Aerospace Education and Research at Princeton University 1942–1975

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Abstract

A brief account is given of the history of aerospace education and research at Princeton University for the period 1942 to 1975. This period covers the initial establishment of the Aeronautical Engineering in 1942, its move to Forrestal Campus, and the eventual return to Main Campus.

1 Introduction

Engineering began at Princeton with the establishment of a Civil Engineering program in 1875 [1]. Fourteen years later, Cyrus Fogg Brackett organized what was apparently the nation's first program in Electrical Engineering. It was not until 1921, however, when Arthur Maurice Green Jr. was asked to organize the School of Engineering as an educational unit to be administered by a Dean of Engineering. In his plan for the new School, Dean Greene inaugurated undergraduate programs in Chemical, Geological and Mechanical Engineering. A program in Basic Engineering was added in 1935.

The classes in ME "...were held in the old School of Science, with a makeshift laboratory in a boiler house across Washington Road, until the John C. Green Engineering Building was constructed in 1928. Starting with only two young assistants in mechanical engineering, Dean Greene taught over half the courses in the department in addition to performing his administrative duties. Louis F. Rahm and Alfred E. Sorenson joined the slowly expanding department in 1926, Lewis F. Moody as professor of fluid mechanics and machine design arrived in 1930.

During the Depression, graduating seniors, unable to obtain employment, returned for graduate study, spurring the development of both the engine and hydraulics laboratories. By 1941, when Dean Greene retired and was succeeded as dean and chairman by Kenneth H. Condit, the Department of Mechanical Engineering was both well staffed and equipped, permitting it to acquit itself well during the hectic war years when year-round teaching of military and civilian students was the order of the day" [2].

Dean Condit and other members of the Princeton engineering community expressed an interest in introducing aeronautical engineering into the School of Engineering curricula and started a search for some outside expert who could advise whether or how this might be done [3]. Gordon Rentschler, a Princeton Trustee and an important executive in the aeronautical industry, exerted some pressure on Condit to persevere. He discussed this idea with a former colleague at McGraw-Hill, S. Paul Johnston, then Editor of *Aviation* magazine. He then decided to invite another former colleague, Daniel Clemens Sayre (figure 1), at that time Associate Administrator of the Civil Aeronautics Board, to make a two month survey. An airplane buff and an MIT graduate, Sayre was a man of many talents. He accepted this assignment and thus started the remarkable relationship between Sayre and Princeton that profoundly influenced the Engineering School in the following years.

2 Founding of the Aeronautics Department

Dan Sayre made his study in the summer of 1942, and recommended to the Dean that Princeton create a new, free-standing Department of Aeronautical Engineering, independent of the Department of Mechanical Engineering. He so impressed the University and the faculty of the Engineering School that his recommendation was accepted with enthusiasm. The new Department was established with Sayre as a Full Professor and the first Chairman. At the outset he was the entire faculty, and the Department [Sayre] had a desk on the balcony of the Mechanical Engineering Laboratory. This situation didn't last long. Dan wanted a building of his own, but he had

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no resources or space to build one.

Sayre sought funds to build some cinder block buildings on the lower campus just above Lake Carnegie and in back of the Observatory where small buildings like this were permitted. He approached local wealthy friends of the University and eventually was able to interest Mrs. Edgar Palmer and her sister Helen Hayes Watson who donated $50,000. Two small cinder block buildings were built very rapidly providing Sayre with office space for his staff and some area for research operations. He then set about acquiring a faculty and a small staff to man the Department and also signed up some undergraduates and a few graduate students to open the franchise.

Sayre had his eyes on two new faculty appointments for which slots had been approved in the initial agreement. He had heard through the MIT grapevine of a remarkable engineer at Sikorsky Aircraft who was interested in an academic career. Alexander Alexandrovitch Nikolsky, a Russian aristocrat had escaped the revolution while a naval cadet serving on a ship in Vladivostok harbor. He and a few other cadets made their way to Japan, then Cairo, and finally Paris. In Paris, Nikolsky enrolled in the Sorbonne where he received a diploma in engineering. He then took a job as a seaman on a freighter bound for New York. On arrival he jumped ship and continued on to Boston. The Russian emigree community came to his aid and helped to enroll him in the Aeronautical Engineering Department of MIT. On graduating with an M.S. degree, Igor Sikorsky, another Russian emigree who was looking after his young countrymen, hired him. Nikolsky rose rapidly in Sikorsky's engineering department and was Chief of the Structures Department when Dan Sayre approached him.

Nikolsky came to Princeton in 1943 as the second appointment of the new Department. He taught courses in aircraft structures at the undergraduate level and both taught and did research with his graduate students on predicting loads on rotor blades at the graduate level. The dozen or so students could choose between six undergraduate and eight graduate courses covering the principles of aerodynamics and aircraft structure and design [4]. Nikolsky became nationally known as an expert on helicopters and wrote a famous book on the subject entitled "Helicopter Analysis." A slight, wiry, friendly man, he was the life of any party and was loved by his many students [3].

3 The War Years

When the School of Engineering was founded in 1921, the trustees set a limit of 400 for enrollment of undergraduates working toward the degree of Bachelor of Science in Engineering. There were fewer than 100 student engineers at that time, but by the time Dean Greene retired in 1940, the School had reached an enrollment of 394 [1].

Then came the war, and enrollment fluctuated all the way from 85 to 600. During part of that period, the faculty of the School conducted training courses for Army Signal Corps technicians, for Army Specialized Training Program engineers, for various individuals enrolled under the Engineering, Science and Managament War Training Program, for Navy V-12 students, and for some 1000 Naval officers being prepared for radar operation and supervision. The teaching load went through cycles of overload and underload. Recruiting of staff in the fields of science and engineering became difficult, impossible, and then to all intents, illegal. Materials disappeared, technical equipment had to be improvised or simply done without [1]. Aeronautical Engineering, with a pocketful of plans for a staff and for laboratories, struggled along as a two-man faculty to teach aeronautical courses as were required.

4 The Post-War Period

The department came into the post-war era with a small nucleus and some useful experience, and because of the wartime restrictions on hiring, with the majority of its basic faculty positions still open for young people who had themselves helped bring about new developments in jet propulsion and supersonic flight that had revolutionized aviation.

When Sayre set out in 1943 to hire the third faculty member of the Department, he approached Courtland Perkins, a flight test engineer who was then at the Army Air Force's Aircraft Laboratory at Wright Field, where he directed research in stability and control. Perkins (figure 1) felt it was not the time to leave Wright Field where the war was generating enormous growth in aeronautical technology, but in early 1945 he accepted the University's offer of an Associate Professorship with tenure. Immediately after V-J Day, Perkins resigned his civil service position in the Army Air Corps, and moved to Princeton, arriving in October 1945.

At this time, almost all of the students were returning veterans with widely varying backgrounds, but with an overwhelming desire to graduate in the very shortest time. Special programs were developed to satisfy their desires and the University requirements. One sophomore who stayed was David C. Hazen who, after he received his B.S. and M.S. degrees became first a Research Assistant, then an Assistant Professor, and ultimately a Full Professor in the department.

Hazen was one of the people helping Perkins to build an instructional wind tunnel, using a large

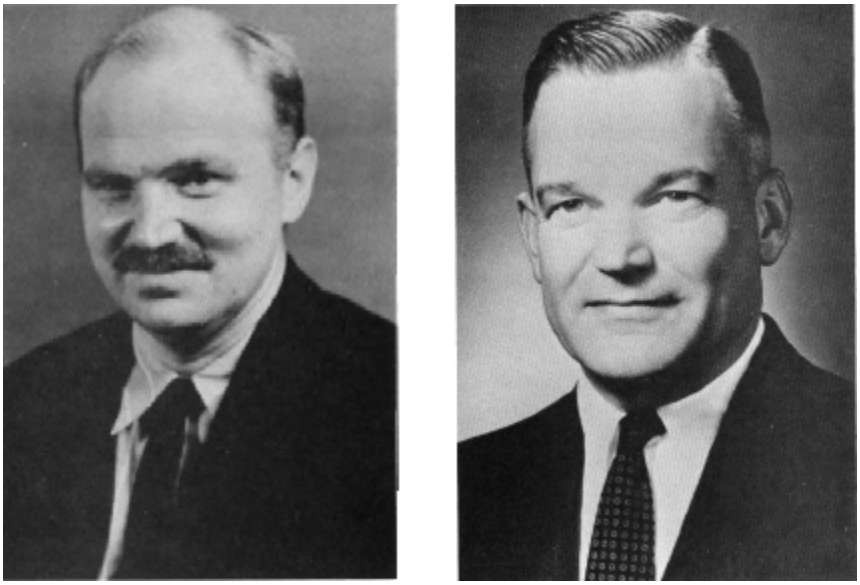

Figure 1: Daniel Sayre and Courtland Perkins.

open pit for a return arm of a wind tunnel, leaving the test section at floor level. A coal mine exhaust fan, designed to absorb 150 horsepower, was used to power the wind tunnel. With a $3' \times 5'$ throat, a speed at the test section of about 120 mph was possible. Together with a surplus motor and a control system, and a six component balance it turned out to be a very useful and important tool.

