Ipatieff: Man and Scientist

Herman Pines

At the Testimonial Celebration in 1942 honoring Ipatieff's 75th birthday, the late Frank Whitmore made the following remarks: "Russia has produced three outstanding chemists among its many great ones. These are Lomonosoff, Mendeleev, and Ipatieff. Ipatieff has had a far greater influence on world chemistry than his two famous countrymen. He is a chemist who was a pioneer 50 years ago and is still pioneering today."

Ipatieff was indeed a pioneer until his death at the age of 85, an extraordinary achievement for a man who in his youth was trained for the army and not for a scientific career.

Vladimir Ipatieff was born in Moscow on 21 November, 1867, by the present calendar. His father was an architect. He was taught to read and write by his mother, who was a well-educated woman and whose kindness and devotion he remembered all his life. Her influence ended when he was 10, when she left for the Crimea because of impaired health. She died 2 years later.

Ipatieff entered the Third Moscow Military Gymnasium at the age of 11, having had 3 years of study at the classical gymnasium. He states in his autobiography that until he was 14 he was a mediocre student. However, after passing to the 6th class in the military school he became interested in his work and began to study hard. His favorite subjects were mathematics and science, especially chemistry.

Upon graduating from the military gymnasium he entered the Alexander Military School, where his interest in chemistry continued. He began to study on his own the then standard texts and Kolbe's book on inorganic chemistry. At the end of 2 years, after having passed competitive examinations, he transferred to the Mikhail Artillery School in St. Petersburg. The chief subjects there were mathematics and ballistics. Although more time was devoted to chemistry, the course was poorly organized and ineffectively taught. Ipatieff's real teachers thus became Mendeleev's *The Fundamentals of Chemistry*, Menshutkin's *Analytical Chemistry*, and Fresenius' *Qualitative Analysis*. He read and reread these books, carrying out the experiments as he proceeded.

Ipatieff graduated with highest grades in both mathematics and chemistry and in 1887 became an officer in the Tsar's Army. Upon his graduation he received a sum of money from the government for a saddle and other equipment and a gift of money from his father for additional clothing. After making his purchases he had 100 rubles left. Although in need of a winter coat, he decided to spend this money to equip a small laboratory—a choice he never regretted, for in this laboratory he experimented at his leisure and acquired a fundamental knowledge of inorganic chemistry.

Eager to increase his knowledge, Ipatieff prepared himself for the competitive entrance examination for training at the Mikhail Artillery Academy, in St. Petersburg, and was admitted in 1889. This academy had been founded to provide advanced technical training for officers who were to serve as engineers in government munition plants, as inspectors of materials, and so on.

The chemical laboratory at the Academy was equipped only for instruction in qualitative and quantitative analysis, not for work in organic chemistry. Because of this, and because the laboratory closed at 5:00 p.m., Ipatieff decided to set up a small laboratory in his apartment. He had to obtain the consent of the police and of the governor of St. Petersburg, since this was a time when home laboratories which might be used to prepare explosives for bombs were suspect.

Later, while still at the Academy, Ipatieff borrowed 300 rubles from his orderly to purchase a well-equipped private laboratory. There he investigated samples of steel used in the making of guns. His results were published in the *Journal of Artillery* in 1892. This paper, "Chemical investigations of the structure of steel," was the first of the several hundred research papers he published over the years.

Publication of Ipatieff's two chemistry manuals for the Academy students, the appearance of his paper on the structure of steel, and his success in the field of chemistry led to his appointment as an instructor in chemistry at the Mikhail Artillery Academy. Soon after, in 1892, he married Barbara Ermakova, who remained his devoted companion for 60 years.

In order to receive tenure as an instructor, Ipatieff was required by Academy regulations to present an independent dissertation. He approached A. E. Favorsky of St. Petersburg University and asked him to suggest a topic. Favorsky advised him to sudy organic chemistry, saying that only through organic chemistry would he learn to think chemically and experiment rationally. Ipatieff began to attend Menshutkin's lectures on organic chemistry and at the same time started to work on his dissertation, "The Isomerization of Allenes and Acetylenes," under Favorsky's guidance. Within 2 years he accomplished his task and was awarded the minor Butlerov prize given annually for the best work done by a young chemist. He was promoted soon after to the rank of assistant professor at the Academy.

