A02-14385

AIAA 2002 — 0567

Aeronautical and Aerospace Engineering At The University Of Michigan

Thomas C. Adamson Jr.
The University of Michigan
Ann Arbor, Michigan

40th Aerospace Sciences Meeting & Exhibit
14-17 January 2002
Reno, Nevada

AIAA 2002 - 0567

Aeronautical and Aerospace Engineering At The University of Michigan

Thomas C. Adamson, Jr[•]
University of Michigan
Ann Arbor, Michigan

ABSTRACT

A brief history is given of the Department of Aerospace Engineering at the University of Michigan and its contributions to the Aerospace field.

The University of Michigan has been involved in aerospace education since the very inception of the field. Indeed, our founder, Felix Pawlowski, is shown with Orville Wright and other early aviation pioneers in Figure 1. To the best of our knowledge, ours was the first undergraduate program for aeronautical engineering offered anywhere. Because of this, we have a large group of graduates, a total of 6403, with 5094 still living.

In the following, I concentrate on an anecdotal history of the department and its graduates and their contributions, rather then repeating only facts and figures. My material comes, in the main, from three sources: A University Publication, "A Century of Engineering Education", published in 1954 (1); "The First Fifty Years (a Fragmentary, Anecdotal History) (2)", written in 1964 on the occasion of our 50th Anniversary; and "The Third Quarter Century, More Fragmentary, Anecdotal History" written in 1989 on our 75th Anniversary (3). I cheerfully admit to using portions of these documents for this manuscript.

Our Department owes its inception to the intense interest in aviation of Professor Herbert C. Sadler, Chairman of the Department of Naval Architecture and Marine Engineering. This interest was evidently traditional in his family – his great-grand-uncle James Sadler was the first English balloonist (late 1700's early 1800's) and two of James's sons became balloonists. Also, Sadler worked at the University of Glasgow (before the U of M) with a man who was a British pioneer in glider flying and a follower of Lilienthal.

In 1911, the U of M Aero Club was started and students built a small wind tunnel for experiments. They also built a glider and flew it as a kite around Ann Arbor, with a student "flying" in it. For lateral control, there were two helpers with lines to the wing tips; the ground helpers were often lifted off the ground by sudden wind gusts or the pilot's too enthusiastic use of the elevator. Sadler was the advisor and repeated the warning given him by Wilbur Wright; "If you will advise them (the students) to build a glider and to fly it, do not let them build it too light!" .

[•] Professor Emeritus, Department of Aerospace Engineering, Fellow

Felix Wladislaw Pawlowski, who had taken the first course in aeronautical engineering ever given, by Lucien Marchis at the University of Paris, came to this country in 1910 and spent two years in Chicago as a designer in the automobile industry. In 1911-1912 he wrote to a number of engineering colleges and technological institutes wanting to develop courses in aeronautics. Most gave negative replies ("e.g. aviation very likely will never amount to anything!"). However, he did receive two encouraging replies, one from MIT which had to decline "for the present" due to lack of funds, and one from the Dean of Engineering at the University of Michigan, Mortimer Cooley, which resulted in his being appointed in 1913 as a teaching assistant in Mechanical Engineering. He was appointed with understanding that he would be permitted to introduce courses in aeronautical engineering, and become an Instructor in 1914. His job as a teaching assistant paid $800 per year! Pawlowski, was a very talented, charismatic person, and also was evidently quite a character. At the age of 32, he had seen the Wright Brothers fly, and was so stirred that he decided to become an aeronautical engineer. He could not afford to learn to fly at the school set up by the Wrights in Paris, France, so he returned to the University of Paris, where he was doing graduate work in Mechanical Engineering. Somehow, he taught himself to fly in the fields outside the city in a monoplane similar to the one Bleriot had used to cross the channel the previous summer. His plan to become an aeronautical engineer was reinforced by the aforementioned course by Marchis, at the University of Paris, where he also received the certificat d'étude.

Interest in aeronautics was stimulated in 1913 by a series of lectures by Pawlowski and Professor Marchis, who came to Ann Arbor from Paris to deliver his talks. His principal subject was the practical application of physics, so that his lectures were not limited to aeronautical ideas, but the appearance of a world-famous authority on an American campus strengthened the increasing academic respectability of aeronautical engineering in this country.

The first course, Theory of Aviation, was introduced in 1914 for two hours of credit; it dealt with the principles of aerodynamics and mechanics of flight. In his autobiography Dean Cooley said, "I hid this course in the Department of Marine Engineering and Naval Architecture for a time, for aeronautical engineering was not considered important enough to make it conspicuous...!" Previous to this, courses were offered without credit to members of the aero club, which built another ("not better") glider, a biplane. It was again flown as a kite; in addition, probably for the first time in the history of aviation, an automobile was used to tow it. In 1915-1916 two new courses, Propulsion of Aeroplanes and Aeroplane Design were added.

The first regular courses in aeronautics and the first curriculum were established at this time. A reproduction of the coursework covered is shown in Figure 2; it was printed in a 1915 issue of "Aerial Age". Of the 14 courses listed, only the first six were required as a minimum to qualify for a degree in aeronautical engineering. The remainder were offered as electives. In 1916-1917 a four-year program leading to a bachelor's degree in aeronautical engineering was arranged and included in the Department of Naval Architecture Marine Engineering and Aeronautics! In June 1917, William Frederick Gerhardt was the first student to receive this degree of Bachelor of Science in Engineering (Aeronautical Engineering), although some controversy was evidently raised when in 1929 one of the first group of students somehow arranged for the Regents to give him a degree predated to 1916. Mr. Gerhardt also became the first student in the department to receive an M.S. in aeronautical engineering, in June, 1918. In later years he became known as the designer of the "venetian blind" multiplane aircraft built at McCoole field and evidently seen regularly in the film made to show spectacularly unsuccessful designs. It should be noted that during this time, and indeed until 1930, there was no separate Department of Aeronautical Engineering.

It is no coincidence that the men who did the most to establish the idea, in Ann Arbor, that aeronautical engineering was a suitable field for university instruction and research – Sadler, Pawlowski and Marchis – were from Great Britain and the Continent. For the French, Russians, Italians, British and Germans had by 1910 long recognized the value of applying science to the problems of aeronautics and were engaged in aeronautical research at universities; such as in Prandtl's laboratory at Göttingen; at military installations, such as the French army aero lab at Chalais-Meudon, at government installations, such as in Alderhof in Germany; and at numerous private laboratories, such as Riabduchinski's in Koutchino, Russia, and those of the English scientists Cayley, Wenham, and Phillips. During this same period the U.S. was dependent largely upon the efforts of a host of amateur inventors who approached the problem empirically and with limited means but great ingenuity. This situation is in part reflected in the number of military aircraft possessed by each of the leading powers at the outbreak of World War I in 1914: France – 1,400; Germany – 1,000; Russia – 800; Great Britain – 400; and the U.S. – 23. But perhaps it is more accurately reflected in the fact that the stimulus and model for university instruction and research not merely in aeronautical engineering but through the entire range of the physical and medical sciences came, to a large extent, from abroad.

During World War I, early in 1917, Professor Pawlowski was granted a leave to accept the position of aeronautical engineer for the U.S. Army. However, the War Department accepted the advice of experts of our Allies and abandoned attempts to develop original designs, to concentrate upon using the country's enormous manufacturing potential. Thus, Pawlowski returned to the University in the fall of 1917 to assist in conducting a special course, Principles of Aviation, which permitted students drafted into the Army to qualify for or to claim preference for Air Corps service. He took another leave of absence in 1919 to organize aeronautical research for the Polish Army and returned in 1920 to teach nearly all of the courses in aeronautical engineering at the University.