The Aeronautical Engineering Department at this time was housed in Sayre's cinder block buildings on the lower campus. All the undergraduate courses were given in the main Engineering Building, then located on Washington Road, about a mile away. There were several sponsored research programs being undertaken by the Department, including one in helicopter rotor de-icing under Sayre, and a theoretical program on rotor loads by Nikolsky. Perkins argued strongly for developing two important fields, one in the theoretical aerodynamics and another in propulsion, with emphasis on Jet Propulsion. Sayre and Nikolsky agreed readily and, with help from President Dodds, had the two slots approved by the University and the Engineering School.

For the Theoretical Aerodynamics position, Perkins approached a friend from MIT and Wright Field days, Lester Lees, then on the staff of the NACA at Langley Field. According to Perkins [3], Lees was an introvert but everyone recognized him as a genius obviously on his way to be becoming a top-flight theoretician. His major research interest was in theoretical aerodynamics with emphasis on the character of laminar and turbulent boundary layers. In particular, Lees had became one of the country's authorities on compressible flow, and Perkins offered him a position as an Assistant Professorship. The work going on in fluid dynamics in the Princeton Physics Department, which included Walker Bleakney doing experimental work with his shock tube, and the work being done by Dr. Ladenberg on interferometry also interested him. Lees joined the faculty in 1946. He brought with him several of his colleagues from NACA, including Abe Kahane and Jerry Schaffer. Importantly, he also brought with him an ONR contract for research in high speed fluid dynamics. He helped start the experimental work in supersonic flow that later was the heart the Princeton Gas Dynamics Laboratory. He was promoted to the rank of Associate Professor in short order, but some years later, when his next promotion was held up at Princeton, CalTech offered him a Full Professorship. Lees took it, and the department lost one of its most important faculty members in 1954.

While these negotiations were underway, a search was started for a candidate to fill a position in the field of Jet Propulsion. At that time the major academic program in Propulsion, and in particular Jet Propulsion, was at CalTech under the leadership of von Kármán. Perkins called von Kármán who suggested Joseph V. Charyk, a Canadian who had received his B.S. degree from the University of Alberta and then went to CalTech for his graduate program. Joe received his Ph.D. in the spring of 1946, and he had a strong interest in propulsion.

Joe came to Princeton to meet Dan Sayre, Nikolsky, and Dean Condit, and he agreed to an appointment as an Assistant Professor and moved to Princeton in the fall. He rose rapidly to Associate Professor, became a first class teacher-scholar, helped stabilize the new Ph.D. program (started in 1946 [5]), and established projects in propulsion that led ultimately to the organization of the Guggenheim

Propulsion Laboratories.

In the early 1950s, under intensifying Cold War pressure, and the demands of the Korean War effort, the U.S. greatly accelerated its missile and space programs and industry started actively recruiting staff for new programs. University faculties were a prime target. In 1955, Charyk finally succumbed to a very significant offer made by Lockheed through its powerful Board member, Lt. Gen. (Ret.) Pete Quesada. This was another great loss to the Department. Not long after this Charyk, with others, broke away from Lockheed and formed a company which after several evolutions became the Aeroneutronics Division of Ford. Several years later he left Ford to become the U.S. Air Force Chief Scientist. In less than a year he rose to the position of Assistant Secretary of the Air Force for R & D, and then ultimately Under Secretary. While in this last job he helped define a new private/public organization for handling space communications, called COMSAT. Charyk became its first President and eventually its Chairman.

The arrival of Lees and Charyk had brought the faculty to five by the end of 1946. Interestingly enough, of the five only one, Charyk, had a Ph.D. The rest had attended MIT and had M.S. degrees. Only a short time later appointment to the Princeton faculty without a Ph.D. became almost impossible.

With the appointment of Lees and Charyk the department had the major elements for growth. The faculty was spread widely, if thinly, across the various modern technologies of aeronautics. All five faculty members were eager to build the new Department into an aeronautical engineering program that would attract national attention. All agreed that Princeton University was a fertile environment to achieve this objective. The department was building up undergraduate demand, attracting graduate students to M.S. and Ph.D. programs, and conducting sponsored research, even if in rather make-shift facilities. All of this became possible through the slow development of a sponsored research program which provided the resources for current activities and future growth, which came faster than anticipated.

In the four years from 1947 to 1950, four windfalls accelerated the Department's growth:

1. The award by the Air Force, Navy, and Army of a graduate program in Applied Aeronautical Engineering with a principal focus on flight research.

2. The development of the Navy's Project Squid with Princeton named prime contractor.

3. An award to Princeton of a program for editing the twelve volume series on high-speed aerodynamics and jet propulsion.

4. A joint award to Princeton and CalTech to be the Guggenheim Jet Propulsion Centers.

The first, the decision of the Armed services to send their top young officers to Princeton for a special M.S. program in Applied Aeronautical Engineering with a principal focus on flight research, was instigated by the Air Force. This service wanted to build up a graduate program in Applied Aeronautical Engineering to balance those that it already had in Theoretical Aerodynamics and Rocket Propulsion at CalTech, and in Instrumentation, Guidance, and Control at MIT. While at Wright Field during the war, Perkins had recommended such a graduate program to the Air Force, and now he had the chance to set it up at Princeton. First the Navy asked to be included, and then the Army joined in, and it developed into one of the department's most important graduate activities.

The impact of this large group of excellent students, many of whom later became illustrious graduates, was very great. A number of civilian students in a similar program contributed to the significance of the group.[1] Their substantial thesis undertakings led to extensive sponsored research and ultimately to the Princeton Flight Research Laboratory, a unique activity that added to the Department's reputation.

The second windfall, code named "Project Squid," originated at the end of World War II when the Navy became interested in the possibilities of pulse jets and ram jets. Eager to influence education and research in these areas, the Navy under the guidance of Dr. Frank Parker, then a Department Head of The Bureau of Aeronautics, decided to set up a research program under contract to one university cooperating with four or five others. A committee made up of the partner universities would run the program with the Navy playing an approval and support role.

The Navy decided in 1946 to award the program to Princeton, much to the surprise of many. Joe Charyk's close connection with the CalTech group who were advising the Navy at the same time may have been part of the reason. Project Squid was duly organized at Princeton and housed in the department's cinder block office. Frank Parker was hired to come to Princeton as executive head of the program. At first the other Universities involved were Purdue, RPI, NYU and Cornell.

As Project Squid got under way, a large budget slowed approval and contracting of the pro-

[1] A brief list includes Glen Edwards*47, Pete Conrad*53, Norm Augustine'57, *59, and Phil Condit*65. Edwards died in 1948 evaluating the Northrop YB-49, the all-jet version of the flying wing bomber, and gave his name to Edwards Air Force Base. Pete Conrad was the third man to walk on the Moon. Augustine became CEO of Lockheed-Martin, and Condit is currently CEO and Chairman of Boeing.

gram. Parker and the Navy were most anxious to get some money spent before the end of the first fiscal year. They therefore expanded Project Squid with a task order to include the ram rocket project under Charyk and the development of supersonic blowdown wind tunnels under Lees. It was difficult to spread the umbrella of Project Squid over a study of shockwave boundary layer interaction, but the project allowed considerable flexibility to do many new things. It also gave the Department important visibility in the propulsion community, and built up the research facilities and the support for graduate students and research staff. Lees' program developed ultimately into the Princeton Gas Dynamics Laboratory, and Charyk's program, combined with others, later emerged under the banner of the Guggenheim Jet Propulsion Laboratory. Project Squid was a very useful program for Princeton in its early years.

One of the most noteworthy participants in the later stages of Project Squid was John Fenn. Fenn had received a B.A. in chemistry from Berea College in 1937 and a Ph.D. from Yale in 1940. In 1959, after a dozen years in industry he came to Princeton as the Director of Project Squid, and as a Professor of Aerospace and Mechanical Sciences. At Princeton, he studied mass spectroscopy using supersonic jets with skimmers. He returned to Yale as Professor of Chemical Engineering and Chemistry in 1967, remaining there as a Research Scientist after becoming Emeritus in 1987. In 1993 he moved to Virginia Commonwealth University as Research Professor. In 2002, Fenn was honored with the Nobel Prize in Chemistry for his invention of a pioneering technique that allows researchers to "weigh" large biological molecules such as proteins with unprecedented accuracy. The technique is a variation of his earlier spectroscopic work called Electrospray Mass Spectrometry whereby species are ionized and then accelerated by strong electric fields. The technique is used in chemistry laboratories around the world to rapidly and simply reveal what proteins a sample contains, contributing to the development of new pharmaceuticals.