In 1896, upon the advice of Favorsky, he left for Munich to study under the great Adolf von Baeyer. In the laboratory he made friends with Moses Gomberg, the discoverer of stable free radicals, and Richard Willstätter, who at the age of 22 was already an accomplished chemist. Ipatieff was assigned the problem of determining the structure of carone. He was able to demonstrate that the oxidation of carone gave two stereoisomeric acids, the *cis*- and the *trans*-caronic acids. This work was published in *Berichte der Deutschen Chemischen Gesellschaft* in 1896, under the joint authorship of Ipatieff and von Baeyer. At the suggestion of von Baeyer, Ipatieff then proceeded to work on his own problem. He chose to establish the structure of isoprene, and soon succeeded in doing so.

Upon his return to St. Petersburg from Munich, Ipatieff continued his re-

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search in organic chemistry. In 1898 he presented his dissertation on the subject of allene hydrocarbons and the synthesis of isoprene, and was promoted to the rank of professor.

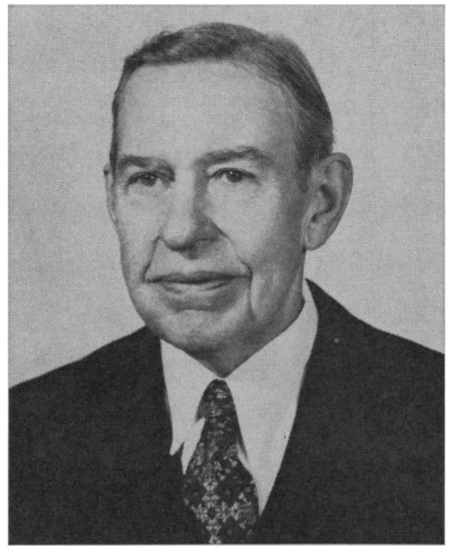
The main breakthrough in Ipatieff's research occurred in 1900 when he noticed that the pyrolysis of isoamyl alcohol passed through an iron tube produced isovaleric aldehyde, and that none of the aldehyde was produced when a quartz tube was used. He realized that he was dealing with a new phenomenon—contact reactions, or contact catalysis. This was the beginning of 50 years of fruitful work in this new field. His first paper on the catalytic dehydrogenation of organic compounds appeared in 1901, even before publication of the famous article by Sabatier and Senderens on hydrogenation of benzene in the presence of reduced nickel.

An avalanche of discoveries followed —the dehydration of alcohols over aluminas, the catalytic isomerization of olefins, the conversion of ethyl alcohol to butadiene, and others. A major success of his work at this period was the introduction of an autoclave for studying reactions at high pressures and temperatures. This technique eventually opened up a new era in the investigation of catalytic reactions. Ipatieff began with studies of the hydrogenation of fats.

Because of his interest in industrial research, he was well acquainted with problems relating to petroleum. As a consultant to Nobel Brothers, the largest petroleum company in Russia, he initiated a program of thermal and catalytic processes for cracking petroleum. He was also active in developing an industrial process for hardening fats. In his role as consultant he surveyed the Baku oil fields and the rich anthracite mines in the Donnets Basin. His research attracted wide attention abroad; he was offered consultantships in several German industrial concerns but refused the offers, fearing that this would interfere with his scientific work.

From 1911 to 1916 Ipatieff studied polymerization of olefins under pressure, hydrogenation of sugars, and displacement of metals. This research was carried out at the Academy of Artillery with untrained assistants since there were no students specializing in chemistry at the Academy.

Research was not Ipatieff's only activity while at the Academy. He reorganized the chemistry curriculum and wrote textbooks, such as *Principal Laws of Chemistry* (1893); *Inorganic Chemistry* (1902), which by 1913 had appeared in eight revised editions; and *Organic Chemistry* (1902), which also appeared in many editions.



Vladimir Ipatieff. [Photograph by Universal Oil Products Company]

According to the then-existing regulation Ipatieff was not qualified to obtain even a master's degree from a university, as he had not graduated from a classical gymnasium and had not had formal academic training. However, in 1905, being already famous, he petitioned the Ministry of Education to waive the regulation and permit him to present a dissertation for a Doctor of Chemistry degree at St. Petersburg University. He successfully defended his dissertation in 1908, at the age of 41. This permitted him, if he so chose, to secure a professorship at a university. He preferred, however, to remain at the Academy of Artillery, where he had a well-equipped pressure laboratory.

