino and benzamino derivatives of isobutylbenzene. J. Am. Chem. Soc., 65:2470.

1944

With H. Pines and R. E. Schaad. Reaction of benzene with butadiene in the presence of sulfuric acid and hydrogen fluoride catalyst. J. Am. Chem. Soc., 66:816.

With R. C. Olberg and H. Pines. The dehydration of 1,4-cyclohexanediol. Synthesis of 1,4-epoxycyclohexane. J. Am. Chem. Soc., 66:1096.

With H. Pines. Studies in the terpene series. I. Dehydration of alcohols in the terpene series under pressure and in the presence of dilute aqueous salt-solutions. J. Am. Chem. Soc., 66:1120.

With G. S. Monroe. The dehydration of the lower aliphatic alcohols in the presence of dilute aqueous solutions of acids and salts. J. Am. Chem. Soc., 66:1627.

1945

With H. Pines, B. Kvetinskas, and L. S. Kassel. Determination of equilibrium constants for butanes and pentanes. J. Am. Chem. Soc., 67:631.

With H. Pines and R. C. Olberg. Studies in the terpene series. II. Hydrogen disproportionation of limonene. J. Am. Chem. Soc., 67:694.

With R. E. Schaad. Heptenes and heptanes from propylene and butylenes. Ind. Eng. Chem., 37:362.

With R. E. Schaad, H. Pines, and G. S. Monroe. Reaction between benzene and butadiene in the presence of silico-phosphoric acid catalyst. J. Am. Chem. Soc., 67:1060.

With H. Pines. Dehydration of 2-methyl-2,4-pentanediol and 4-methyl-x-penten-2-ol under pressure and in the presence of dilute aqueous salt solutions. J. Am. Chem. Soc., 67:1200.

With H. Pines. Studies in the terpene series. III. Hydrogen transfer reaction during the dehydration of terpenic alcohols. J. Am. Chem. Soc., 67:1226.

With L. Schmerling. *p*-Acetamino-(β-chloro-*t*-butyl)-benzene. J. Am. Chem. Soc., 67:1624.

With H. Pines. Reaction of methylcyclopentane with olefins in the presence of sulfuric acid and hydrogen fluoride catalysts. J. Am. Chem. Soc., 67:1631.

With L. Schmerling. *p*-Di-(β-chloro-*t*-butyl)-benzene. J. Am. Chem. Soc., 67:1862.

With H. Pines. Studies in the terpene series. IV. Method for the determination of rings in bicyclic dihydroterpenes. Isomerization of pinane in the presence of dilute aqueous salts. J. Am. Chem. Soc., 67:1931.

With G. S. Monroe. Synthesis of methanol from carbon dioxide and hydrogen over copper–alumina catalysts. Mechanism of reaction. J. Am. Chem. Soc., 67:2168.

With H. Pines and A. Edeleanu. Isomerization accompanying alkylation. IV. Reaction of cycloheptanol and cycloheptene with benzene. Synthesis of cycloheptylbenzene. J. Am. Chem. Soc., 67:2193.

With V. Haensel. Selective demethylation of paraffin hydrocarbons. J. Am. Chem. Soc., 68:345.

1946

The Life of a Chemist. Stanford: Stanford Univ. Press.

With L. Schmerling. Ethylation of benzene in the presence of solid phosphoric acid. Ind. Eng. Chem., 38:400.

With H. Pines and R. C. Olberg. Studies in the terpene series. V. Action of dilute aqueous salt solutions on 3,3,5-trimethylcyclohexanol and 1,1,3-trimethyl-x-cyclohexene. J. Am. Chem. Soc., 68:1709.

With V. Haensel. Polytreating of catalytically cracked gasolines. Ind. Eng. Chem., 38:1045.

1947

With H. Pines, V. Dvorkovitz, R. C. Olberg, and M. Savoy. Studies in the terpene series. VI. Cyclic isomerization of limonene. J. Org. Chem., 12:34.

With G. S. Monroe. The catalytic formation of toluene from benzene and benzene–methane at high pressures. J. Am. Chem. Soc., 69:710.

With H. Pines. Reaction of propane with carbon monoxide in the presence of aluminum chloride. J. Am. Chem. Soc., 69:1337.