Another outgrowth of Project Squid was the slow development of the concept of publishing a series of volumes on modern development in high speed aerodynamics and jet propulsion. The idea took shape through discussions between Lees and Charyk with von Kármán at CalTech, and Hugh Dryden, the Administrator of NACA. It finally came to a head in 1948 when Princeton received a contract from the Air Force and the Navy to develop a twelve volume series on these topics. It was to be an attempt to update modern aeronautical technology along the lines of the Durand Series of prewar fame. The Princeton University Press assumed responsibility for the contract for publishing the series under the leadership of Herbert Bailey'42, one of the Press's most able and vigorous administrators. Princeton organized an editorial board composed of von Kármán, Hugh Dryden and H. S. Taylor, and hired Dr. Martin Summerfield from CalTech's JPL to be the Editor. Joe Charyk became Associate Editor.

Development of the series turned out to be a long and agonizing effort, but the twelve volumes were finally printed successfully. It took several changes in editors and contracting arrangements, and much sweat and tears before it was finished. It did bring notice to the Department during this early period, but, more important, Martin Summerfield's broad interest in propulsion and his own expertise in solid propellant rockets led to his appointment as a Full Professor in 1950. This dynamic and brilliant man played a large role in the development of the Department's Propulsion Laboratories.

5 The Guggenheim Foundation

In 1948 the new Aeronautical Engineering Department at Princeton initiated discussions on the future of rocketry and jet propulsion with Harry F. Guggenheim, the head of the Daniel and Florence Guggenheim Foundation of New York. This Foundation had a history of interest in the various fields of aviation. It supported the development of aeronautical engineering education and research facilities at several leading schools including MIT, CalTech, NYU and Georgia Tech. It also supported work in aviation safety, helped Charles Lindbergh in many ways, and became involved with the work of Robert H. Goddard, the famous rocket pioneer.

After World War II, Harry Guggenheim began a study of how a relatively small institution like the Daniel and Florence Guggenheim Foundation might advance the new fields of rocketry and jet propulsion. He was helped by his friend and advisor on rocketry, G. Edward Pendray. At first they considered commissioning studies at several universities to design rocket ships for commercial missions like carrying the mail from New York to London. It did not take long to discover that the state of the art of rocketry was still far too primitive for such schemes. A return to fundamentals was needed, including acceleration of research in rocketry, but even more important, a major improvement in graduate education programs and motivation for bright young students to participate in the burgeoning new technology.

Guggenheim decided to create two centers for improving the technologies of rocketry and jet propulsion: one at the California Institute of Technology and the other at Princeton University. It surprised no one that he picked CalTech as it was already involved with rocket experiments. Princeton's Aero-

Figure 2: Rear two rows, from left to right: Arthur Kovitz, John Scott, Edward Kepler, George Sutherland, Richard John, Irvin Glasmman, Gary Mallard, Andrew Hammitt, Sydney Reiter, Daniel Bershader, David Harrje, Walter Warren, Bud Marshall. Second row from front, left to right: Unknown, Joseph Charyk, Lester Lees, Ronald Probstein, Seymour Bogdonoff, Arnold Brooks, Edward Potlein. Front row, left to right: Daniel Sayre, Luigi Crocco, Theodore von Kármán, Dean Kenneth Condit, Walter Davis, Martin Summerfield. Circa 1950.

nautical Engineering Department also had a strong interest in propulsion and it was a young and hungry Department, well oriented to working in new fields. Princeton advised the Guggenheim Foundation that their resources were needed for educational purposes, faculty and fellowships, and not for funding actual research, which would be more appropriately conducted under contract with concerned government agencies.

On December 14, 1948 the two grants were announced, each for $240,000. The programs were initially referred to as Daniel and Florence Guggenheim Jet Propulsion Centers and included faculty and fellowship support for an original term of five years. The major figures involved with this program are shown in figure 2.

The Guggenheim grant provided each school with resources to fund a Chair in jet propulsion. To honor the great rocket pioneer that the Guggenheim Foundation had supported so strongly, these were referred to as the Robert H. Goddard Chairs. At Princeton, a worldwide search was started for an eminent scholar for the position, culminating in the appointment of Dr. Luigi Crocco of the University of Rome. Crocco was the son of a renowned aeronautical scientist, General Gaetano Arturo Crocco, who was internationally known for his work in theoretical aerodynamics. Crocco came to Princeton in 1948, becoming the Departments sixth faculty member. A former student of Crocco, Thomas Brzustowski*63, currently President of Canada's National Science and Engineering Research Council, described him as "a patrician Italian, white-haired, distantly related to Pope Pius XII, and with a fabulous accent he cultivated."

The Guggenheim Center not only provided the Department with a world class professor, but helped focus research programs in many aspects of the fields

Figure 3: Princeton Cessna 140, used as a flight laboratory [9].

Figure 4: Modified North American Navion A, used to study flight stability (Courtesy Rob Stengel).

of jet and rocket propulsion. It also led directly to the establishment of our Guggenheim Jet Propulsion Laboratories some years later.

By 1950 the Department had grown rapidly, although it was still housed in the cinder block buildings that Dan Sayre had developed on the lower campus. Research facilities had been expanded into areas of the campus that permitted makeshift construction, primarily temporary structures just behind Palmer Stadium, neighbors to Walker Bleakney's Shock Tube Laboratory and, a little farther away, George Reynold's Cosmic Ray Laboratory, both part of the Physics Department.

During this period the department maintained a small airplane, a Cessna 140, for undergraduate flying laboratory experiments and also for flight research (figure 3). At first it was flown out of the Nassau Airpark, then on Route 1, but later it moved to the Robbinsville Airport, and finally to the Princeton Airport on Route 206. The department eventually acquired a Stinson L-5, and still later a Navion (figure 4). For a short time the Air Force lent a B-25 which the department's Air Force officers operated from McGuire Air Force Base.

As the programs grew, it brought in many highly competent research staff, financed through the various sponsored research programs. In the beginning many were part-time graduate students with a rank of Research Assistant. As they completed their graduate program they would be shifted to full-time Research Associates. In some cases they were ap-

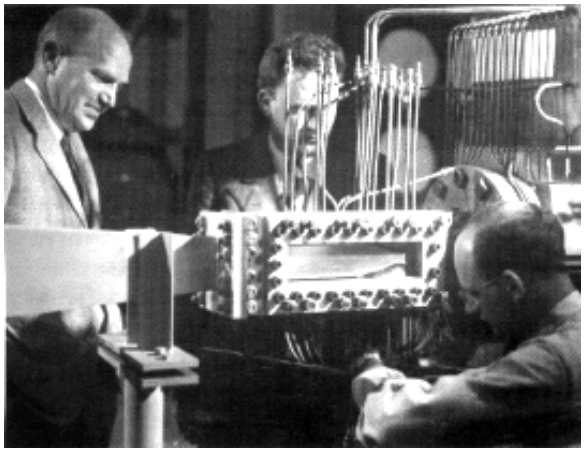

Figure 5: Chairman Daniel Sayre and Lester Lees look on as Seymour Bogdonoff adjusts a supersonic wind tunnel [9].

pointed to the faculty as Assistant Professors. One of the first new research appointments was Seymour Bogdonoff who had been a colleague of Lees at the NACA. He came to Princeton in 1946 with Lees to become his Assistant in Research and to work out a Master's degree. Bogdonoff was soon heavily engaged in setting up the blowdown tunnel facility (figure 5). Bogdonoff got his M.S. degree in 1949 and was immediately appointed an Assistant Professor. Another of the outstanding graduate students at that time was Edward Seckel. A former Princeton undergraduate, he had returned after the war to work on an M.S. degree, becoming an Assistant in Research to Nikolsky. After getting his degree he took a position on the technical staff of the Cornell Aeronautical Laboratory. Perkins enticed him back to Princeton and made him an Assistant Professor in 1950.

By the end of this period the major foci of the Department's activities emerged more clearly. First were the flight activities run by Perkins, heavily supported by our large military officer program.

The second emerging focus was a deep interest in high speed aerodynamics, led by Lester Lees and Seymour Bogdonoff. They taught both graduate and undergraduate courses in this area, but spent a great deal of effort in developing one of the world's first supersonic blowdown wind tunnels. They were studying, both theoretically and experimentally, the problems of boundary layers and their interaction with shock waves. Many graduate students were interested in this area and one of them received one of the department's first Ph.D.s in 1949.