As a military man, Ipatieff's promotion to higher ranks was rapid. In 1904 he became a colonel, in 1910 a major general, and in 1914 a lieutenant general. The promotion to the rank of general was a great event in his military life. This high rank seemingly endowed its possessor with the courage to speak his mind and compel the authorities to listen to him. But, although generals were always addressed as "Your Excellency," he insisted that the people in his laboratory and his friends continue to call him by his first name and his patronymic.

Ipatieff was much interested in the education of his three sons and daughter. During the turbulent years 1904 and 1905 he became the chairman of the general parent-teachers association for the city of St. Petersburg. Through his diplomacy and persuasiveness he prevented a strike of students, on the opening day of school, in protest over the expulsion of 15 upperclassmen for leftist ideas, and arranged for the students to be reinstated.

In 1905 Ipatieff bought a 140-acre farm in the vicinity of Moscow, on the shores of the Ugra River. He wanted his sons to work in the fields during their summer vacations. Since he himself knew little about farming, he read extensively in books on agriculture. For 3 or 4 years his farming was not very successful, but gradually the farm began to yield crops of high-quality rye and the neighboring farmers began to buy his grain for seed.

As befitted an artillery officer, Ipatieff was an excellent horseman. He used to buy wild Arabian horses and break them in as saddle horses. He applied his experience with horses to the human race. "Give the subordinates enough rein," he often said, "but let them know who the master is."

In these years Ipatieff received many honors for his scientific accomplishments. He was awarded the Ivanov prize by the Russian Academy of Science in 1906. In 1913 he was given the Moshuin prize by the University of Moscow, and in 1920 he won the major Butlerov prize. For his contribution to the army and to industry he was awarded numerous medals and orders, and in 1916 he was made a Commander of the French Legion of Honor. In the same year he was elected to the Russian Academy of Sciences.

World War I and Revolution

At the outbreak of World War I, Ipatieff was placed at the head of the Chemical Committee. Its function was to organize and unite all branches of the chemical industry to serve the needs of the army and to prepare for the eventual return of industry to a peacetime role. When the war erupted, the Russian chemical industry was totally unprepared for the great task required of it, and the nation's stockpile of munitions was very low. In a short time, under Ipatieff's energetic leadership, the production of explosives increased from 60 to 3300 tons per month, and within 2 years a substantial chemical industry had been brought into existence.

After the Germans used poison gas on the Warsaw front in 1915, killing 7000 to 8000 men in one night, Ipatieff's Committee was charged with making plans for preparing poison gases and providing gas masks. The Committee was also responsible for the construction of plants for the manufacture of basic organic chemicals and drugs.

In the last days of February 1917 the Russian Empire entered an epoch of dyarchy and disorder, followed by the October Revolution led by Lenin. According to Ipatieff, Lenin saved the country from anarchy and temporarily preserved the intelligentsia and the country's material wealth. In November 1917 he was approached by the Soviet Government and asked to help the chemical industry change over from wartime to peacetime production. Owing, however, to lack of transportation and to hardship and disorder, little was accomplished by the Chemical Committee.

The years 1917 to 1920 were inactive ones for Ipatieff. His research had been largely interrupted by lack of facilities, food, and fuel. In 1920 the Communist government, aware of his contribution to the development of the Russian chemical industry during World War I, appointed him to direct the Institute of Scientific and Technical Investigation. Shortly afterward he was also made a member of the presidium of the Supreme Council of National Economy.

In 1921 he was made a member of the all-powerful Planning Commission, which consisted of specialists in every branch of industry. In the same year he received a letter signed by Lenin, Chairman of the Council of People's Commissars, stating that, by the decision of the All-Russian Central Executive Committee, he had been appointed a member of the presidium of the Supreme Council of National Economy and Chairman of the Chemical Administration. He thus became a non-Party member of the Soviet Government. The Chemical Administration's main function was to develop plans and restore the Soviet chemical industry.

Although his governmental duties occupied much of Ipatieff's time in 1923 and 1924, he still found time to continue his scientific work and to study the destructive hydrogenation of polycyclic compounds to benzene and toluene.

Ipatieff's most important move in the presidium was to submit a memorandum on the reorganization of Soviet industry. Since the cancellation of all property rights of foreign and domestic owners had resulted in inefficiency and low productivity, Ipatieff suggested that former foreign owners be allowed to rent their factories on a long-term basis, and to operate them with foreign capital. He volunteered to go abroad to meet the owners. Although it was rumored that Ipatieff proposed a counterrevolutionary scheme, the government nevertheless decided to send him abroad to negotiate with foreign financiers in furtherance of his plan. His travels took him to England, France, Belgium, Germany, and Italy, and he established many contacts with scientists and industrialists. Not all the contacts were pleasant, as the Russian émigrés resented Ipatieff's cooperation with the Soviet regime. The plan failed, as neither the government nor the émigrés evinced much interest in it.