With H. Pines and M. Savoy. Studies in the terpene series. VII. Destructive hydrogenation of bicyclic dihydroterpenic hydrocarbons. J. Am. Chem. Soc., 69:1948.

With L. L. Gershbein and H. Pines. Reaction of isopropyl alcohol in the presence of catalysts containing magnesium oxide. J. Am. Chem. Soc., 69:2888.

With V. Haensel. Selective demethylation of paraffin hydrocarbons. Ind. Eng. Chem., 39:853.

1948

With R. E. Schaad. Polymerization of pentenes. Ind. Eng. Chem., 40:78.

With H. Pines. Reaction of methylcyclopentane with propene in the presence of aluminum bromide–hydrogen bromide. J. Am. Chem. Soc., 70:531.

With H. Pines and R. C. Olberg. Studies in the terpene series. VIII. Effect of catalyst solvent and temperature on the dehydrogenation of pinane and *p*-menthane. J. Am. Chem. Soc., 70:533.

With W. W. Thompson and H. Pines. The potassium permanganate test for detection of unsaturation. J. Am. Chem. Soc., 70:1658.

With H. Pines and B. M. Abraham. Isomerization of saturated hydrocarbons. V. The effect of cyclohexene upon the isomerization of methylcyclopentane and cyclohexane. J. Am. Chem. Soc., 70: 1742.

With H. Pines and R. C. Olberg. Hydrogen transfer. I. Reaction of *p*-cymene with olefinic hydrocarbons in the presence of sulfuric acid and hydrogen fluoride catalysts. J. Am. Chem. Soc., 70:2123.

With G. S. Monroe and L. E. Fischer. High pressure laboratory flow apparatus. Ind. Eng. Chem., 40:2059.

With L. Schmerling. Effect of hydrogen on action of aluminum chloride on alkanes. Ind. Eng. Chem., 40:2354.

With H. Pines and Anna Weizmann. Hydrogen transfer. II. Reaction of diisopropyltoluene and isopropylcyclohexyltoluene with methylcyclohexene. J. Am. Chem. Soc., 70:3859.

1949

With H. Pines and E. Aristoff. Isomerization of saturated hydrocarbons. VI. Effect of benzene upon the isomerization of methylcyclopentane. J. Am. Chem. Soc., 71:749.

With G. S. Monroe, L. E. Fischer, and E. E. Meisinger. Decomposition of alcohols over nickel–kieselguhr and other catalysts, influence of different factors on decomposition. Ind. Eng. Chem., 41:1802.

With H. Pines and E. E. Meisinger. Destructive hydrogenation of indan and hexahydroindan. J. Am. Chem. Soc., 71:2685.

With H. Pines and E. E. Meisinger. The influence of the walls of the autoclave upon the hydrogenation of *p*-cymene. J. Am. Chem. Soc., 71:2934.

With H. Pines and W. R. Strehlau. Hydrogen transfer. III. Reaction of *p*-ethyltoluene and *p*-propyltoluene with methylcyclohexene. Synthesis of diarylalkanes. J. Am. Chem. Soc., 71:3534.

With H. Pines and G. J. Czajkowski. Synthesis of 1,3-*di-t*-butylbenzene and 1,3-*di-t*-butylcyclohexane. J. Am. Chem. Soc., 71: 3798.

1950

With G. S. Monroe and L. E. Fischer. Low temperature hydrogen production. Ind. Eng. Chem., 42:92

With H. Pines and D. R. Strehlau. Hydrogen transfer. IV. Reaction of *p*-isobutyltoluene and *p*-*s*-butyltoluene with methylcyclohexene. J. Am. Chem. Soc., 72:1563.

With E. E. Meisinger and H. Pines. Isomerization accompanying alkylation. V. Reaction of 4-methylcyclohexene with benzene in the presence of hydrogen fluoride. J. Am. Chem. Soc., 72:2772.

With H. Pines and J. D. LaZerte. Isomerization accompanying alkylation. VI. Reaction of isobutylene and 2-butene with benzene. J. Am. Chem. Soc., 72:2850.