The third area of concentration was in aspects of propulsion and combustion processes, strongly supported by the Guggenheim Jet Propulsion Center award with its Goddard Professor, Luigi Crocco, and his chief assistant David Harrje*53. Joe Charyk was

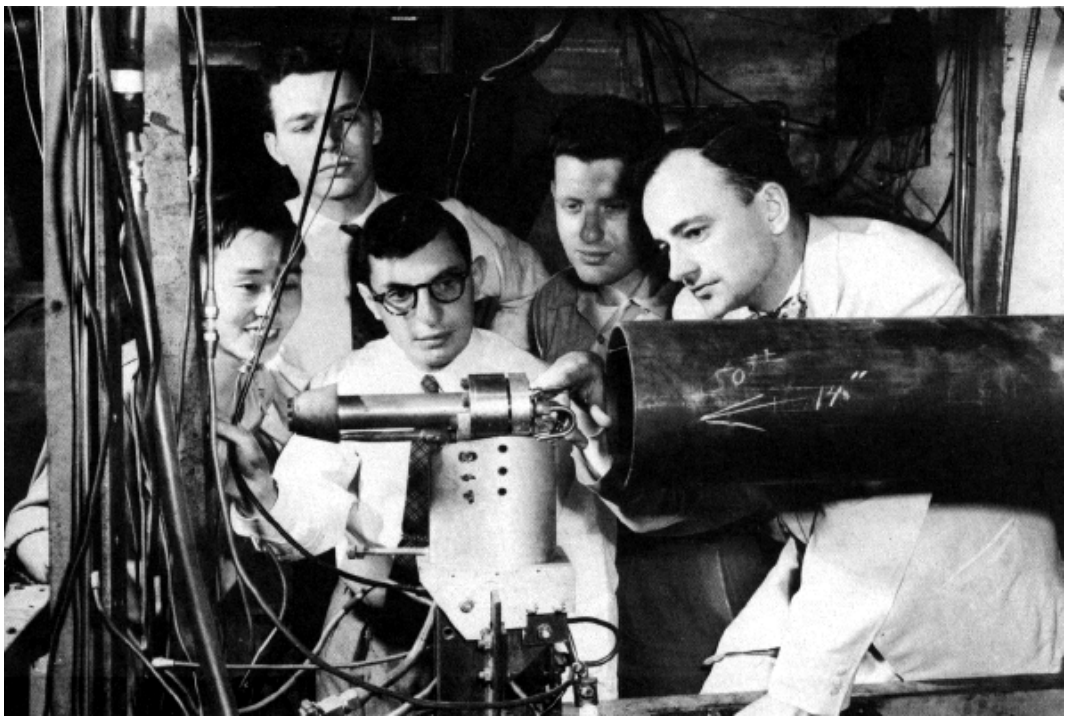

Figure 6: Left to right: Graduate students Sin-I Cheng*52, John Scott, Jr.*54, *59, Clarence B. Cohen*52, *54, David Ross*52, and Professor Joseph V. Charyk. Circa 1952.

doing research in ram jets, later assisted by Martin Summerfield whose research interest was in solid propellant rocket motors (see figure 6).

A fourth area of interest centered on Nikolsky and his work on helicopters and the aerodynamics of rotors. Ed Seckel, and later another graduate assistant Pat Curtiss, helped him in this work. This group started to develop unique experimental facilities for investigating rotor problems of helicopters, VSTOLs and others.

A fifth area of faculty interest emerged at the end of this era, the aerodynamics of low speed flight. It grew from the development of undergraduate experimental facilities. It had originally been an interest of Dan Sayre's, aided strongly by Dave Hazen. They performed many experiments in flow visualization, including smoke tunnels and water tables. Most this work was sponsored by the Navy.

The faculty, then, in the fall of 1950 was as follows: Dan Sayre (Chairman), Nikolsky, Perkins, Lees, Charyk, Crocco, Bogdonoff, Summerfield and Seckel. Some of these people are shown in figures 7–10. Six out of these nine were subsequently elected to The National Academy of Engineering after it was formed in 1964. The Department was growing its professional research staff including graduate students, Research Assistants and Research Associates. Some years later an even higher research rank was established, that of Senior Research Associate. Many of the research appointments carried the additional statement "With rank of Associate or Full Professor." Besides a faculty of nine in 1950, there were 40 graduate students, twelve of them in the Ph.D. program. Nineteen were civilians, 14 were Air Force, 4 were Navy, and 3 were Army. Total staff of all ranks amounted to 70. The value of the sponsored research program totalled about $550,000. At that time only the Physics Department had a larger program; the rest of the Engineering School was not building up equivalent programs.

6 Establishment of Forrestal Campus

In 1949 and early 1950, Dan Sayre and Court Perkins started to study seriously how they could better house the sprawling Department. Every cubic foot in the original buildings was filled, and the distance from the rest of the University was workable but inconvenient. The cinder block or wooden construction hardly conformed to Princeton architecture and was barely adequate for the department's needs. "Charyk's work was both noisy and noisome, producing malodorous fumes that did even less to endear the department to the astronomers in the nearby FitzRandolph Observatory. Adding to the cacophony of roaring test engines was the caterwaul of the so-called 'blowdown' wind tunnel used by Lees and Bogdonoff." [4].[2]

[2]The tunnel was built out of war surplus material "to hold down the costs so that it could be used ... even if outside

Figure 7: Left to right: Professors Irvin Glassman, Martin Summerfield; Senior Research Associate J. Preston Layton, Professor Luigi Crocco, and Jerry Grey. June 1962.

Figure 8: Left to right: Professors Jerry Grey, Luigi Crocco, Robert G. Jahn'51, *55 and Martin Summerfield; Senior Research Associate J. Preston Layton, Professor Irvin Glassman. June 1962.

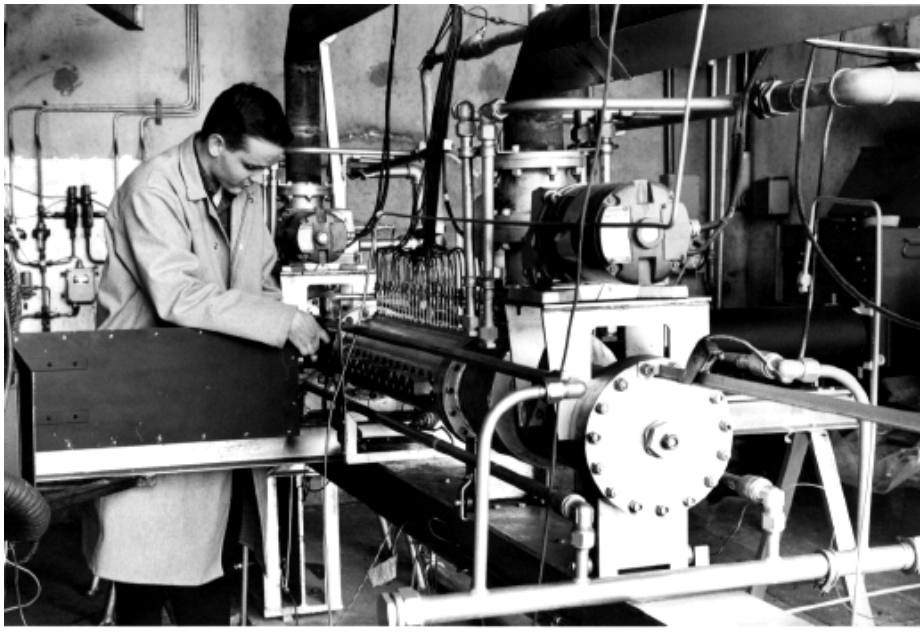

Figure 9: Graduate student C. T. Bowman*66 adjusting an optical system for measuring mean droplet sizes during combustion in a flow reactor. June 1962.

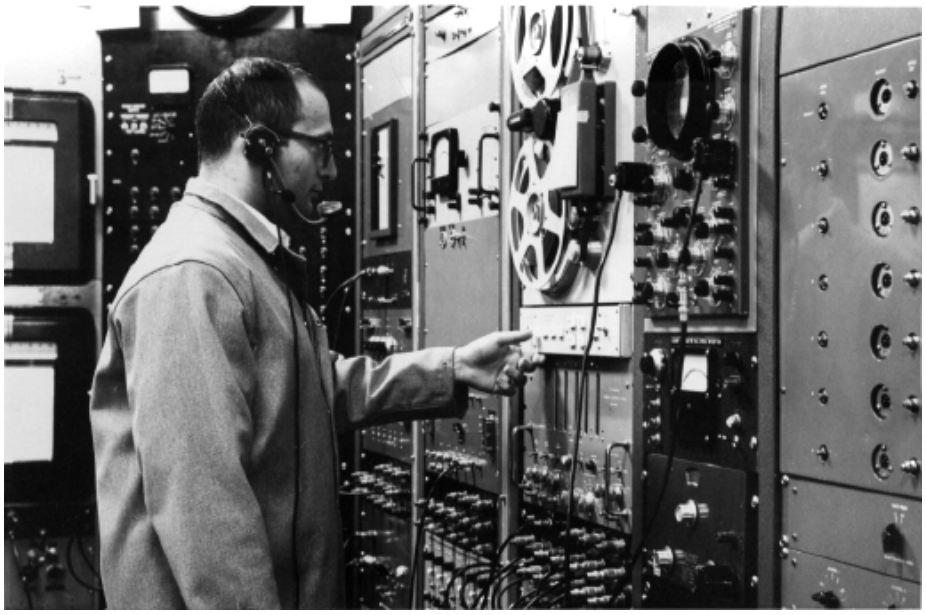

Figure 10: Graduate student W. A. Sirignano*64 prepares equipment to study rapid transients in liquid rocket instability. June 1962.