On one of his frequent trips, at a dinner given by Walther Nernst, Ipatieff met Albert Einstein, who asked him why he did not take up permanent residence abroad. He replied that, as a Russian, he believed he could be of service to Russia, and that civilized life could be reestablished there through the united effort of all the Russians. Einstein agreed and commented that a man could act no differently. Within a few years both Ipatieff and Einstein had left their native countries for the United States.

On 21 January 1924 Lenin died. After his death there were many changes in the Supreme Council of National Economy. There was sharp disagreement over the future of various branches of the chemical industry. Ipatieff experienced many unpleasant incidents while performing his duties. In 1927 he was removed from both the Supreme Council of National Economy and the Scientific and Technical Administration.

At the close of 1926 Ipatieff began to organize another laboratory for catalytic experiments at high pressures. With a staff of five senior members and three assistants, the work progressed satisfactorily, and during 1927 and 1928 he published 25 research papers. He studied destructive hydrogenation of aromatic compounds of high molecular weight, oxidation of phosphorus, and displacement and precipitation of metals. He also served as a consultant to the Bayerisch Laboratory in Germany, where a pilot plant for the conversion of phosphorus to phosphoric acid was established. Ipatieff's contribution to science was recognized throughout Europe, and he was invited to address various international congresses. In 1928 the French Society of Industrial Chemistry awarded him the Berthelot Medal.

In 1929 E. I. Spitalsky, a close associate and friend of Ipatieff's, was arrested by the dreaded G.P.U. (State Political Administration). All attempts made by Ipatieff to free his friend were fruitless, and he was advised to stop agitation; otherwise, suspicion would fall on him too. On his return from Japan in 1929, where he had attended the International Engineering Congress, news reached him that five military technical engineers, former students and co-workers of his, had been shot without a trial. Arrests of many others of his associates followed.

Early in 1930 he noticed more than the usual nervous tension among the workers in various Soviet institutions; the arrests of many employees had excited everyone, and no one knew whose turn would be next. Ipatieff was secretly warned by a friend that he was on the list of those to be arrested. He reluctantly concluded that he could no longer be of benefit to his country. In June 1930 he was sent to Germany to attend a scientific congress. After crossing the Russian-Polish border he turned to his wife, who had been permitted to accompany him for reasons of health, and said, "Take a good look at your country, as we are leaving it for good."

Emigration

It did not take Ipatieff long to adjust to life in Germany. While still in Russia he had, with the approval of the Soviet Government, made an arrangement with the Bayerische Stickstoff Werke to spend 6 months of the year in their laboratories to conduct research on the precipitation of metals and their oxides from solutions by means of high-pressure techniques.

At the 12th International Power Congress, in Berlin, he was introduced to

Gustav Egloff of the Universal Oil Products Company. Egloff invited Ipatieff to visit his company in Chicago and helped him obtain an American visa—a difficult matter for a Russian subject.

Ipatieff arrived in the United States at the end of 1930. Soon afterward he was asked by H. J. Halle, president of Universal Oil Products Company, to establish a research laboratory for studying catalytic conversions of petroleum hydrocarbons. His contract with the American firm permitted him to divide his time between his research in Germany and his work for Universal Oil. In 1931, after the contract arrangement in Germany terminated, Ipatieff returned to the United States. This was made possible through the efforts of Ward V. Evans of Northwestern University, who, at the suggestion of Egloff, secured for Ipatieff a position as lecturer in the department of chemistry. The academic visa permitted Ipatieff and his wife to establish permanent residence here. Incidentally, Ipatieff's short stay in Germany netted him a sizable sum of money, which he received for the inventions he had made there.

Ipatieff's fame had preceded his arrival in the United States by many years. While visiting the Shell Oil Company installations on the West Coast he was shown a plant for converting isopropyl alcohol to acetone. The superintendent of the plant explained that they were using the "Ipatieff method" for the dehydrogenation of alcohol. Ipatieff said, "I am he; I am the inventor." "Oh, no," said the superintendent, "the inventor is dead. He died a long time ago."