As pressure for research capabilities grew, it was decided to build a wind tunnel and so one was included in the plans for the East Engineering building; the wind tunnel was built into the foundation of the building. Started in 1924, it was completed in 1926 with the aid of a gift of $28,000 from the Guggenheim Fund. In addition, the Guggenheim fund provided $50,000 for a professorship of applied aeronautics for ten years. Mr. Laurence Kerber, Class of 1918, was first appointed to this position. Professor Kerber, with Mr. Gerhardt, wrote the Manual of Flight Test Procedure; his interest in this area led to his association with the CAA where he was instrumental in establishing the first set of procedures for obtaining the "approved type certificate". Later, Professor Pawlowski was appointed to this professorship.

Finally, in 1930, nearly 20 years after Sadler and Pawlowski had aroused interest in aviation at the University of Michigan, the Department of Aeronautical Engineering was established as a separate department. The first chairman was Edward A. Stalker (AeE'19, MSE, '23).

There is no more colorful, adventurous chapter in the history of aeronautical engineering at the University of Michigan, than the one recounting student efforts to fly – in gliders, balloons, and primitive airplanes. In one example a model "B" hydroplane built by the Wrights in 1912 was donated to the Aero Club in 1915 by two wealthy Detroiters. During a trial flight from Barton Pond, shortly after the airplane arrived, the hydroplane crashed and was ruined. Happily, the untrained student pilot survived. During this time also, gliders were built and used to train student fliers, both as kites and as free gliders pulled up behind automobiles as mentioned previously. Many of the glider enthusiasts went on to become distinguished pilots, both as test pilots and in the armed services. The most adventurous of the activities however, were those connected with free ballooning, begun in 1926. Indeed, although Lindbergh's flight in 1927 electrified the world, the balloonists were not overly impressed. After all, they had persisted in spite of the stench of coal gas, the complications of rotting fabric, inadequate funds, being shot at by farmers, struck by lighting, caught in trees, nearly drowned or frozen to death, or lost in the wilds of Ontario! They really wanted to fly! The wilds of Ontario are mentioned because one of the students decided to take a balloon trip from Cleveland to Ann Arbor to attend the Michigan-Minnesota football game. He left Cleveland at 11:00 PM on the Friday before Thanksgiving in 1931, was caught in a violent snow and sleet storm over Lake Erie, spent all night going down and up as ice formed and then melted, sighted a shoreline after 18 hours, landed in a fire-charred desolate woods, and after three days came stumbling out of the woods in northwest Ontario, 70 miles north of Michigan. The balloon was never found; he missed the game.

The aforementioned wind tunnel supported by the Guggenheim fund had an open-throat test section with a maximum size of eight feet across the flat sides of its octagonal cross section. It had curved guide vanes at corners or bends and short lengths of stove pipes used as straighteners at several points. Initially the model was supported primarily by three vertical wires, two at the leading edge and one near the tail, also used to change the angle of attack. Forces were measured using the wire balance systems first developed by Ludwig Prandtl, whose laboratory, Pawlowski had visited. A two-bladed propeller was powered by two electric motors, one 200 horsepower, the other 50 horsepower, with fairly rough control systems. Maximum airspeed was 80 MPH; this tunnel probably had a high turbulence and noise level, but was very useful, nonetheless.

Indeed, work in this wind tunnel led to the start of the career of our department's, and the nation's, most famed designer, Clarence "Kelly" Johnson. He was hired in 1930 as a student assistant by the department Chairman, Edward Stalker, and was put to work in the wind tunnel. Seeing its potential, Johnson asked if he could rent the tunnel (for

$35 per day plus power charges) and so he and his college friend, Don Palmer, became part-time proprietors of the University of Michigan wind tunnel (4). They immediately approached the Studebaker Motor Company and were hired to test the Pierce Silver Arrow; they found that the big, ugly headlamps on Studebakers were eating up 16% of the engine power at 65 MPH and had them shaped into the fenders. This and many other jobs kept them relatively well to do, but they stopped this consulting when the faculty noticed how lucrative it became!

After graduating in 1932, Kelly and his friend traveled to the west coast in a car borrowed from a professor and found that there was no work. However, The Lockheed Company had just been purchased from receivers for $40,000 (!) and was being reorganized, and the chief engineer suggested that Kelly return to the University of Michigan for a Masters degree and then come to work for them. He did this, and while working for the University in the wind tunnel once again, performed some tests on the new airplane being proposed by Lockheed, the Electra; (see Figure (3)). At the end of this year, Kelly returned to Lockheed. The first thing he did was to inform the secretary of the company and the chief engineer was that he didn't agree with the official report of the University and that their airplane was unstable! To the credit of the Lockheed Company, Johnson was sent back to the University of Michigan with the Electra Model (he drove). After 72 tunnel runs, he found that removing the wing-body fillet and adding end-plates on the horizontal tail made this tail more effective, and that more rudder area was needed for directional control for one-engine operation. And so a double vertical tail was the answer to the problems, a feature of several Lockheed airplanes; this was extended to three rudders in the Constellation. The Company was very impressed. Kelly went on to be responsible for the designs of the Hudson Bomber, the Constellation and Super constellation, as well as the P-38, C-130, T-33 trainer, F-80, F-104, U-2, YF12-A and the SR-71 Blackbird, among others. He was, arguably, the top airplane designer in this country and, indeed, in the world.

In the 30's and 40's research became increasingly important in the development of the department. Improvements to the existing wind tunnel, the addition of another smaller subsonic tunnel, supersonic tunnels and structures laboratories and testing equipment allowed broader research interests to flourish and this in turn led to the introduction of more sophisticated course work. With the advent of World War II, the Army and Navy sent graduate officers to the University of Michigan for education in aeronautics. In addition, faculty positions and the number of students enrolled in aeronautical engineering increased enormously during this 20 year period except, of course, during the actual war years from 1941 to 1945. In 1946, more than thirty years after he had first kindled interest in aviation at the University of Michigan, Professor Pawlowski retired to live in Paris, France. He died in 1951; all who knew him experienced a great feeling of loss.

It was at the end of this 20 year period, in 1950, that a major impact on our field was made with the introduction of the book *Foundations of Aerodynamics* by Professors Arnold Kuethe and Jay Schetzer. This text became an instant success and was used by nearly every major department in this country and throughout the world. Indeed, the latest edition, with Professor Chuen-Yen Chow replacing Jay Schetzer as the second author, is still in use; it ranks with the important texts in aerodynamics.

A significant far-reaching event in the research program occurred in 1946 when Professor Myron Nichols brought to the Aero Department several engineers and physicists from the Palmer Physical Laboratory at Princeton. They, along with several other people already in Ann Arbor, formed a group identified only as "Research Techniques" which was installed in a laboratory at Willow Run Airport. They concentrated on two areas, the development and use of analog computers and differential analyzers, and the structure of the upper atmosphere. Each of these studies resulted in the development of large research and educational programs.

The first of these activities led to formation of the well-known graduate program in Instrumentation Engineering, which evolved into the graduate program in Information and Control Engineering. Fundamental research involving many PhD students resulted from this foray into the new area of control theory. As the research broadened the program was enlarged to become a College of Engineering graduate program called Computer, Information and Control Engineering (CICE). It involved faculty from Electrical Engineering and Mechanical Engineering as well as those from the Aero Department. Finally, in the 1980's CICE was discontinued as a program, with continued work being carried out in each faculty member's home department.