Figure 11: Left to right: Lester Lees (project head), Chairman Daniel Sayre, Rear Admiral Thorvald A. Solberg (chief of the Office of Naval Research), President Harold W. Dodds, and Seymour Bogdonoff (project engineer) [6].

Sayre and Perkins made a drawing of a possible new building, between the Stadium and Prospect Street, where the University built its Computer Center some years later. Lawrence Rockefeller, at that time a member of the Departmental Visiting Committee, helped with the study and made suggestions for raising the million dollars it was estimated to cost. Within a few weeks a remarkable event forced a solution to these housing problems that dominated the life of the Department for many years to come.

In the words of Court Perkins [3]: "During the fall term of 1950, I was teaching an undergraduate course in the Engineering Building when the door opened and Dan Sayre put his head in and told me to dismiss the class and follow him. We got in his car and drove out Route 1 to the grounds of a Division of the New York based Rockefeller Institute for Medical Research. The Princeton Division concentrated on plant and animal pathology. This large property extended from Carnegie Lake nearly to the Pennsylvania Railroad, an area of 825 acres, with some twenty buildings on it (figure 12. Dan told me that The Rockefeller Institute was going to close down this whole Division and return parts of it to New York City. The land, buildings, and improvements were being put up for sale, and our alumni,

support ... should ever be withdrawn." At the wind tunnel's dedication (figure 11), President Dodds commended the idea of recycling military supplies, saying, "a valuable research weapon has been forged from an especially warlike set of materials. The compressors and red flasks outside this room were originally designed for ... naval torpedoes ... The sides of the tunnel were intended for armor plating on the USS Illinois. That material designed for wartime use can be converted to high scientific purpose should encourage us in our hope that scientific purpose can also serve the cause of peace..." [6], as quoted by [5].

Figure 12: Aerial view of the Forrestal Research Center (Princeton University Archives).

John D. III, and Lawrence Rockefeller were trying to interest the University in buying it. We were being asked whether or not the Aeronautical Engineering Department would move into this area if the University acquired it. If we did, it would solve our space problems for all time, but we would be four miles from the main campus instead of one, and we had found one inconvenient. The advantage to the University of acquiring the property, almost doubling the University campus, was so obvious that we felt we should agree to move in, if it was purchased, and try to solve the distance problem."

With considerable help from the Rockefellers, the University purchased the property for $1,500,000, a magnificent price for this large new area. Another $500,000 would be needed for the renovation and conversion of facilities [4]. The whole Aeronautical Department was moved into this area and it was also used to house expanding research interests of other departments. The deal was finally consummated and the complicated move to the new area began. Many Princeton alumni contributed to this new acquisition and the whole area was named The James Forrestal Research Center after the United States' first Secretary of Defense, who served from 1947 to 1949. Forrestal (figure 13) was a Princeton graduate, Class of 1915, and a former Charter Trustee. During his term as Secretary of Defense he was responsible for founding the Office of Naval Research, he initiated work that led to the introduction of nuclear powered submarines, and he authorized research on a satellite space platform [7].

According to Perkins [3]: "The decision to move ended what I like to refer to as the "cinder block" era of the Department. No longer were we almost sitting on top of each other in makeshift facilities. Nevertheless, we had all been having a grand time. We had built up a nationally ranked Department of

Figure 13: Portrait of James Forrestal by Raymond P. R. Neilson.

Aeronautical Engineering, and at little cost to the University. We all felt euphoric about our situation. We had a very friendly group of about 75 in 1950, including faculty, research staff, technicians, graduate students, mechanics, and secretaries. As a majority were married, it was a large group of people when we all got together, which we did quite often. The Department became famous for its Christmas parties, and many of our friends outside the Department were delighted to be invited to these festive occasions. These activities were usually led by our super party man, Dan Sayre, but he was ably supported by the rest of us, including Nikolsky, our vigorous Russian, and our most enthusiastic graduate students." "..... this was a highly motivated, friendly and successful group. We were delighted with what we were accomplishing and enjoyed being together."

There was considerable debate within the University as to how to utilize this new facility that nearly doubled the size of the campus. It was decided the new Center should be used for expanding research programs of various university departments, that it should house the Aeronautical Engineering Department and, very importantly, that it should be free of normal University rules on architecture. It was also decided to put the activities of the Center under a new administrative office which would supervise grounds and buildings, planning for new occupants, financing and working with the University administration. The Administrative Office of The James Forrestal Research Center was established with Dan Sayre in charge. The responsibility was complicated, and Sayre found that it took him full time. President Dodds then asked Court Perkins to replace Dan Sayre as Chairman of the Department, and Perkins took over this position on February 19, 1951.

After the move, the Aeronautical Engineering Department started a relatively rapid expansion of their facilities in this new area. Other programs in the University also started to move in. One of the first was a new research program in fusion power under the leadership of Dr. Lyman Spitzer, then Chairman of the Astronomy Department. A doughnut-shaped torus for magnetic containment of a plasma of tritium and deuterium was conceived, and the AEC funded a program at Princeton with the first experiments carried out in several modified buildings at Forrestal. Because of the secrecy involved, a whole new set of buildings was constructed. At the outset the program was called "Project Matterhorn," and the main building became known as the Matterhorn Building. When it became evident very rapidly that the problem was very complex and that the physics of high temperature plasmas was not understood, the classification of the program was removed and the program took on the more appropriate title of Plasma Physics Laboratory.

Within a few years the development of a proton synchrotron was undertaken — again under the aegis of the AEC. This project was led by Dr. Milton White, an eminent experimental physicist who had helped design many high energy physics research facilities. The AEC arranged to have the University of Pennsylvania associated with this project, and the new accelerator became the Princeton-Penn Proton Synchrotron. No sooner had it been completed and the first experiments run, when it was closed by the AEC. The machine was obsolete, and the whole project cancelled. This, of course, was an academic trauma for the Physics Department and a financial one for the University.

The two large physics experiments plus the multiple small facilities of the Aeronautical Department were the heart of The Forrestal Research Center. The Forrestal Administrative group occupied the first floor of the main office building (later named Sayre Hall) and the Aeronautical Engineering Departmental headquarters was on the second along with several members of the faculty. A conference room and later a fine library, were also established on the first floor.

After Perkins became Chairman a set of departmental offices were established on the second floor of Sayre Hall. Then, all of the department's research operations were moved into this new area. This required the modification of many buildings for housing of these facilities and for the faculty, graduate students, research staff, mechanics and secretaries.

The undergraduate laboratory facilities with the $3' \times 5'$ wind tunnel were among the first to move in.

Behind Sayre Hall was an elaborate series of greenhouses that had been used by the Rockefeller Group for plant disease studies. In the middle was a fine small building that had been used as a potting shed. This was converted to house the wind tunnel. In a greenhouse next to the shed another wind tunnel facility for instructional purposes was built. Designed by Dan Sayre, it had a central diffuser and power section feeding two separate test arms. One circuit had a small $3' \times 1'$ test section and the other had a $6' \times 3'$ test section. An auditorium to house an audience of about 150 was built, and soon became an important part of the life of the Department in its new location. At the back of the greenhouse area a utility building was converted to house Nikolsky's research with an addition for his experiments on helicopter rotor dynamics.

Moving the high speed aerodynamics work of Lees and Bogdonoff into one of the long shed-like animal research laboratories required a great deal of modification to house not only the supersonic throats, but also the reciprocating compressors and the high pressure bottle farm. This was a most difficult transition, particularly as the sponsors of this program were nervous about continuing their support despite long delays.

The work in propulsion and combustion under Charyk, Crocco and Summerfield was another difficult transition. At the outset they set up shop in another of these animal research units, but they didn't fit in very well. Planning proper housing for this expanding operation, which later became one of our largest research activities, had to begin at once.

Flight research was improved immeasurably by acquisition of a very large field suitable for an airport right in the middle of the Forrestal area. The very soft field gave trouble at first, but eventually a macadam runway and proper hangars were built, and it became a very fine and unique operation.