With H. Pines and E. Aristoff. Isomerization of saturated hydrocarbons. VII. The effect of light upon the isomerization of methylcyclopentane in the presence of aluminum bromide–hydrogen bromide. J. Am. Chem. Soc., 72:4055.

With H. R. Appell and H. Pines. Studies in the terpene series. IX. Isomerization accompnaying cycloalkylation of benzene. J. Am. Chem. Soc., 72:4260.

With H. Pines and E. Aristoff. Isomerization of saturated hydrocarbons. VIII. The effect of oxygen and light upon the isomerization of methylcyclopentane in the presence of aluminum bromide. J. Am. Chem. Soc., 72:4304.

With H. Pines. Composition of W-6 Raney–nickel catalyst. J. Am. Chem. Soc., 72:5320.

With H. Pines and D. R. Strehlau. Hydrogen transfer. V. Reaction of *m*-cymene and *o*-cymene with methylcyclohexene in the presence of hydrogen fluoride. J. Am. Chem. Soc., 72:5521.

1951

With W. W. Thompson and H. Pines. Studies in the terpene series.

X. Isomerization accompanying hydrogenolysis of alcohols. J. Am. Chem. Soc., 73:553.

With J. E. Germain and H. Pines. Decarboxylation catalytique des sels de sodium en solution aqueuse. Essai de différenciation des acides cyclopentanique et cyclohexaniques. Bull. Soc. chim. France, 18(5):259.

With G. J. Czajkowski and H. Pines. Studies in the terpene series. XI. The dehydroxymethylation of bicyclic primary terpenic alcohols by hydrogenolysis in the presence of nickel catalysts. J. Am. Chem. Soc., 73:4098.

With H. Pines and W. D. Huntsman. Isomerization accompanying alkylation. VII. Reaction of benzene with methylcyclopropane, ethylcyclopropane, and with dimethylcyclopropanes. J. Am. Chem. Soc., 73:4343.

With H. Pines and W. D. Huntsman. Isomerization accompanying alkylation. VIII. Reaction of benzene with 2- and 3-pentanol. J. Am. Chem. Soc., 73:4483.

With H. Pines and F. J. Pavlik. Isomerization of saturated hydrocarbons. IX. Isomerization of ethylcyclopentane, 1,3-dimethylcyclopentane, and 1,1-dimethylcyclopentane in the presence of aluminum bromide. Synthesis of 1,1-dimethylcyclopentane. J. Am. Chem. Soc., 73:5738.

1952

With L. L. Gershbein. Hydrogenation of organo-tin and lead compound under pressure. J. Am. Chem. Soc., 74:1540.

With J. E. Germain, W. W. Thompson, and H. Pines. Studies in the terpene series. XII. Cyclic isomerization of limonene. Proof of the structure of a new bicycloterpene. J. Org. Chem., 17:273.

With H. Pines. Studies in the terpene series. XIII. Reaction of benzene and *p*-cymene with 2,6-dimethylbicyclo-[3.2.1]-2-octene. J. Org. Chem., 17:485.

With H. Pines and A. Rudin. Investigation of preparation of bromides from 1-, 2-, and 3-pentanol. Synthesis of pure bromopentanes. J. Am. Chem. Soc., 74:4063.

With H. Pines and R. C. Olberg. Studies in the terpene series. XIV. Skeletal isomerization and hydrogen transfer of cyclic olefins in the presence of aluminum–hydrogen chloride and silica–alumina catalysts. J. Am. Chem. Soc., 74:4872.

With G. J. Czajkowski and H. Pines. Studies in the terpene series. XV. Cycloisomerization of α- and β-pinene, α-terpineol, and 1,8-terpin hydrate. J. Org. Chem., 17:1431.

With H. Pines and F. J. Pavlik. Isomerization of saturated hydrocarbons. X. Catalytic isomerization of cycloheptane. J. Am. Chem. Soc., 74:5544.

1953

Early work on the displacement of metals and metal oxides. J. Chem. Educ., 30:110.

With H. Pines and R. W. Meyerholtz, Jr. Synthesis of 2,2,4-trimethyl-4-phenylpentane and 2,2,4-trimethyl-4-cyclohexylpentane. Reactions of 2,2,4-trimethyl-4-phenylpentane. J. Am. Chem. Soc., 75:937.