The second activity was the beginning of a long and successful program of upper atmosphere research and thus to the formation of a High Altitude Research Laboratory. The research focused on the structure of the atmosphere, now extended to the limit of the terrestrial atmosphere, and included phenomena of meteorological significance. Some of the early experiments involved scientific payloads placed on V-2 Rockets captured from Germany and fired at White Sands Proving Ground. The Army invited laboratories at Johns Hopkins, Princeton and Michigan, all of whom had upper-air research programs, to install payloads on their flights. This group formed a committee, the V-2 Rocket Panel, which served until the formation of NASA as a quasi-official commission guiding upper air rocket research in the United States. This panel was very influential, and as its crowning achievement, set up for the National Academy of Science, the U.S. program in rocketry for the International Geophysical Year (IGY). It also published the first standard atmospheric table based on in situ measurements by rockets. Later this included several solid propellant rockets. In this regard, the Nike – Cajun rocket used throughout the world as a sounding rocket was developed at the University of Michigan High Altitude Research Laboratory, as were the 3-stage Exos and 5-stage Strongarm sounding rockets. In ongoing efforts to refine the measurement techniques, the use of very delicate instruments, including mass spectrometers, in the high g-load environment of a rocket payload, was pursued with eventual great success. This research in aeronomy was carried out until the 1980's, when support decreased.

Although Air Force Officers had been sent to the University of Michigan in the late 1940's for training in the field of Pilotless Aircraft, a new Guided Missiles program for Air Force personnel was begun in the early 1950's, at the request of the Air Force Institute of Technology. The curriculum was set up such that in two calendar years and one summer session, the enrollees received two master's degrees, one in aeronautical engineering and one in instrumentation engineering. Many of the Air Force Officers who went on to work in space-related activities, including astronaut training, were graduates of this program. Also officers from several foreign countries attended these classes.

Several of the Officers trained at the University of Michigan went on to become astronauts. Indeed, several space flights were all Michigan. The first of these was the Gemini GT-4 mission flown in 1965. It was an earth-orbital flight with the first attempt at rendezvous and the first space walk by Ed White with Jim McDivitt as pilot. These two astronauts were granted honorary Doctor of Aerospace Engineering Degrees in a convocation in which an amusing but far reaching gaffe occurred. In 1964 we had changed our name to the Department of Aeronautical and Astronautical Engineering. At the convocation our University President introduced our chairman, as the Chair of Aeronautical and Astronomical Engineering. With great fear of the time when astrological might replace astronomical, we changed our name once again to Aerospace Engineering; in 1966, this became the Department's name and remains thus to this day. The second all Michigan flight was Apollo 15, with Astronauts Al Worden, Jim Irwin, and Dave Scott. They left on the moon a document representing the Alumni Association of the University of Michigan, Charter Number 1, certifying that the U of M Club of the Moon is a duly constituted unit of the Alumni Association, Figure (4). Finally, one of our Astronauts, Jack Lousma, was on Skylab for 57 days, and later piloted the shuttle on one of its flights. He has been an adjunct Professor in the Aerospace Engineering Department. It is also important to note that one of our faculty, Professor Harm Buning, spent considerable time at the NASA Johnson Space Center in Houston, giving courses in orbital mechanics to the first two groups of astronauts.

Although exploits in space were headline news in the 1960's, one of our faculty members did his bit to advance the art of aircraft design. Professor Ed Lesher designed, built, and flew two of the pusher-prop designs for which he became internationally known. The first was built to prove the design feature, in particular the long shaft between the engine mounted immediately behind the pilot and the pusher propeller mounted at the rear of the fuselage. The dynamic problems conquered, Ed then built a smaller, lighter version conforming to the FAI class for aircraft with a total maximum weight of 500 kg Figure (5). The Teal first flew in 1965 and by 1967 was beginning its series of record breaking flights, the first three for speed in a closed circuit. Then, in 1970 Ed, broke the previous record for distance in a closed circuit by 311 miles, roughly 25% longer than the record. Next, he broke two records for speed over a measured course. Finally, for his seventh record flight Ed set the record for distance in a straight line (1835.4 miles from St. Augustine, Florida to Goodyear Arizona). One of the greatest demands for this flight was his diet; each pound he lost was a pound of fuel added! All in all, Professor Lesher was awarded four Bleriot medals by the FAI. It should be noted that the students in Ed's design class checked all numbers. They were aiding in the design of a real airplane and were very involved and interested in it. Not many of them realized how fortunate they were to be taught by a man who could design, build, and then fly an airplane, let alone one with such innovative and creative ideas in its design.

Faculty at the University of Michigan have been fortunate throughout the years in having excellent facilities. After World War Two, new subsonic and supersonic wind tunnels were added, as were the latest strength testing machines, and analog computer equipment since replaced by digital computers. This led to the formation of several laboratories and research groups, each involving several faculty members and many graduate students, which have evolved to the present state of the curriculum and research

In the aerodynamics laboratory group, founded by Professor Arnold Kuethe, fundamental work in turbulent flows, supersonic and subsonic mixing, and flow separation has been carried out. Many papers were published, also, on theoretical works in transonic flow and wing theory, for both stationary and rotating wings. More recently, a research group in computational fluid dynamics was begun by Professor Bram van Leer, this being the genesis of the W.M. Keck Laboratory for Computational Fluid Dynamics. From this laboratory have come advances in the accuracy robustness and efficiency of numerical methods for compressible flow, including work on genuinely multi-dimensional methods, solution-adaptive methods, optimal preconditioning, and multigrid acceleration techniques. Additionally, contributions have been made to numerical methods for electromagnetics, aeroacoustics, magnetohydrodynamics, non-continuum flows, modeling of advanced propulsion devices, and meteorological flows.

The analog computer laboratory begun by Professor Myron Nichols grew to include work in controls, as mentioned previously, and indeed spawned a departmental instrumentation program which evolved into a college wide program in computer information and control engineering, lasting until 1983. In the Department of Aerospace Engineering this work was and has been carried out by the faculty in the flight dynamics and control section. Important contributions have been made in computer simulation, the foundation of control system theory, optimal aircraft and spacecraft maneuvers, control of flexible space structures, and aircraft and spacecraft dynamics and control. A company named Applied Dynamics, specializing in very fast computers for real-time simulation was started by four faculty members and still flourishes. Finally two renowned text books, *Principles of Dynamics and Classical Dynamics* written by Professor D.T. Greenwood, are used throughout the world.

The discipline of structural mechanics has undergone remarkable changes since the early days of aircraft design. The ubiquitous concern to minimize weight first led our faculty and others to do research in efficient structural design and methods for accurate structural analysis. Considerable work also was done, on optimal structures. More recently, a dramatic modernization of laboratory facilities, including state of the art testing machines, materials processing and characterization instrumentation, and intensive computing facilities has taken place. This has allowed more fundamental research in the interaction of structures with electro-magnetic fields and new interactive materials as well as with the more traditional interactions with fluids, thermal fields, and failure processes. More specifically, research is being conducted in the areas of aero-servo elasticity of helicopter rotors, advanced composites, modeling of composite rotor blades, life cycle durability of components and the use and fundamental behavior of adaptive materials, such as shape memory alloys, piezoelectric material, magneto-rheological solids, and eletrodynamic membranes. In addition, the modeling of fracture and the effect of microstructure is being studied. Both experimental and theoretical work involving many graduate students is being carried out in these areas.