The Department during 1951 to 1953 was heavily involved with this move, but left it with almost unlimited room for expansion. The principal disadvantage was the distance from main campus. There was little inconvenience to the graduate students who had cars, and could have offices in the new buildings of the Forrestal Research Center (FRC). However, although the faculty gave their undergraduate courses in the Engineering Building on main campus, they started giving some graduate courses in the FRC. Undergraduate laboratories were also in the new facilities, and the undergraduates had to be transported by bus. Nevertheless, most of the undergraduates enjoyed coming out to the FRC where they could see first line research in progress, and in some cases they were able to get involved in the various programs. They liked this new arrangement, but they would have been happier with the Department offices and the faculty at closer range. The distance problem continued to nag the Department for many years, but Forrestal campus provided a remarkable area for expanding departmental operations, that now included five Laboratories. These Laboratories were entitled: the Flight Research Laboratory; the Gas Dynamics Laboratory; the Guggenheim Propulsion Laboratory; the Low Speed Aerodynamics Laboratory; and the Rotor Dynamics Laboratory.

7 Aeronautical Engineering at Forrestal

During the decade between 1953 and 1963, the Department had its greatest growth and reached considerable strength as an Aeronautical Engineering Department. The launch of Sputnik in 1957, and the failure of the Vanguard rocket in the same year gave an enormous boost to all U. S. research efforts in aerospace, and the departments activities in propulsion research benefited greatly.

The first faculty appointment made after moving into the FRC was that of David Hazen who was promoted from Research Staff to Assistant Professor in 1953. He was engaged in setting up research programs for the Navy in flow visualization, and is perhaps best known for his film on the subject as part of the NSF Films in Fluid Mechanics, distributed by the Encyclopedia Britannica. However, the biggest changes in the Department faculty were not additions, but two serious resignations. In 1953 Lester Lees left to accept a Full Professorship at CalTech. Soon thereafter Joe Charyk left to accept his research appointment with Lockheed.

When Lees left, he was the Head of the rapidly expanding program in high speed aerodynamics, but he had a dynamic and able associate, Seymour Bogdonoff who took over running this program. Since Bogdonoff was basically an experimentalist, a search was started to find a theoretical person to fill the shoes of Lees. This brought Dr. Wallace Hayes to Princeton in 1954. Hayes had achieved considerable fame for his theoretical work in transonic flows, and laid down some of the theoretical basis for the experimental work done by Whitcomb of the NACA, that brought the Area Rule into prominence. Hayes had received his Ph.D. from CalTech and then worked as a theorist, first for Lockheed, and later for the U.S. Navy. He was later to write a most influential book *Hypersonic Flows Theory* with Ronald Probstein*52, as well as another on *Gasdynamic Discontinuities*.

Some excellent research talent was attracted to the staff of this Laboratory, many of them ending up on the faculty. Among these were Sin I. Cheng, Harvey S. H. Lam, George Bienkowski, Enoch Durbin, and Jerry Smith. Two very able Senior Research Associates, Andrew Hammitt and Irvin Vas, also

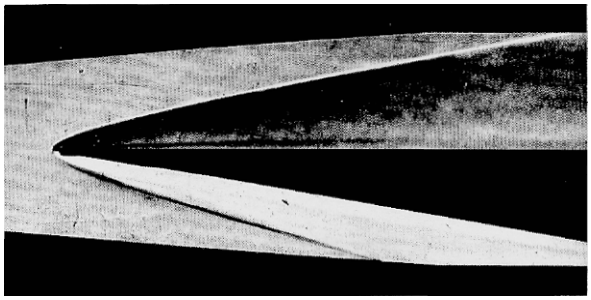

Figure 14: Schlieren photograph of a blunted flat plate in helium at Mach 11.6. The boundary layer is visible over the top of the plate. The shock shape is close to a power-law shape, with a measured exponent of 0.66 ± 0.01. This may be compared to the theoretical value by Hayes & Probstein of 0.667. Photo courtesy of the Gas Dynamics Laboratory, Princeton University.

played an important role in the development of this Laboratory. Bogdonoff rapidly had this group working smoothly with a very sophisticated program in super and hypersonics, both theoretical and experimental, and the activity was called the "Gas Dynamics Laboratory." The combination of experimental and theoretical work proved a powerful combination (fiure 14. By the end of the decade this group was full of graduate students and running a renowned program in high speed theoretical and experimental aerodynamics.

Charyk was a great loss, but Crocco and Summerfield remained, together with Dr. Irvin Glassman, a Research Associate under Charyk. Glassman was appointed to the staff in 1954 and was made an Assistant Professor in 1955. Drs. Jerry Grey and Robert Jahn were added to the faculty and Preston Layton was appointed as a Research Associate to handle the complicated propulsion installations. This group organized themselves around the Guggenheim grants, and they became the "Guggenheim Laboratory for the Jet Propulsion Sciences." Crocco and Cheng made major contributions to the understanding of rocket motor instabilities, and in 1956 coauthored a highly influential monograph on *"Theory of Combustion Instability in Liquid Rocket Motors".* Another important contribution was Martin Summerfield's *"Burning Rate Theory of Solid Propellant"* in 1958. In 1962, Bob Jahn founded the Electric Propulsion and Plasma Dynamics Laboratory, and in 1968 wrote the book *"Physics of Electric Propulsion",* which was instrumental in founding the field of electric propulsion for space applications.

The Rotor Dynamics Laboratory, under Nikolsky, was strengthened by Pat Curtiss, first as a Ph.D. student, then as Research Staff, and then as an Assistant Professor after he completed his Ph.D. in 1965. Two very able research staffers who kept the whole program afloat were Joe Traybar and William Putnam.

In other areas, Dunstan Graham'43, was appointed to the faculty in 1958. Tom Sweeney, became a Research Associate in 1958, and Barry Nixon, a fine test pilot and engineer, joined the staff in 1959. Also, Woldemar von Jaskowsky joined Bob Jahn's growing effort in electric propulsion in 1962.

During this decade the department suffered two further grievous losses. Dan Sayre died of cancer in 1956, and Alexander Nikolsky died of a sudden heart attack in 1963. These were the department's first two faculty members and they had played a large role in getting the Department started. Perkins was now the only member of the first five still present in 1963.

At the end of 1963 the department had 70 graduate students and an equivalent number of undergraduates. The sponsored research funds totalled just over $1,000,000, and the total staff came to 250. At this time a national survey of Departments of Aeronautical Engineering rated Princeton the #2 school in the country.

A new office-type building was built to house the Gas Dynamics Laboratory, as well as a few ancillary buildings for new blowdown wind tunnels and facilities to recover the working fluid when it was helium. A grant from the NASA was used to build the Guggenheim Laboratories. Rocket pits, instrumentation rooms, molecular beam rooms and others were added to this fine building (figures 15 and 16). The flying field was improved by building a 3,200 ft. runway, including taxiways and ramps. A hangar was added with rudimentary rooms for some staff and graduate students. Some of the greenhouses were replaced with a new building to house the Low Speed Aerodynamics Laboratory and finally the research facilities for the Rotor Dynamics Laboratory were expanded. This expansion was completed with the building of a unique facility called "The Long Track" designed to test helicopters, VSTOL designs and ground effect machines. This facility was basically a long shed that housed a 450 ft track (later lengthened to 750 ft) for flying aircraft in still air at low speeds, especially useful for studying problems encountered in hover (figures 17 and 18). The Princeton group, led by Curtiss, became a center for helicopter studies, especially for understanding problems in stability and control.

All of these expansion efforts cost some three to four million dollars, so fund-raising programs were essential. A major resource for these purposes was the "Corporate Associate Program" where industry was asked to support the Department by making annual contributions to this special fund. In return, they received all of the research reports, invitations to the Department for special programs, better access to the graduate students for recruiting, and ac-

Figure 15: View of Forrestal Campus facilities. The office building is in the center of the photograph with experimental areas behind it. To its rear are the atmospheric test facilities and to its left, partially obscured, are the liquid propellant rocket test cells. The bottle farm and ejector tower servicing the supersonic and hypersonic facilities may be seen in the lower left. The solid propellant processing laboratory is in the upper left hand corner. June 1962.

Figure 16: Test cells at Forrestal Campus used for studying liquid propellant rocket combustion dynamics. June 1962.

cess to the faculty for special discussions. For this service they would make an annual payment ranging from five to twenty thousand dollars. This program grew to about $200,000 per year and it was referred to as "White Money" because it was fully credited to the Department. The University charged no overhead against the expenditures from this fund and the Departmental Chairman could approve all outlays. This resource was used to build facilities, and occasionally for other Departmental purposes such as add-ons to fellowship awards, special research projects, and so on. This money gave the department great freedom of decision and some freedom from normal University constraints. When the rapid Departmental growth was questioned, President Dodds would turn to critics and say, "But they cut their own feed" [3].