With H. Pines and W. D. Huntsman. Isomerization accompanying alkylation. IX. The reaction of benzene with *n*- and isopropylcyclopropane. J. Am. Chem. Soc., 75:2311.

With H. Pines and W. D. Huntsman. Isomerization of saturated hydrocarbons. XI. The isomerization of alkylcyclopropanes and alkylcyclobutanes in the presence of aluminum halide catalysts. J. Am. Chem. Soc., 75:2315.

With F. J. Pavlik and H. Pines. Studies in the terpene series. XVI. Hydrogenolysis of pinane in a flow type apparatus in the presence of hydrogenation catalysts. J. Am. Chem. Soc., 75:3179.

With B. Kvetinskas, E. E. Meisinger, and H. Pines. High pressure thermal reactions of propylbenzene, *p*-cymene and *s*-butylbenzene. Isomerization of alkyl groups. J. Am. Chem. Soc., 75:3323.

With H. Pines and E. Aristoff. Isomerization of saturated hydrocarbons. XII. The effect of experimental variables, alkyl bromides, and light upon the isomerization of methylcyclopentane in the presence of aluminum bromide. J. Am. Chem. Soc., 75:4775.

With J. E. Germain and H. Pines. The structure of *di*-(methylcyclohexyl)-benzene from cycloalkylation of 4-methylcyclohexene with benzene in the presence of hydrogen fluoride. J. Am. Chem. Soc., 75:6056.

With H. Pines and H. G. Rodenberg. Synthesis of cyclobutane by the dehydroxymethylation method. J. Am. Chem. Soc., 75:6065.

With W. D. Huntsman and H. Pines. Studies in the terpene series. XVII. The thermal isomerization of pinane at high pressure. J. Am. Chem. Soc., 75:6222.

With H. Pines and E. F. Jenkins. Studies in the terpene series. XVIII. Isomerization accompanying the dehydrogenation of 1,1,3-trimethylcyclohexene and of 1,1,3-trimethyl-x-cyclohexene. J. Am. Chem. Soc., 75:6226.

1954

With H. Pines and H. G. Rodenberg. Dehydroxymethylation of primary alcohols. J. Am. Chem. Soc., 76:771.

With H. Pines and A. Rudin. Studies in the terpene series. XIX. Hydroisomerization and hydrogenolysis of cyclohexane, methylcyclohexene, and *p*-menthene in the presence of hydrogenation catalysts. J. Am. Chem. Soc., 76:2640.

With H. Pines and N. E. Hoffman. Studies in the terpene series. XX. The thermal isomerization of pinane at atmospheric pressures. J. Am. Chem. Soc., 76:4412.

1955

With H. Pines and B. Kvetinskas. Oxidative condensation of *p*-cymene, isopropylbenzene, and chloroisopropylbenzene. J. Am. Chem. Soc., 77:343.

With H. Pines and J. A. Vesely. Migration of double bonds in olefinic and diolefinic hydrocarbons catalyzed by sodium. Dehydrogenation of *d*-limonene to *p*-cymene. J. Am. Chem. Soc., 77:347.

With H. Pines and J. A. Vesely. Sodium catalyzed reactions. II. Side-chain ethylation of alkyl hydrocarbons catalyzed by sodium. J. Am. Chem. Soc., 77:554.

1959

My Life in the United States. Evanston, Illinois: Northwestern Univ. Press.

A large number of articles in the *Soviet Encyclopedia* and other encyclopedias and chapters in books.

UNITED STATES PATENTS

1933

1,895,329	With Carl Freitag. Process of Producing Phosphoric Acid and Hydrogen.

1934

1,960,631	Treatment of Hydrocarbon Gases.

1935

1,993,512	Treatment of Hydrocarbons.
1,993,513	Treatment of Hydrocarbons.
1,994,249	With Aristid V. Grosse. Synthesis of Hydrocarbons.
2,001,906	Treatment of Hydrocarbon Oils.
2,001,907	Treatment of Motor Fuel.
2,001,908	Treatment of Hydrocarbons.
2,001,909	Treatment of Hydrocarbons.
2,001,910	Treatment of Hydrocarbon Oils.
2,005,861	Manufacture of Hydrocarbons.
2,006,695	Treatment of Hydrocarbon Oil.
2,018,065	Catalysts.
2,018,066	Treatment of Hydrocarbon Oils.
2,020,649	Treatment of Hydrocarbons.