A propulsion laboratory begun by Professor Richard Morrison at facilities at the Willow Run Airport became the Gas Dynamics Laboratory back on North Campus and grew to include more general research in reacting gas flows. A great deal of work was and has been done on detonation phenomena in this laboratory. Indeed, Professor Arthur Nicholls, who became its director, was the first to establish a standing detonation wave. Considerable work was also done on combustion instabilities, underexpanded nozzle flows, and steady and unsteady transonic channel flows. Now headed by Professor G. Faeth, typical research areas are supersonic mixing and combustion, microgravity combustion, micro fluids and combustion systems for propulsion, turbulent flow drag reduction and turbulent flames. Fundamental work is carried out also in determining the formation, structure, and combustion of sprays, as well as in the formation growth, and radiative properties of soot. In addition, new diagnostic techniques are being employed to aid in measuring combustion products in engines; these studies aid in developing realistic models of engine combustion. This work, experimental and theoretical, has resulted in a multitude of PhD theses over the years.

A relatively recent facility, one of the largest vacuum chambers in the country, was obtained from the Bendix Corporation when it left Ann Arbor; testing for the Apollo program was carried out in the chamber. In this laboratory, supervised by Professor Alec Gallimore, experiments in electric space propulsion are carried out. The chamber is large enough that propulsion units can be run for significant test times in near vacuum conditions found in space. Figure (6) shows a test run of a P5 Hall thruster designed by the people in this lab and built by the USAF; it is operating at full power (9.2 kw, 2800s, 400 mn) with a chamber pressure maintained at roughly 10^{-5} torr.

As usual, many of the subjects in the above mentioned research areas are later found in graduate and undergraduate courses. A comparison of these subjects with those covered in our first curriculum, Figure 2, illustrates the incredible increase in sophistication and breadth of study that has occurred in the past eighty-eight years. Also apparent, in 1914 and in the intervening years to the present, is the fact that the aerospace field truly exemplifies cutting-edge technology

It is often of interest to know where faculty members of a given department received their graduate training. Of the twenty-one members of the Department of Aerospace Engineering at the U of M, four come from Caltech, three each from MIT and The University of Michigan, two each from Princeton and the University of Texas-Austin, and one each from Columbia, Penn State, Brown, Georgia Tech, Cambridge, (U.K), Leiden, (Holland) and the University of South Hampton (U.K.). Seven work in the areas of propulsion, aerodynamics, and combustion; three in computational fluid dynamics, six in structural mechanics, and five in flight dynamics and control.

Finally, a note about the superlative support given to the Aerospace Department and aerospace engineering in general by the François-Xavier Bagnoud Association. In 1982, a young Swiss man, François-Xavier Bagnoud, graduated with a degree in

Aerospace Engineering, and joined his father at Air Glaciers, the largest private Alpine rescue and mountain flying company in Switzerland. He became, at age 23, the youngest professional IFR pilot in Europe, of both airplanes and helicopters. Within three years, in addition to his regular piloting responsibilities, he completed 300 successful rescue and flight operations in the Alps and two Paris – Dakar races. Tragically, François-Xavier flew a fatal helicopter mission in 1986 in the desert in Mali, West Africa, while flying for another Paris-Dakar road race.

The François-Xavier Bagnoud Foundation was born out of the desire of the parents of François-Xavier, Countess Albina du Boisrouvroy and Bruno Bagnoud, his stepfather, and close friends to commemorate his caring for others and his passion for all things aerospace. This Foundation has been instrumental in philanthropic aid for worthy causes, especially those involving sick children all over the globe. Also, in memory of his great interest in and fond memories of the Department of Aerospace Engineering at the University of Michigan, the Association provided major funding for our new building, four graduate fellowships, a chaired Professorship, and a center for Rotary and Fixed Wing Aircraft Design. In addition the François-Xavier Bagnoud Aerospace prize was created and is administered by the University of Michigan.

The François-Xavier Bagnoud Building is an outstanding facility Figure (7). Containing 94000 square feet of area, with a large atrium, it houses 19 laboratories, several with 18 foot ceilings, three which are blast resistant, and one a CFD lab, three classrooms, a design lab, a large lecture hall, 32 offices for faculty and staff, 25 offices for graduate students, a library, three conference rooms, and two student organization offices; it is truly one of the outstanding educational facilities in the country. Figure (8) shows the setup for an experiment on vibration control of a large-aperture spaceborne telescope for astronomy, illustrating the space available for relatively large scale equipment.

The FXB Fellowships provide for up to five years of graduate study leading to a Ph.D. including tuition, fees, excellent stipends, and one trip home each year. These are our most prestigious fellowships.

The FXB Center for Rotary and Fixed Wing Air Vehicle Design is headed by Professor Peretz Friedmann. who also holds the FXB Professorship. This center focuses on multidisciplinary analysis that plays a key role in the design of manned and unmanned air vehicles. The areas emphasized are interactions between computational aeroelasticity and aerodynamics, controls, flight mechanics, active materials and composite structures, including innovative lightweight nanotube based composites, and high temperature aerospace vehicle structures. The goal is the development of lightweight, highly efficient vehicles with low vibration and noise levels, good damage tolerance characteristics, and low cost.

Lastly, the FXB Aerospace Prize consists of a $250,000 prize for outstanding accomplishments in the aerospace field. It is awarded biannually and is international in scope. The awardee is chosen by an international selection committee, representing the aerospace community; this committee is nominated by the FXB Prize Board. Further information is available on the net at http://www.fxb.org.

In summary, the Department of Aerospace Engineering at the University of Michigan has a long and proud history and tradition. Its graduates have attained many positions of great responsibility as designers, engineers, pilots, top executives in industry and government, teachers, and researchers. As we enter our eighty-eighth year of operation, we look forward to continuing contributions to the aerospace community. Further information on our programs and faculty can be found on the web at www.engin.umich.edu/dept/aero.

Acknowledgements

The author wishes to express his gratitude to his colleagues, Professors H. Buning, E. Gilbert, M. Sichel, R. Howe, and K. Powell, for their advice and suggestions in preparing this manuscript.

References

1) A Century of Engineering Education, University of Michigan Press, Ann Arbor; 1954, pp 1181-1189.
2) The First Fifty Years (A Fragmentary, Anecdotal History), Robert P. Weeks, Professor of English, College of Engineering, October, 1964.
3) The Third Quarter Century (More Fragmentary, Anecdotal History of the Department of Aerospace Engineering), Helena S. Buning, October, 1989.
4) Kelly, More Than My Share of It All, Clarence L. "Kelly" Johnson with Maggie Smith, Smithsonian Institution Press, Washington, D.C., 1985.