During this decade, Perkins was on leave without pay from Princeton on two occasions to take assignments from the government. The first was an appointment as U.S. Air Force Chief Scientist, a rotating position advisory to the Chief of Staff of the Air Force, at that time General Nate Twining, serving in the Pentagon from June 1956 through September 1957. The second leave, from February 1960 through January 1961, was a Presidential appointment as Assistant Secretary of the Air Force for R & D. In each case, Nikolsky was made Acting Chairman.

8 Aerospace and Mechanical Sciences

This was the state of affairs at the start of the 1963-64 academic year. At this time the Mechanical Engineering Department was falling on difficult times. Most of the new high technology fields that might have been taken over by the ME Department were swallowed rapidly by the AE Department, leaving ME few new objectives to grow on. They were more accustomed to the normal Princeton Engineering scene and viewed the startling growth of AE with some concern. ME had taken on a program in Solid State Physics that had largely been abandoned by the Physics Department, but besides that there was little excitement in this Department, and there had been a drop in student demand for ME. The Department was becoming largely moribund [3].

The Engineering School made a study of ME and what might be done. They seemed to have three choices. They could try to revitalize the Department at the risk of running head on into the programs of the AE Department. They could abolish the Department altogether, but this would be anathema to many of the powerful Princeton alumni and to the strong professional society, the ASME, a politically difficult choice that was soon abandoned. The third possibility was to merge ME with AE, in the hope

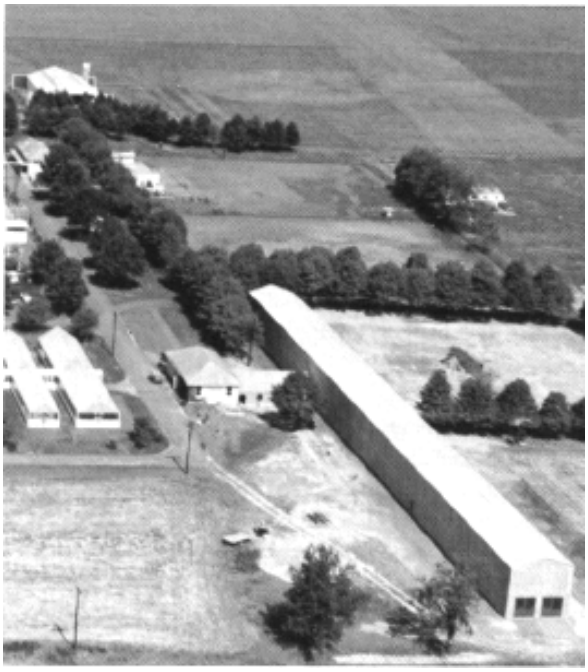

Figure 17: Aerial view of the Long Track Laboratory used in studying helicopter and VSTOL aircraft aerodynamics, stability and control.

that the sum of the parts would be greater than the sum of each. The steady development of and growth of the engineering science approach had brought the curricula, course offerings, and research interests of the two departments closer and closer together. On the decision of Professor Drake, Chairman of the ME Department, to resign from the University in June 1963, it therefore seemed reasonable to consider the merger of the two departments [8]. This made good sense, and the merger was approved by the University and the Engineering School and announced on May 31, 1964. Perkins was asked by President Goheen to Chair this new Department, and after much study and argument the newly merged Department was named the Department of Aerospace and Mechanical Sciences (AMS). This new department combined the full activity of the old AE Department based at Forrestal with the activities of the old ME based in the Engineering Quadrangle, a new building completed in 1962 to house the entire School of Engineering and Applied Science (figure 19).

At first Perkins maintained the Departmental offices in Sayre Hall in the FRC, and set up another office in the old ME Chairman's office in the Quadrangle. Slowly but surely, however, the Departmental office in the Engineering Building became headquarters and office space was provided for AE faculty members in the Engineering Quadrangle. This arrangement went a long way to alleviate the problem of distance from the department's students and the rest of the University faculty. At the same time it started moving attention from the FRC and back

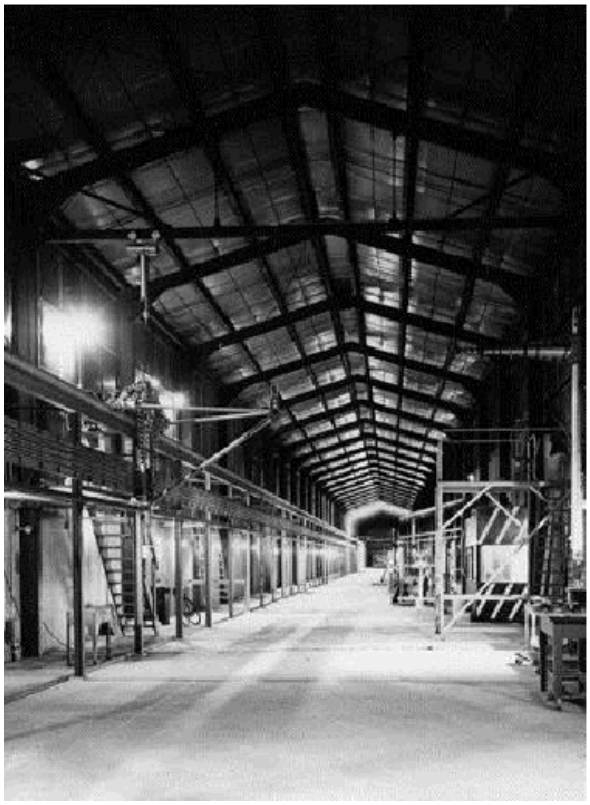

Figure 18: Interior view of the Long Track Laboratory (courtesy Rob Stengel).

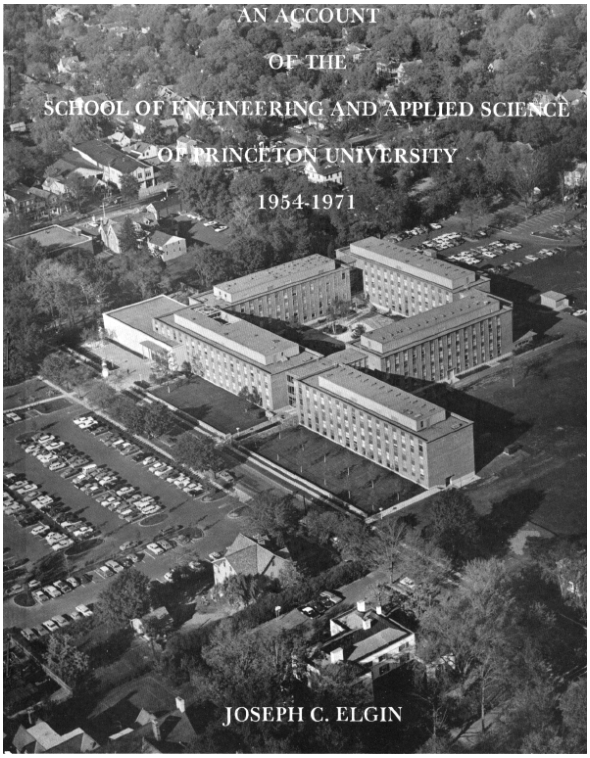

Figure 19: Aerial view of the Engineering Quadrangle, circa 1971 [8].

to the main campus. This was destined to have a damping effect on the growth of the Department. Inevitably the tightly knit group that had formed in the old AE Department was starting to break up, and the department was never were quite the same again.

A study was carried out how to operate this newly merged Department and its much larger faculty and student body during the academic year 1963–64. The faculty of the AMS Department was now one of the largest in the University with a record number of graduate students, and had one of the largest sponsored research programs in the University and a very complex group of research facilities. It was a complicated organization.

From 1963 to 1966 the AMS Department grew to be one of the largest in the University, with 29 regular faculty members and a large research staff, 130 graduate students and a sponsored research program of over $3,000,000, most of which was based on the activities at Forrestal.

During the next few years the department lost quite a few of the original ME faculty. Robert Drake, who was Chairman of the ME Department at the time the merger was being discussed, had left to join the Engineering Department at the University of Kentucky. A year later he took Roger Eichhorn with him. John Fenn left to go to Yale. Jerry Grey of the old AE Department left to form his own company, Greyrad. One of the ME faculty that stayed on, Barrie Royce, continued to pursue his interests in spectroscopy and solid state physics. A student of his, Eli Harari*73, went on to found SanDisk Corporation, and currently serves as President and CEO. George Mellor's contributions evolved from his original interests in turbomachinery, to modelling turbulence, to modeling geophysical flows. He was instrumental in bringing the Bureau of Commerce's Geophysical Fluid Dynamics Laboratory to Forrestal Campus in 1968 from its original home in Washington, D.C.

There were some additions also. Cemal Eringen came from Purdue to help develop a Solid Mechanics Laboratory to parallel the fluid mechanics activities. Jerry Smith and Arnold Kelly came from CalTech, Bill Sirignano*64 from Carnegie Mellon, Richard Grot from Purdue, and Francis Moon from Cornell. Mark Knowlton'51 was appointed a Lecturer in 1962, serving for some 30 years in that capacity. Francis Hama joined the department as Senior Research Scientist in 1969, and remained at Princeton for about 20 years.