1936

2,035,889	Purification of Gases.
2,037,789	Treatment of Hydrocarbon Oils.
2,037,790	Treatment of Hydrocarbon Oils.
2,037,791	Treatment of Hydrocarbon Oils.
2,037,792	Treatment of Hydrocarbon Oils.
2,039,798	Treatment of Hydrocarbon Oils.
2,039,799	Treatment of Hydrocarbons.
2,046,900	Manufacture of Alkyl Phenols.
2,051,859	With Vasili Komarewsky. Polymerization of Olefins.
2,057,432	With Aristid V. Grosse. Treatment of Hydrocarbon Oils.
2,057,433	Treatment of Hydrocarbon Oils.
2,058,881	Treatment of Inhibitors.
2,061,871	Manufacture of Hydrocarbons.
2,062,312	Manufacture of Alkyl Phosphates.
2,063,933	Conversion of Hydrocarbon Oil.

1937

2,067,764 Treatment of Hydrocarbons.
2,081,357 Method of Improving Gasoline.
2,088,598 With Aristid V. Grosse. Manufacture of Alkylated Cyclic Hydrocarbons.
2,098,045 With Vasili Komarewsky. Treatment of Hydrocarbons.
2,098,046 With Vasili Komarewsky. Treatment of Hydrocarbons.
2,099,738 Alkylation of Trihydric Phenols.
2,101,857 With Raymond E. Schaad. Manufacture of Motor Fuels.
2,102,073 With Raymond E. Schaad. Treatment of Hydrocarbons.
2,102,074 With Raymond E. Schaad. Treatment of Hydrocarbons.

1938

2,104,424 With Aristid V. Grosse. Manufacture of Aromatic Derivatives.
2,107,794 With Vasili Komarewsky. Manufacture of Alcohols.
2,112,846 With Herman Pines. Treatment of Hydrocarbons.
2,112,847 With Herman Pines. Treatment of Hydrocarbons.
2,113,654 With Ben B. Corson. Treatment of Catalysts.
2,116,151 With Ben B. Corson. Manufacture of Motor Fuels.
2,120,702 With Raymond E. Schaad. Manufacture of Catalysts.
2,131,806 With Vasili Komarewsky. Treatment of Hydrocarbons.

1939

2,145,657 With Vasili Komarewsky. Process for the Hydrogenation of Hydrocarbon Oils.
2,147,256 With Herman Pines. Process for Alkylating Phenols.
2,157,208 With Raymond E. Schaad. Polymerization and Catalyst Therefor.
2,169,494 With Herman Pines. Treatment of Butane.
2,170,306 With Herman Pines. Treatment of Hydrocarbons.
2,174,883 With Herman Pines. Treatment of Hydrocarbons.
2,179,092 Manufacture of Ethers.
2,181,942 With Herman Pines. Polymerization of Olefins.

1940

2,187,034 With Herman Pines. Treatment of Hydrocarbons.
2,197,872 With George S. Monroe. Treatment of Hydrocarbons.

2,199,564 With Herman Pines. Hydrocarbon Reactions.
2,202,104 With Raymond E. Schaad. Manufacture of Motor Fuels.
2,211,207 With Louis Schmerling. Treatment of Catalysts.
2,211,208 With Ben B. Corson. Manufacture of Catalysts.
2,214,463 With Raymond E. Schaad. Treatment of Hydrocarbons.
2,217,019 With Aristid V. Grosse. Treatment of Hydrocarbons.
2,225,782 With Ben B. Corson. Reaction of Metal Catalysts.

1941

2,236,099 With Herman Pines. Treatment of Paraffin Hydrocarbons.
2,253,034 With Raymond E. Schaad. Manufacture of Ketones and Aldehydes.
2,267,735 With Ben B. Corson. Manufacture of Catalysts.
2,267,736 With Ben B. Corson. Treatment of Catalysts.
2,267,737 With Vladimir Haensel. Treatment of Hydrocarbons.