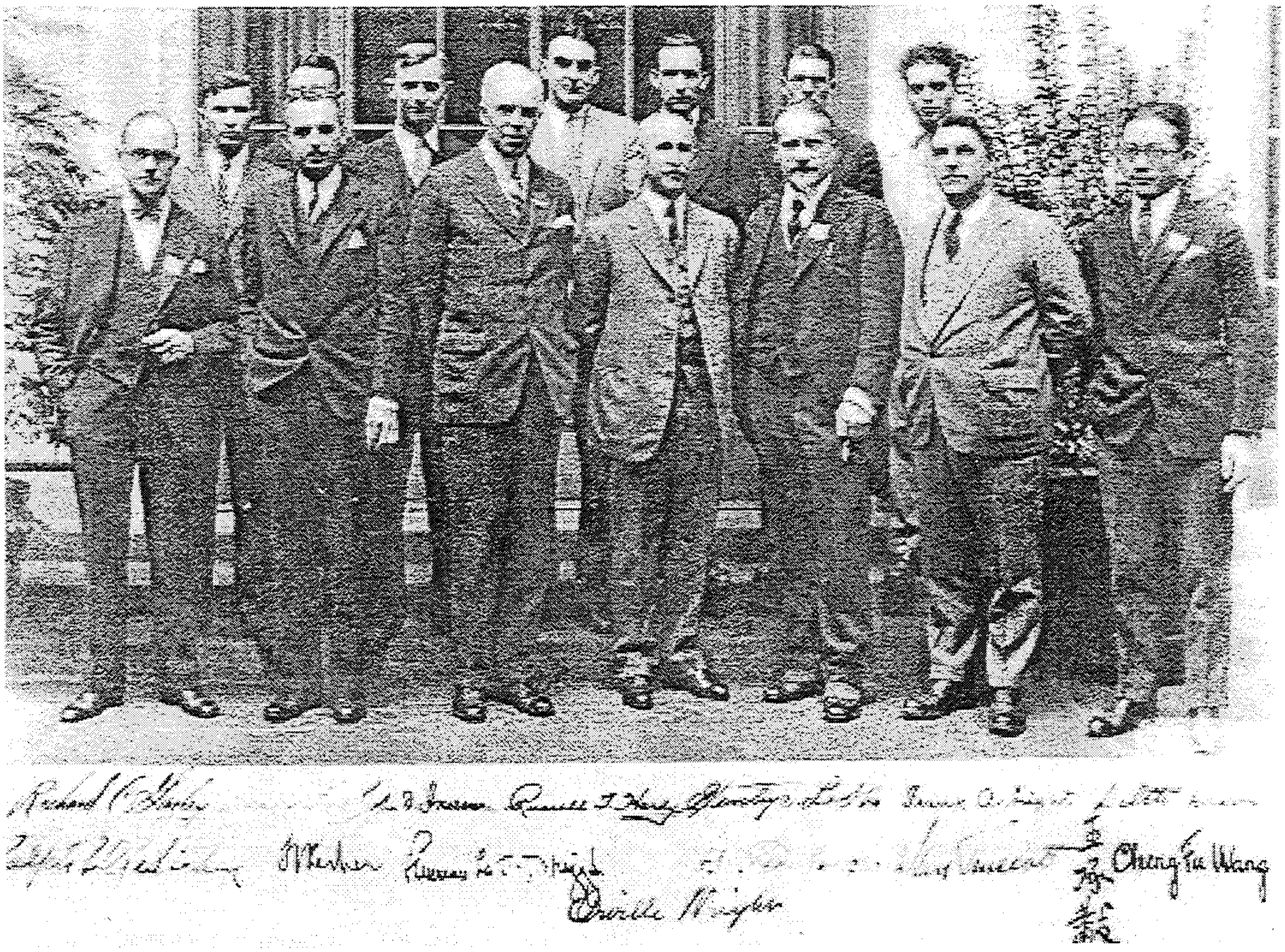
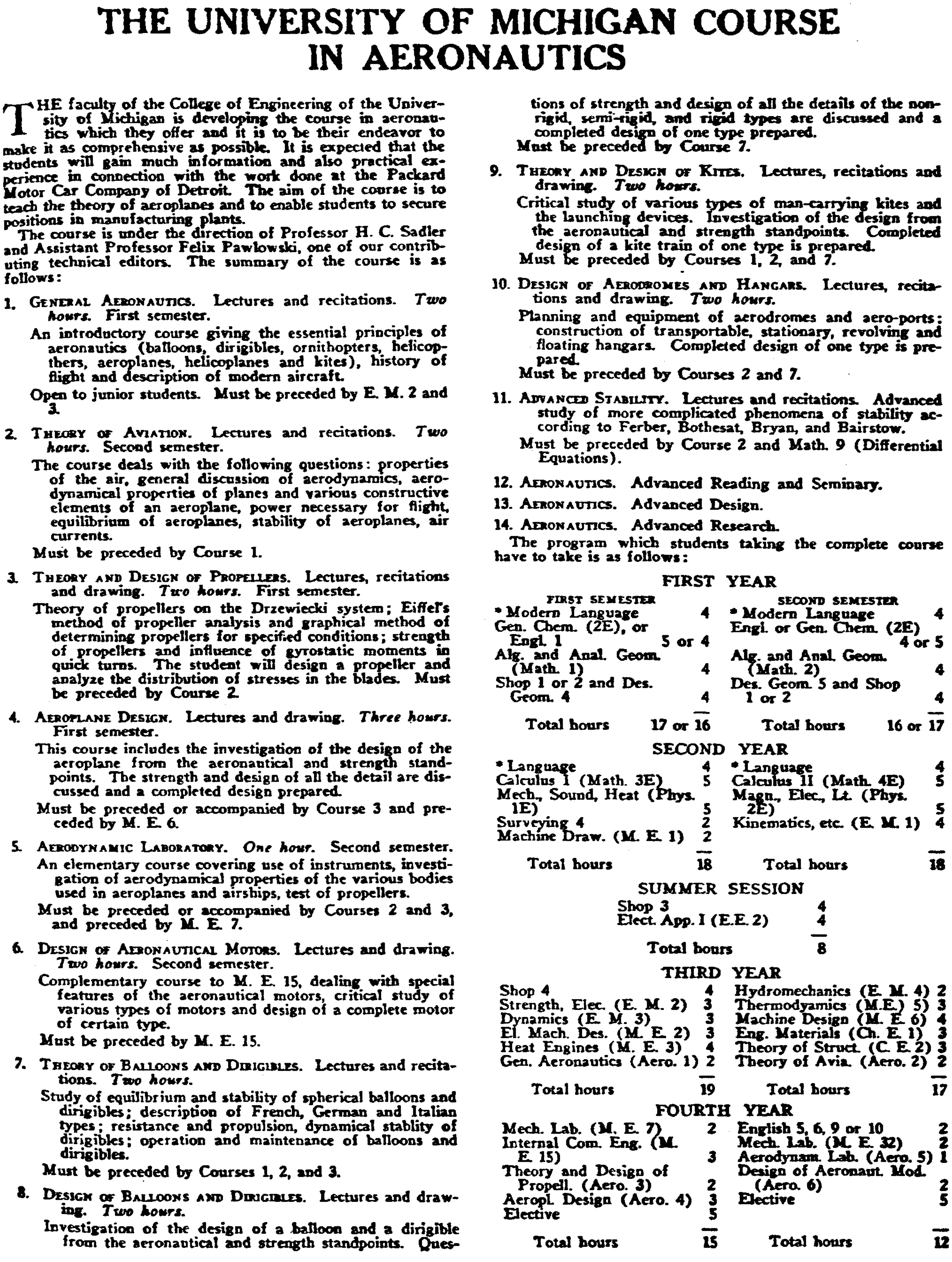


FIGURE 1 Aviation pioneers, including Orville Wright (4th from right, front row) and University of Michigan Aeronautical Engineering Program Founder Felix Pawlowski (3rd from right, front row)



THE UNIVERSITY OF MICHIGAN COURSE IN AERONAUTICS

THE faculty of the College of Engineering of the University of Michigan is developing the course in aeronautics which they offer and it is to be their endeavor to make it as comprehensive as possible. It is expected that the students will gain much information and also practical experience in connection with the work done at the Packard Motor Car Company of Detroit. The aim of the course is to teach the theory of aeroplanes and to enable students to secure positions in manufacturing plants.