This period saw the development of Pinceton as a center for fundamental studies in engineering and applied science. It became particularly noted for its efforts in developing the fundamental understanding of fluid mechanics and combustion processes. In fluid mechanics, Hama's contributions to the un-

derstanding of laminar-to-turbulent transition over the entire speed range from hypersonic to incompressible flows are still widely recognized for their importance. The work in hypersonic and supersonic flows contiuned unabated under the direction of Bogdonoff, Cheng, Hayes, and Bienkowski. The combustion group, led by Martin Summerfield, Irv Glassman and Bill Sirignano, included Frediano Bracco*70 and Fred Dryer*72 who were later to join the faculty. Glassman's book *Combustion* appeared in 1977 (currently in its third edition), and founded the Combustion Science and Technology Journal. In dynamics and control, Rob Stengel*68 designed the Lunar Module manual control system, and Earl Dowell and Pat Curtiss authored the book *Modern Course in Aeroelasticity* in 1978.

In 1974, after a record 23 years, Court Perkins stepped down as Chairman, and was succeeded by Seymour Bogdonoff. Perkins stayed on as Associate Dean for one year under the new Dean of the Engineering School, Bob Jahn, another AE faculty member, and on July 1, 1975 Perkins went on a three-year leave without pay to become President of the National Academy of Engineering in Washington, D.C. In 1978 he was given a four-year extension of his term at the Academy, and became Professor Emeritus. Apart from many other honors he has received through the years, he was awarded an Honorary Doctorate from Princeton University in 2001.

9 Accreditation

Accreditation was important to the department, but not all accreditation visits went smoothly. Accoring to Perkins [3]: "In the early 1960s we had a visit from the ECPD (Engineering Council for Professional Development) Accreditation Committee that operated in conjunction with the Engineering Professional Societies. We had to undergo these visits every sixth year. The Accreditation Committee this year was led by my old friend Dr. Raymond Bisplinghoff, then on the MIT faculty in Aeronautical Engineering. I had first met Ray at Wright Field during World War II, when he was serving in the Dynamics Branch of the Aircraft Laboratory. His major interest at that time was wing flutter, and he eventually wrote a book on Aeroelasticity with his colleague Holt Ashley. Now, at that time, we were not very strong in those areas of aeronautical technology that dealt with structures. Our only faculty member who was competent in these areas was Nikolsky, and his interests had shifted to other fields. We had to shotgun some of our younger faculty into teaching undergraduate courses in this field and there was essentially no graduate program at all.

As was inevitable, Ray Bisplinghoff complained of this situation and asked us how we expected to be a first class Department of Aeronautical Engineering without a strong program in the structural fields that would match our powerful programs in Flight, Fluid Dynamics, Propulsion and Combustion, Rotor Dynamics and Low Speed Aerodynamics. We certainly recognized this problem, so asked Ray to recommend someone to us from his Sc.D. candidates at MIT. He recommended to us Eugene Brunelle, and after a visit to us Brunelle was appointed to the faculty as an Assistant Professor in 1962, but shortly left to accept a higher ranked position at RPI.

We then went back to Ray Bisplinghoff for a suggestion of a more acceptable candidate for us. This time he recommended one of his top Sc.D. students, Earl Dowell, for this position. We found Earl excellent and appointed him as an Assistant Professor in 1963. Earl satisfied our needs for a faculty member in structures and structural dynamics, and in short order proved himself to be a top flight teacher-scholar with a growing sponsored research program and many graduate students. Perhaps he was too good, for some twenty years in 1982 Earl was made Dean of Engineering at Duke University, and the Department was back where we started. In 1983, Dr. Jim Marr, now MIT's expert in structural dynamics visited the Department as a member of its Visiting Committee. He remarked, 'How can Princeton have a first class program in Aeronautical Engineering without a faculty competence in structures and structural dynamics?' "

10 More Recent Times

The department continued to prosper under Bogdonoff, who served as Chairman from 1975 to 1983. He was followed in that position by Harvey Sau-Hai Lam (1983–1989), Irvin Glassman (1989–1990), and Garry L. Brown (1990–1998). The present Chairman is Alexander J. Smits.

The period from 1975 to the present day deserves a separate treatment, as the department saw through some momentous changes, not the least of which were the impact of co-education that began in 1969, the end of the space race following the successful landings on the Moon, the Arab oil embargo of 1973 and the ensuing energy crisis, the aftermath of the Vietnam War that ended in 1975, and the strong anti-war sentiment that grew during the protest era.

One particularly noteworthy development was the establishment in 1970 of the Center for Energy and Environmental Studies (CEES). Irvin Glassman became its director in 1972, and "He, Enoch Durbin, and other combustion scientists turned their attention from rocket and jet engines to improving fuel efficiency in automobile engines. David Harrje, who had worked with Luigi Crocco on liquid-fuel rockets, applied his technical expertise to problems of

home-energy consevation, using the nearby housing development of Twin Rivers, New Jersey, as his laboratory" [4]. Robert Socolow joined the department in 1974, and on his arrival took over the leadership of CEES. In 2000, the Center was subsumed in the Princeton Environmental Institute (PEI).

In another development, the AMS Department changed its name in 1978 to the Mechanical and Aerospace Engineering Department, in alignment with national trends to gain better name recognition from prospective students.

Four of the department's students became astronauts: Pete Conrad'53, Gerry Carr*62, Jim Adamson*77, and Greg Linteris*90.

The department currently has 24 Faculty (16 Full, 4 Associate, and 4 Assistant Professors), 4 Senior Research Scientists, 22 Research Staff, 16 Research Associates and Assistants, 11 Professional Technical Staff, 4 Senior Technical Support Staff, and 13 Administrative Support Staff. It is loosely organized into five groups, based on the faculty research interests: Materials (Professors Royce, Soboyejo, Srolovitz, Suo); Applied Physics (Professors Choueiri, Jahn, Miles, Suckewer); Fluid Mechanics (Professors Brown, Martinelli, Smits, Martin) Dynamics and Controls (Professors Holmes, Kasdin, Leonard, Littman, Rowley, Stengel) Combustion (Professors Bracco, Dryer, Law, Ju). In addition, Professor Nosenchuck is in Design and Manufacturing, and Professor Socolow continues his work on energy assessment through PEI.

The enrollment statistics for 2002–2003 show a student body of 34 sophomores, 39 juniors, and 32 seniors (105 total). Of the 32 seniors, 10 intend to graduate as mechanical engineers, 19 as combined aerospace and mechanical engineers, and 3 as aerospace engineers). The graduate student body for 2002–2003 totals 89, with 79 Ph.D., 4 MSE, and 6 ME candidates. The research income for 2001-2002 is reported at $11,600,000. In the most recent NRC Report by Goldberg & Meher (1995), the Aerospace Program was ranked #4 in the country, and the Mechanical Engineering Program was ranked #6.

Acknowledgments

Ms. Maureen Hickey, for rescuing and archiving many of the documents relating to the history of the department. Barrie Royce, for his comments on an earlier draft.

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1942	1950	1963	1963-64	1975	2002
Sayre (chair)	Sayre (chair)	Perkins (chair)	Perkins (chair)	Bogdonoff (chair)	Smits (chair)
Nikolsky	Nikolsky	Bogdonoff	Suppiger	Cheng	Bracco
	Perkins	Cheng	Bogdonoff	Curtiss	Brown
	Lees	Crocco	Cheng	Durbin	Dryer
	Charyk	Hayes	Crocco	Glassman	Holmes
	Crocco	Nikolsky	Durbin	Graham	Jahn
	Bogdonoff	Seckel	Fenn*	Hayes	Law
	Summerfield	Summerfield	Glassman	Hazen	Littman
	Seckel	Glassman	Hazen	Jahn	Miles
		Graham	Hayes	Lam	Royce
		Grey	Seckel	Mellor	Soboyejo
		Hazen	Smoluchowski*	Seckel	Socolow
		Dowell	Summerfield	Sirignano	Srolovitz
		Jahn	Daniels*	Smoluchowski	Stengel
		Lam	Eichorn*	Summerfield	Suckewer
			Graham	Bienkowski	Suo
			Grey	Royce	Choueiri
			Jahn	Smith	Leonard
			Kittridge*	Socolow	Martinelli
			Lam	Bracco	Nosenchuck
			Mellor*	Miles	Ju
			Sorenson*	Sweet	Kasdin
			Bienkowski		Martin
			Criminale*		Rowley
			Dillon		
			Dowell		
			Leigh*		
			Royce*		
			Welch*		

Table 1: Members of the faculty of the AE, AMS and MAE Departments. Asterisks indicate members originally from the ME Department.