The first months at the Universal Oil Products Company laboratories were grueling. He could not understand his assistants and they could not understand him. He found it difficult to learn English at the age of 63. Through sheer perseverance and long hours with a private tutor he reached the point where his spoken English could be understood. The following year he gave a series of lectures at Northwestern on catalytic reactions of organic substances. He wrote his lectures in Russian, had them translated into English, and then spent hours reading them to his tutor.

The original research group assigned to Ipatieff consisted of four people; within a year this group had been increased to about ten, including three Russian chemists with whom he had been associated professionally in Germany. Ipatieff's inspiring leadership, his practical experience, and his canny foresight in assigning problems yielded new discoveries and new commercial processes within a short time. Some of the processes were based on newly discovered reactions which invalidated then accepted principles of organic chemistry.

His discovery of "solid phosphoric acid" catalyst for the polymerization of olefinic gases enabled the refiners to convert waste gases into high-octane gasoline. In World War II his catalyst was used for the manufacture of cumene, an important component of aviation gasoline for bombers. The polymerization of olefins was the first commercial application of catalysis to the manufacture of gasoline, and it is a process still widely used throughout the world.

The discovery of alkylation and isomerization of paraffins was the basis of the production of aviation gasoline during World War II, and is the basis of production of today's high-octane gasoline. Reactions such as conjunct polymerization, alkylation of aromatics with olefins, and dehydrogenation of paraffins were discovered and investigated during this period. Between 1935 and 1939 Ipatieff and his co-workers published over 50 scientific papers. His accomplishments were recognized in this country and abroad. In 1939 he was elected to the National Academy of Sciences and the following year was awarded the coveted Willard Gibbs Medal. He was decorated by King Boris of Bulgaria, received the Lavoisier medal, and was elected Officier de l'Académie Française.

His achievements were not unnoticed in his native country. Ambassador Troyanovsky, at the request of Stalin, approached Ipatieff on several occasions to try to persuade him to return to Russia, as his services were needed there. Ipatieff did not place much faith in Troyanovsky's guarantee that he would be permitted to return to the United States. A year later the ambassador was removed from his post and his fate became shrouded in a Soviet cloud of oblivion. In 1937 Ipatieff was expelled from the Russian Academy of Sciences and deprived of his Soviet citizenship. In a public meeting his son Vladimir, professor of chemistry, was made to renounce his father, and Ipatieff's name was no longer cited in the Russian chemical literature. When reference was made to his work, only the names of his co-workers were mentioned. In 1965 at a special meeting of the Academy, however, Ipatieff was reinstated to membership, and he was acclaimed in the press as a Russian patriot, which indeed he was.

In 1939, in appreciation of the assistance he had received from Northwestern University in settling in this country, he donated funds for the establishment of a catalytic laboratory. Through the years he kept on augmenting the fund, and he willed his estate to it. In recognition of Ipatieff's contribution, Universal Oil Products Company equipped the laboratory which bears his name.

In 1939 he also established a fund, now being administered by the American Chemical Society, for a prize in the field of high-pressure reactions and catalysis. The Ipatieff prize is awarded every 3 years.

Ipatieff is the father of the modern petrochemical industry, for it was he who pioneered the application of catalysis to the field of petroleum. In his investigations he blended fundamental scientific studies with practical applications, and he advocated this approach to industrial research laboratories.

Ipatieff was a man of modest desires and simple habits. He never owned a car, preferring to walk for miles every day. His worldly possessions would hardly have filled a few suitcases. He ran his life on schedule and was upset when anything interfered with the schedule. He hated to waste time and never postponed any task that needed to be done; his speeches and lectures were prepared weeks in advance. In his busy schedule he found time to write his scientific autobiography, *Catalytic Reactions at High Pressures and Temperatures* (Macmillan, 1936) and his personal autobiography, *The Life of a Chemist* (Stanford University Press, 1946).

He was democratic and broadminded; when asked by the judge, upon receiving his citizenship, what church he attended, Ipatieff replied, "Any church, this is a free country." He was endowed with a fine sense of humor. At the Willard Gibbs Medal dinner, when a congratulatory telegram from his old friend Nobel was read, he remarked: "From Nobel I get praises but not prizes." Fortunate were those who could understand his native language, for he was a raconteur par excellence, drawing his stories from the reservoir of Russian folklore and personal experiences.