The course is under the direction of Professor H. C. Sadler and Assistant Professor Felix Pawlowski, one of our contributing technical editors. The summary of the course is as follows:

1. General Aeronautics. Lectures and recitations. *Two hours.* First semester.
   An introductory course giving the essential principles of aeronautics (balloons, dirigibles, ornithopters, helicopthers, aeroplanes, helicoplanes and kites), history of flight and description of modern aircraft.
   Open to junior students. Must be preceded by E. M. 2 and 3.
2. Theory of Aviation. Lectures and recitations. *Two hours.* Second semester.
   The course deals with the following questions: properties of the air, general discussion of aerodynamics, aerodynamical properties of planes and various constructive elements of an aeroplane, power necessary for flight, equilibrium of aeroplanes, stability of aeroplanes, air currents.
   Must be preceded by Course 1.
3. Theory and Design of Propellers. Lectures, recitations and drawing. *Two hours.* First semester.
   Theory of propellers on the Drzewiecki system; Eiffel's method of propeller analysis and graphical method of determining propellers for specified conditions; strength of propellers and influence of gyrostatic moments in quick turns. The student will design a propeller and analyze the distribution of stresses in the blades. Must be preceded by Course 2.
4. Aeroplane Design. Lectures and drawing. *Three hours.* First semester.
   This course includes the investigation of the design of the aeroplane from the aeronautical and strength standpoints. The strength and design of all the detail are discussed and a completed design prepared.
   Must be preceded or accompanied by Course 3 and preceded by M. E. 6.
5. Aerodynamic Laboratory. *One hour.* Second semester.
   An elementary course covering use of instruments, investigation of aerodynamical properties of the various bodies used in aeroplanes and airships, test of propellers.
   Must be preceded or accompanied by Courses 2 and 3, and preceded by M. E. 7.
6. Design of Aeronautical Motors. Lectures and drawing. *Two hours.* Second semester.
   Complementary course to M. E. 15, dealing with special features of the aeronautical motors, critical study of various types of motors and design of a complete motor of certain type.
   Must be preceded by M. E. 15.
7. Theory of Balloons and Dirigibles. Lectures and recitations. *Two hours.*
   Study of equilibrium and stability of spherical balloons and dirigibles; description of French, German and Italian types; resistance and propulsion, dynamical stablity of dirigibles; operation and maintenance of balloons and dirigibles.
   Must be preceded by Courses 1, 2, and 3.
8. Design of Balloons and Dirigibles. Lectures and drawing. *Two hours.*
   Investigation of the design of a balloon and a dirigible from the aeronautical and strength standpoints. Questions of strength and design of all the details of the nonrigid, semi-rigid, and rigid types are discussed and a completed design of one type prepared.
   Must be preceded by Course 7.
9. Theory and Design of Kites. Lectures, recitations and drawing. *Two hours.*
   Critical study of various types of man-carrying kites and the launching devices. Investigation of the design from the aeronautical and strength standpoints. Completed design of a kite train of one type is prepared.
   Must be preceded by Courses 1, 2, and 7.
10. Design of Aerodromes and Hangars. Lectures, recitations and drawing. *Two hours.*
    Planning and equipment of aerodromes and aero-ports: construction of transportable, stationary, revolving and floating hangars. Completed design of one type is prepared.
    Must be preceded by Courses 2 and 7.
11. Advanced Stability. Lectures and recitations. Advanced study of more complicated phenomena of stability according to Ferber, Bothesat, Bryan, and Bairstow.
    Must be preceded by Course 2 and Math. 9 (Differential Equations).
12. Aeronautics. Advanced Reading and Seminary.
13. Aeronautics. Advanced Design.
14. Aeronautics. Advanced Research.

The program which students taking the complete course have to take is as follows:

FIRST YEAR

FIRST SEMESTER		SECOND SEMESTER	
* Modern Language	4	* Modern Language	4
Gen. Chem. (2E), or Engl. 1	5 or 4	Engl. or Gen. Chem. (2E)	4 or 5
Alg. and Anal. Geom. (Math. 1)	4	Alg. and Anal. Geom. (Math. 2)	4
Shop 1 or 2 and Des. Geom. 4	4	Des. Geom. 5 and Shop 1 or 2	4
Total hours	17 or 16	Total hours	16 or 17

SECOND YEAR

* Language	4	* Language	4
Calculus I (Math. 3E)	5	Calculus II (Math. 4E)	5
Mech., Sound, Heat (Phys. 1E)	5	Magn., Elec., Lt. (Phys. 2E)	5
Surveying 4	2	Kinematics, etc. (E. M. 1)	4
Machine Draw. (M. E. 1)	2		
Total hours	18	Total hours	18

SUMMER SESSION

Shop 3	4
Elect. App. I (E.E. 2)	4
Total hours	8

THIRD YEAR

Shop 4	4	Hydromechanics (E. M. 4)	2
Strength, Elec. (E. M. 2)	3	Thermodyamics (M.E.) 5)	3
Dynamics (E. M. 3)	3	Machine Design (M. E. 6)	4
El. Mach. Des. (M. E. 2)	3	Eng. Materials (Ch. E. 1)	3
Heat Engines (M. E. 3)	4	Theory of Struct. (C. E. 2)	3
Gen. Aeronautics (Aero. 1)	2	Theory of Avia. (Aero. 2)	2
Total hours	19	Total hours	17

FOURTH YEAR

Mech. Lab. (M. E. 7)	2	English 5, 6, 9 or 10	2
Internal Com. Eng. (M. E. 15)	3	Mech. Lab. (M. E. 32)	2
Theory and Design of Propell. (Aero. 3)	2	Aerodynam. Lab. (Aero. 5)	1
Aeropl. Design (Aero. 4)	3	Design of Aeronaut. Mod. (Aero. 6)	2
Elective	5	Elective	5
Total hours	15	Total hours	12

Reprinted from *Aerial Age,* 1915.