1942

2,270,302 With Raymond E. Schaad. Manufacture of Hydrocarbons.
2,270,303 Hydrogenation of Hydrocarbons.
2,271,299 With Herman Pines. Manufacture of Catalysts.
2,273,041 With Herman Pines. Treatment of Hydrocarbons.
2,273,042 With Herman Pines. Treatment of Hydrocarbons.
2,273,043 With Herman Pines. Treatment of Hydrocarbons.
2,273,320 With Aristid V. Grosse. Hydrocarbon Reactions.
2,275,181 With Ben B. Corson. Process for Hydrogenating Hydrocarbons.
2,275,182 With Raymond E. Schaad. Manufacture of Catalysts.
2,283,142 With Herman Pines. Isomerization of Normal Butane.
2,283,143 With Herman Pines. Isomerization of Normal Butane.
2,290,189 With Herman Pines. Conversion of Straight Chain Olefins to Isoparaffins.
2,291,254 With Herman Pines. Conversion of Hydrocarbons.
2,297,769 With Vladimir Haensel. Hydrogenation of Alkyl Aryl Ketones.
2,298,383 With Herman Pines. Treatment of Hydrocarbons.

1943

2,311,232	With Herman Pines. Manufacture of Catalysts.
2,315,078	With Herman Pines. Conversion of Hydrocarbons.
2,316,247	With Herman Pines. Isomerization of Paraffins.
2,316,248	With Herman Pines. Isomerization of Paraffins.
2,318,225	With Herman Pines. Production of Isobutane.
2,318,226	With Herman Pines. Production of Isobutane.
2,318,781	With Herman Pines. Treatment of Hydrocarbons.
2,322,025	With Aristid V. Grosse. Conversion of Hydrocarbons.
2,325,122	With Herman Pines. Treatment of Butane.
2,327,188	With Herman Pines. Treatment of Paraffins.
2,327,189	With Vladimir Haensel. Treatment of Hydrocarbons.
2,329,858	With Louis Schmerling. Treatment of Hydrocarbons.
2,332,467	With Carl B. Linn. Production of Ethers.
2,334,099	With Herman Pines. Treatment of Hydrocarbons.
2,334,100	With Vladimir Haensel. Hydrogenation of Ketones.
2,335,246	With Vladimir Haensel. Hydrocarbon Conversion.

1944

2,340,557	With Herman Pines. Conversion of Hydrocarbons.
2,341,782	With Louis Schmerling. Treatment of Hydrocarbon Oils.
2,342,865	With Herman Pines. Alkylation of Hydrocarbons.
2,345,751	Production of Diolefinic Hydrocarbons.
2,346,701	With Herman Pines. Treatment of Propane.
2,347,266	With Louis Schmerling. Isomerization of Paraffinic Hydrocarbons.
2,348,700	With Herman Pines. Treatment of Butane.
2,348,702	With Louis Schmerling. Hydrogenation of Hydrocarbon Materials.
2,349,834	With Louis Schmerling. Treatment of Hydrocarbons.
2,352,199	With George S. Monroe. Production of Toluene.
2,352,200	With George S. Monroe. Production of Toluene.
2,353,899	With Herman Pines. Isomerization of Paraffin Hydrocarbons.
2,355,219	With Vladimir Haensel. Hydrogenation of Aryl Carboxylic Acids.
2,356,001	With Herman Pines. Conversion of Hydrocarbons.

2,358,011 With Louis Schmerling. Treatment of Hydrocarbons.
2,361,065 With Louis Schmerling. Alkylation of Aromatic Hydrocarbons.
2,366,126 With Herman Pines. Production of Cycloolefinic Hydrocarbons and Aromatic Hydrocarbons.