No human life is free of misfortunes, and Ipatieff had his share. His oldest son, Dimitrii, gave his life in World War I; his second son, Nicolai, died in the Belgian Congo while experimenting with a new antimalarial drug. Cut off from his country, his children forbidden to communicate with him, he suffered greatly. With deep concern he followed the events of World War II when his country was invaded by Germany and he was unable to help her. Two of his grandsons perished in the war.

Ipatieff's philosophy of life is best expressed in a passage in his autobiography: "Scientists should be very modest in evaluating their achievements and realize, although they have devoted their whole life to science and in spite of their great discoveries, that they play a relatively small part in the progress of scientific knowledge whose problems are illimitable. A true scientist derives his greatest satisfactions in handing on his ideas to others for further development."

On 29 November 1952, while awaiting the arrival of the writer of this article to discuss some problems of the laboratory, he passed away suddenly. His wife followed him 10 days later.

NEWS AND COMMENT

Space Budget: Congress Is in a Critical, Cutting Mood

The political atmosphere surrounding the U.S. space program is today murkier and less hospitable than at any time since 1961 when President Kennedy decided to send men to the moon. This does not necessarily mean that NASA is in any danger of falling off of its $5-billion-a-year budgetary plateau (give or take a few hundred million). But it is clear that, where Congress is concerned, the agency has lost much of its innocence and therefore its plans are to be reviewed with the caution and skepticism reserved for, say, a new farm-subsidy scheme.

Before looking at the recent House and Senate actions on space legislation, consider for a moment the short but dynamic history of the space program. Born during the intense cold-war rivalry of the late 1950's, the program was—and is—cheered on by a public and a Congress moved by excitement, patriotism, and a Hollywood taste for supercolossal productions. Scientific interest has helped advance the space effort, but, by much of the public, the U.S. and Soviet space programs seem to have been regarded as a kind of celestial stock-car race.

The unbroken string of successful manned orbital flights of the Mercury and Gemini projects created a euphoric mood and led to the assumption that the vastly more difficult Apollo flight to the moon would be accomplished without mishap. The loss of a three-man Apollo crew in the spaceship fire last January was NASA's first real setback. Weaknesses in the NASA management were exposed. The garrulous and sometimes evasive and testy manner of Administrator James E. Webb before congressional committees investigating the Apollo fire produced a greater awareness that NASA, like other agencies, is not beyond confusing its public image with the public interest.

However, by its massive spending program of the last 5 years, NASA has acquired a lot of devoted friends. As a gigantic engineering project, Apollo has brought contracts and profits to thousands of companies and has become the economic mainstay of a number of communities such as Huntsville, Alabama (*Science*, 10 March), and Brevard County (Cape Kennedy), Florida.

Some members of Congress are remarkably frank in indicating that their principal interest in the space program lies in the economic benefits it brings their districts. In the recent House debate on the space bill, a congressman from the Los Angeles area, which has been thriving on space contracts, compared the economic effects of the space effort to those of military buildups. "This country of ours became strong and grew wealthy while it was doing things all of us would agree are not sensible to do," he said. A New Orleans congressman, F. Edward Hébert, whose area benefits from NASA dollars spent at the Michoud Saturn assembly plant, said "I am unalterably opposed to the so-called giveaway programs, the so-called poverty programs, the so-called do-good-here and do-good-there programs. . . . Not one of those programs produces a single item of income . . . [But] every dollar put into the [space] program comes out in a productive manner. . . ."

The deep involvement of university scientists and engineers in Apollo and in NASA's scientific programs (which, though small by comparison with Apollo, involve hundreds of millions of dollars) has extended the NASA constituency still further. Speculation concerning NASA's prospects must take into account the strength of this multifarious constituency and the tendency of the administration and Congress to continue to recognize the budgetary claims of a new agency once it has become established. Inertia and the politician's desire to avoid conflict are factors always working for a more or less stable, if not a rising, agency budget. Indeed, one might be justified in predicting that the major budgetary struggles of the future will be less concerned with how much money NASA gets than with how NASA spends the money it does get. The principal contestants could turn out to be, on the one hand, a NASA officialdom dominated by people largely interested in spectacular manned space flights and engineering feats and, on the other hand, scientists interested in the advancement of knowledge and their professional reputations.

The great momentum achieved by an ongoing program, on which billions of dollars already have been spent, is evident from the fact that Congress probably will provide nearly all of the $2.5 billion NASA has requested this year for Apollo. The NASA budget of