FIGURE 2 First curriculum for Aeronautics at the University of Michigan

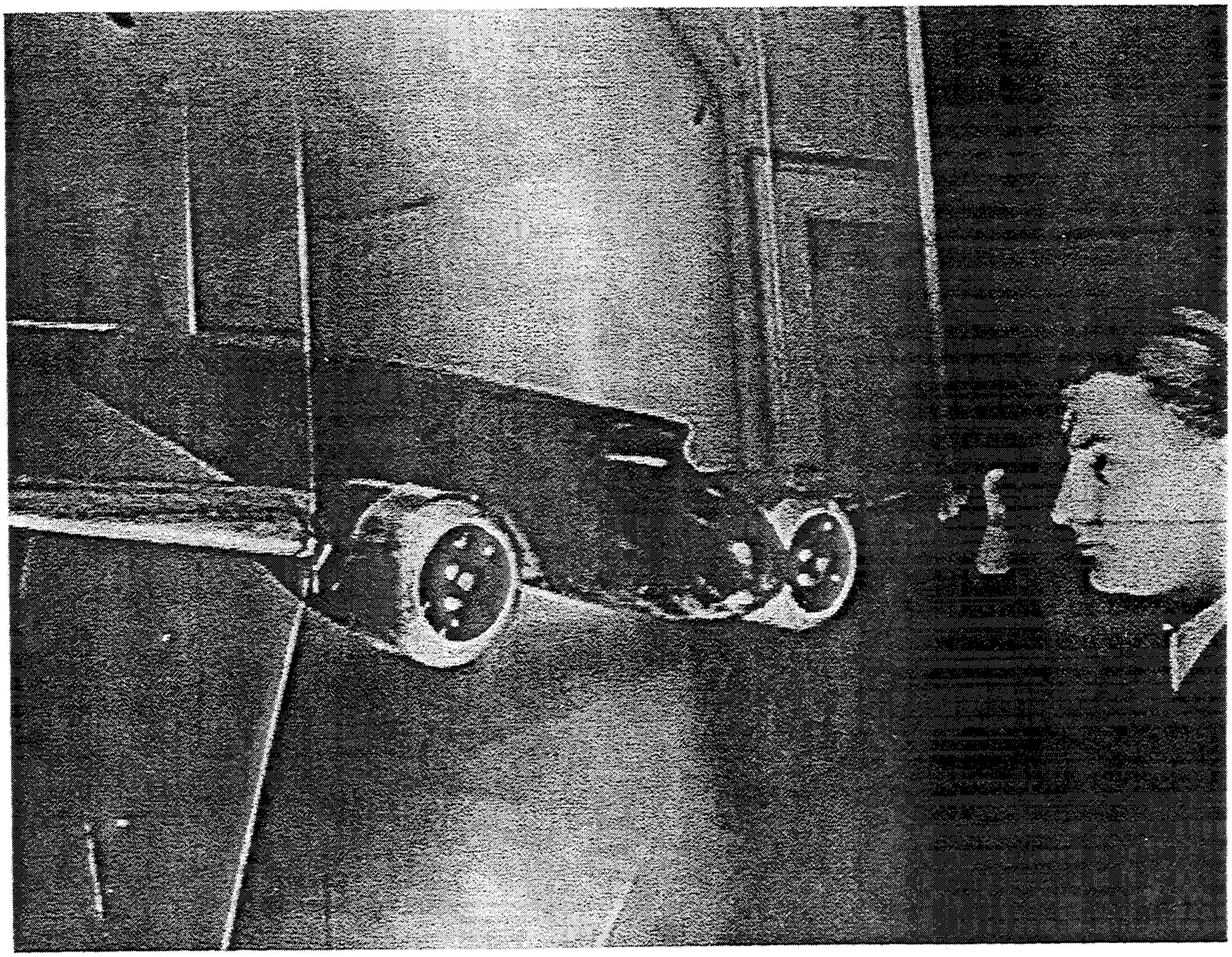
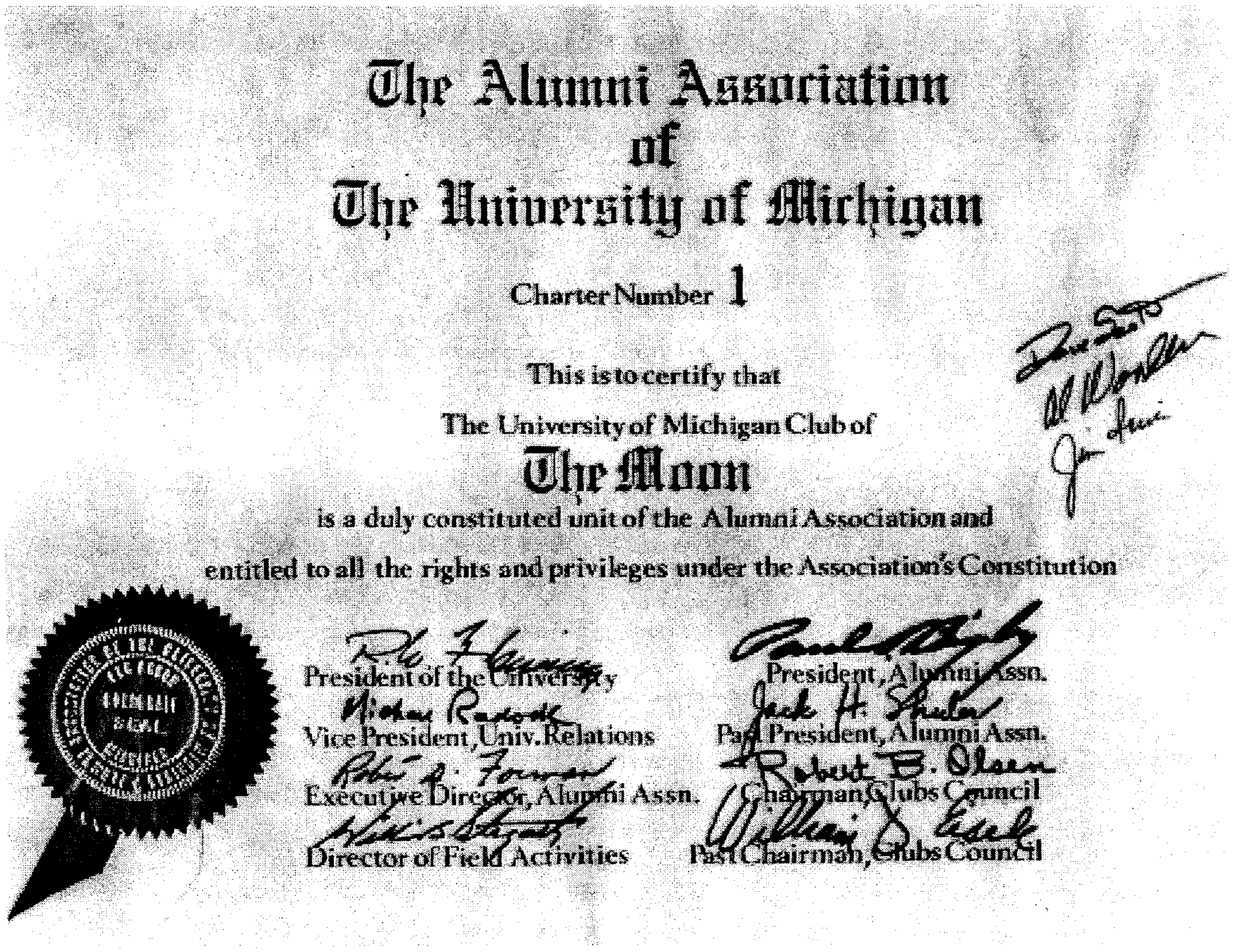


FIGURE 3 Kelly Johnson with model of Lockheed Electra in wind tunnel built into the foundation of the East Engineering Building, circa 1934.



The Alumni Association
of
The University of Michigan

Charter Number 1

This is to certify that
The University of Michigan Club of
The Moon
is a duly constituted unit of the Alumni Association and
entitled to all the rights and privileges under the Association's Constitution

Dave Scott
Al Worden

President of the University
Vice President, Univ. Relations
Executive Director, Alumni Assn.
Director of Field Activities

President, Alumni Assn.
Past President, Alumni Assn.
Robert B. Olsen
Chairman, Clubs Council
Past Chairman, Clubs Council

FIGURE 4 Alumni Seal for the University of Michigan Club of the Moon, Charter Number 1, left on the moon by astronauts John Irwin, Al Warden, and Dave Scott, Apollo 15.