1945

2,366,531 With Vladimir Haensel. Dehydrogenation of Hydrocarbons.
2,366,731 With Carl B. Linn. Alkylation of Isoparaffins.
2,366,736 With Carl B. Linn. Alkylation of Isoparaffins.
2,369,495 With Louis Schmerling. Treatment of Aromatic Hydrocarbons.
2,369,691 With Louis Schmerling. Catalyst Manufacture.
2,374,433 Production of Butadiene.
2,374,600 With Louis Schmerling. Alkylation of Aromatic Hydrocarbons.
2,375,041 With Louis Schmerling. Alkylation of Aromatic Hydrocarbons.
2,381,828 With Carl B. Linn. Conversion of Hydrocarbons.
2,382,318 With Raymond E. Schaad. Alkylation of Benzene.
2,382,881 With Herman Pines. Isomerization of Saturated Hydrocarbons.
2,382,882 With Herman Pines. Isomerization of Saturated Hydrocarbons.
2,384,337 With Herman Pines. Manufacture of Catalysts.
2,385,300 With Herman Pines. Conversion of Hydrocarbons.
2,386,007 With Louis Schmerling. Production of Aromatic Ketones.
2,386,468 With Raymond E. Schaad. Process for Isomerizing Normal Butenes to Isobutene.
2,386,957 With Vladimir Haensel. Dehydrocyclization of Aliphatic Hydrocarbons.
2,388,937 With Louis Schmerling. Treatment of Hydrocarbon Oils.
2,389,780 With Vladimir Haensel. Conversion of Ethylene.
2,391,508 With Herman Pines. Manufacture of Butadiene.
2,391,509 With Herman Pines. Manufacture of Butadiene

1946

2,392,924 With Herman Pines. Production of Isobutane.

2,394,691 With Herman Pines. Destructive Hydrogenation of Polycyclic Hydrocarbons.

2,399,224 With Vladimir Haensel. Conversions of Hydrocarbons.

2,399,741 With Herman Pines. Conversion of Dicyclic Dihydroterpenes to Cyclopentene Hydrocarbons and Pentamethylene Hydrocarbons.

2,401,636 With Vladimir Haensel. Process for Reducing the Olefin Content of an Olefinic Distillate.

2,402,051 With Louis Schmerling. Catalysts.

2,402,847 With Louis Schmerling. Alkylation of Aromatics with a Ferrous Chloride Catalyst.

2,403,439 With George S. Monroe. Process for Isomerizing Monoolefins.

2,404,498 With George S. Monroe. Production of Toluene.

2,404,536 With Louis Schmerling. Alkylation of Hydrocarbons.

2,404,537 With Louis Schmerling. Treatment of Hydrocarbons.

2,404,538 With Louis Schmerling. Manufacture of Arylalkene Hydrocarbons.

2,404,927 With Louis Schmerling. Manufacture of Isoparaffins.

2,406,630 With Herman Pines. Production of Cycloolefinic Hydrocarbons and Aromatic Hydrocarbons.

2,406,631 With Herman Pines. Production of Cycloolefinic Hydrocarbons and Aromatic Hydrocarbons.

2,406,632 With Herman Pines. Production of Cycloolefinic Hydrocarbons and Aromatic Hydrocarbons.

2,406,639 With Louis Schmerling. Catalytic Reactions.

2,410,445 With Herman Pines. Production of Diolefinic Hydrocarbons by Reaction of an Alcohol with an Acetylenic Hydrocarbon.

2,410,553 With Louis Schmerling. Manufacture of Alkylated Aromatic Compounds.

2,410,554 With Herman Pines. Production of Aromatic Compounds.

2,411,047 With Carl B. Linn. Alkylation of Aromatics.

2,412,012 With Louis Schmerling. Preparation of Aldehydes and Acetals.

1947

2,416,106 With Carl B. Linn. Polymerization of Olefinic Hydrocarbons in the Presence of Boron Fluoride and an Acid Fluoride of a Metal.

2,419,142 With Carl B. Linn. Treatment of Alkyl Ketones to Form Condensation Products Thereof.

2,419,690 With Herman Pines. Conversion of Hydrocarbons.

2,420,749 With Herman Pines. Treatment of Monocyclic Olefinic Hydrocarbons.

2,421,936 With Vladimir Haensel. Production of Octenes.

2,421,946 With Carl B. Linn. Polymerization of Olefinic Hydrocarbons.

2,422,435 With Herman Pines. Manufacture of Cyclohexene Oxides.

2,422,670 With Vladimir Haensel. Selective Demethylation of Paraffinic Hydrocarbons.

2,422,671 With Vladimir Haensel. Process for Lowering the Molecular Weight of Non-Aromatic Hydrocarbons.

2,422,672 With Vladimir Haensel. Selective Demethylation of Trimethylpentanes to Form Triptane.

2,422,673 With Vladimir Haensel. Treatment of Alkyl Aromatic Hydrocarbons.

2,422,674 With Vladimir Haensel. Selective Demethylation of Saturated Hydrocarbons.

2,422,675 With Vladimir Haensel. Selective Demethylation of Saturated Hydrocarbons.

2,427,791 With Louis Schmerling. Hydrogenation of Halogenated Hydrocarbons.

2,428,279 With Carl B. Linn. Alkylation of Aromatics.

2,430,190 With Louis Schmerling. Alkylation of Phenols.

2,431,754 With Carl B. Linn. Condensation of Alkyl Ketones in Presence of Aqueous Ammonium Halide Solutions.

2,431,756 With Herman Pines. Treatment of Terpenic Hydrocarbons.

1948

2,434,409 With Carl B. Linn. Process for Purifying a Hydrocarbon Mixture Containing Small Amounts of Organic Fluorine Compounds.

2,435,443 With Herman Pines. Separation of Gem Cyclic Hydrocarbons from Nongem Cyclic Hydrocarbons by Selective Dehydrogenation.

2,438,215 With Louis Schmerling. Treatment of Polyalkyl Aromatics.

2,439,982 With George S. Monroe. Production of Dehydrated Castor Oil.

2,441,663 With Vladimir Haensel. Process for Purifying Saturated Hydrocarbons Involving Selective Demethylation.

2,442,878 With Louis Schmerling. Manufacture of Alkylated Aromatic Hydrocarbons.

2,443,732 With Carl B. Linn. Dehydration of Alkyl Ketones.

2,444,509 With Vladimir Haensel. Composition of Matter.

1949

2,465,475 With Herman Pines. Purification of Cyclic Olefinic Ketones.

2,476,416 With Herman Pines. Isomerization of Paraffin Hydrocarbons by Contact with Catalyst Comprising Aluminum Chloride and Ferric Chloride.

2,478,270 With George S. Monroe. Dehydration of Alcohols.

2,480,268 With Herman Pines. Manufacture of Bicycloalkyl Aromatic Compounds and Hydrocarbons.

1950

2,502,569 With Herman Pines. Manufacture of Alkylcyclopentane Hydrocarbons.

2,514,546 With Herman Pines. Production of Cycloalkylperhydroindan Hydrocarbons.

2,519,576 With Herman Pines. Production of Arylindans.

2,519,577 With Herman Pines. Production of Arylindan Hydrocarbons.

2,526,895 With Herman Pines. Production of Polycyclic Aromatic Hydrocarbons.

2,526,896 With Herman Pines. Production of Diaryl Alkanes.

2,526,897 With Herman Pines. Production of Aryl Indans.

1951

2,538,248 With George S. Monroe. Isomerization of Olefins.

2,557,505 With Herman Pines. Production of Diarylalkanes.

2,563,037 With George S. Monroe. Conversion of Aromatic Amines to Aromatic Hydrocarbons.

2,578,207 With Herman Pines. Di-(Alkylphenyl)-Alkenes.

1952

2,584,103 With Herman Pines. Alkylation of Aromatic Hydrocarbons.

2,586,535 With Herman Pines. Catalytic Hydrogenation of Aromatic Hydrocarbons in a Stainless Steel Reactor.

2,587,577 With Herman Pines. Production of Arylindanes.

2,622,110 With Herman Pines. Di(cycloalkyl)alkanes.

1953

2,630,460 With Herman Pines. 4-Alkylbiphenyls.

2,631,174 With Herman Pines. Polycyclic Benzene Hydrocarbons.

1954

2,671,114 With Herman Pines. Bis(hydronopyl) Ether.

2,671,120 With Herman Pines and Bruno Kvetinskas. Noncatalytic Isomerization of Aromatic Compounds.

2,694,730 With Herman Pines. Bicyclooctene Derivatives.

1956

2,750,261 With George S. Monroe. Hydrogen.

2,751,406 With Herman Pines. Oxidative Condensation.

2,758,140 With Herman Pines and Bruno Kvetinskas. Noncatalytic Condensation of Aromatic Compounds with Unsaturated Hydrocarbons.