FIGURE 5 Professor Ed Lesher flying over Ann Arbor in his Teal Airplane, holder of seven world records for the FAI class of aircraft with a total weight of 500 kg.

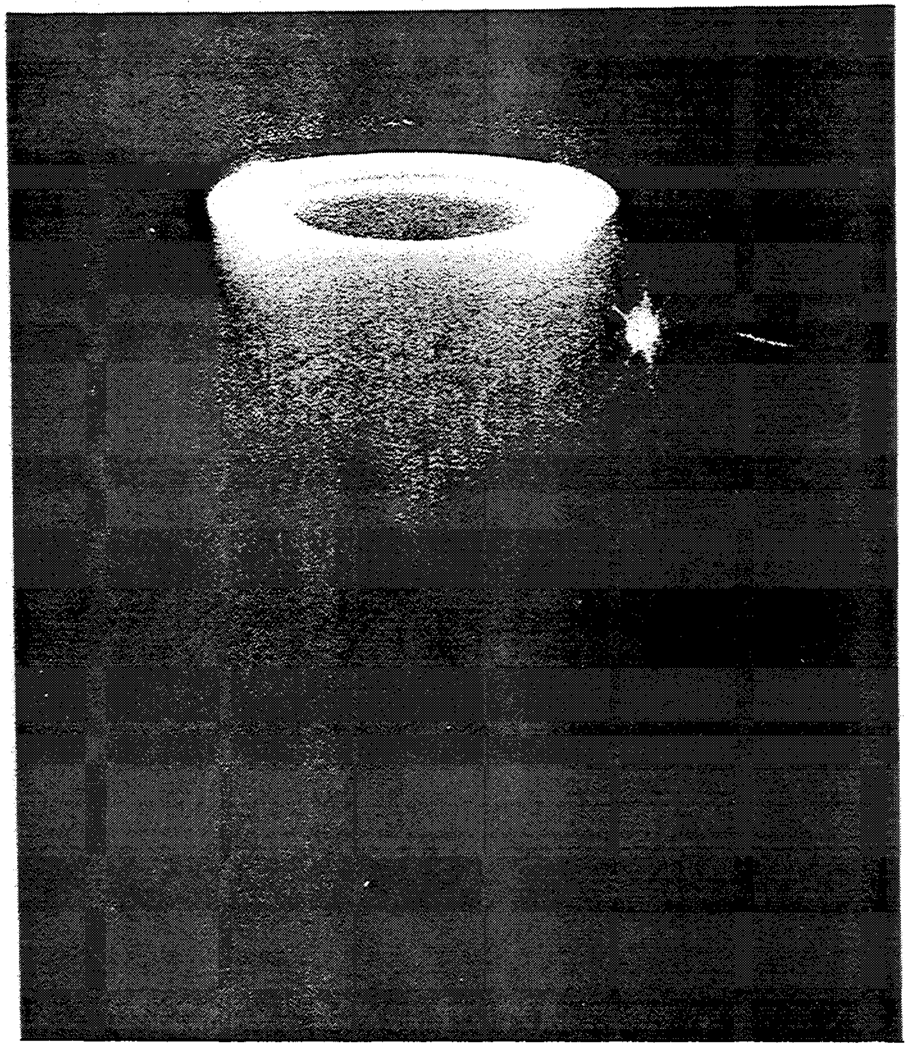


FIGURE 6 Hall Thruster running at full power (9.2 kw, 2800 s, 400 mn) in vacuum chamber at 10^{-5} torr.

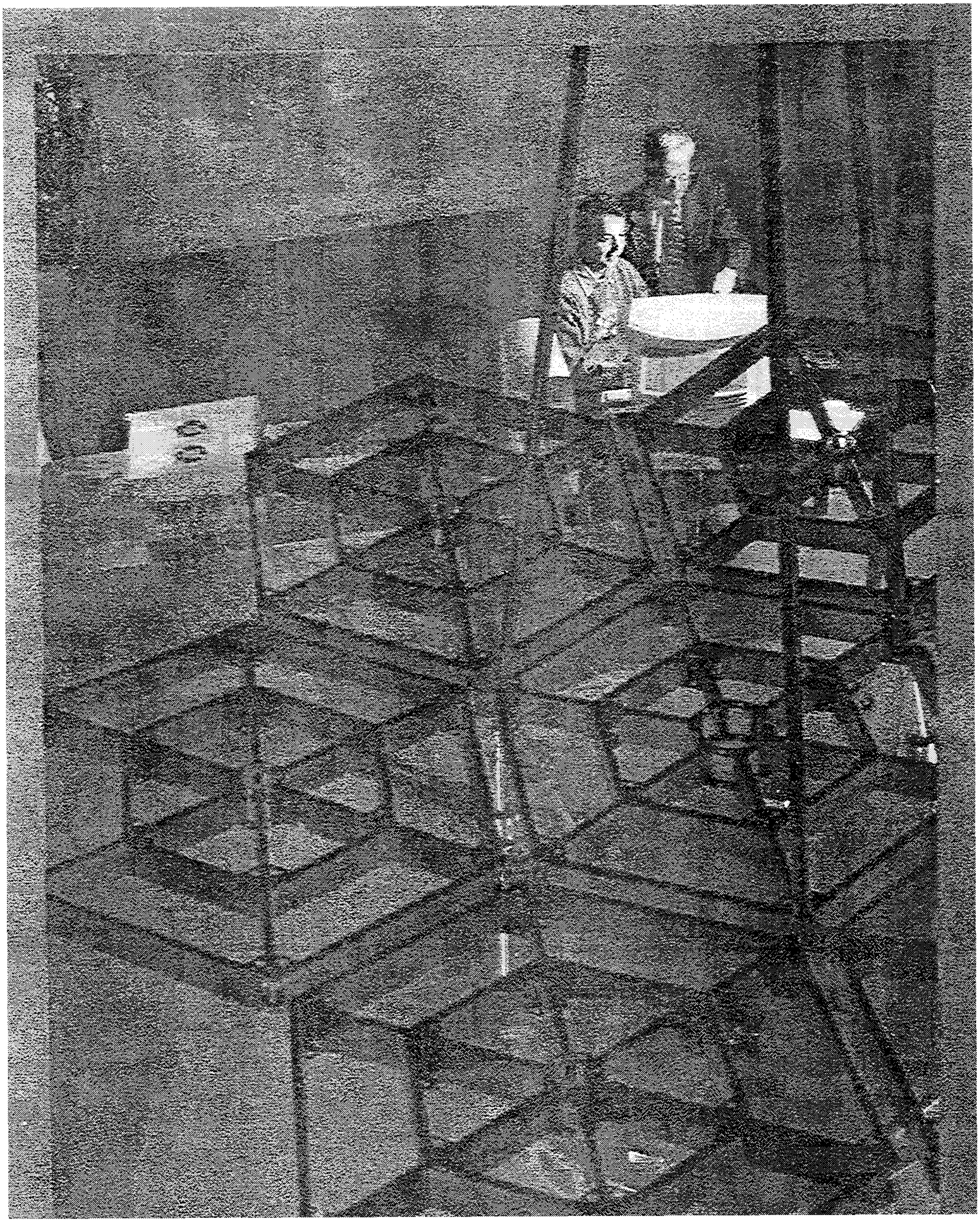


FIGURE 7 Experiment on vibration control of a large aperture spaceborne telescope for astronomy, illustrating high bay laboratories available for large scale experiments in the FXB Aerospace Engineering Building.

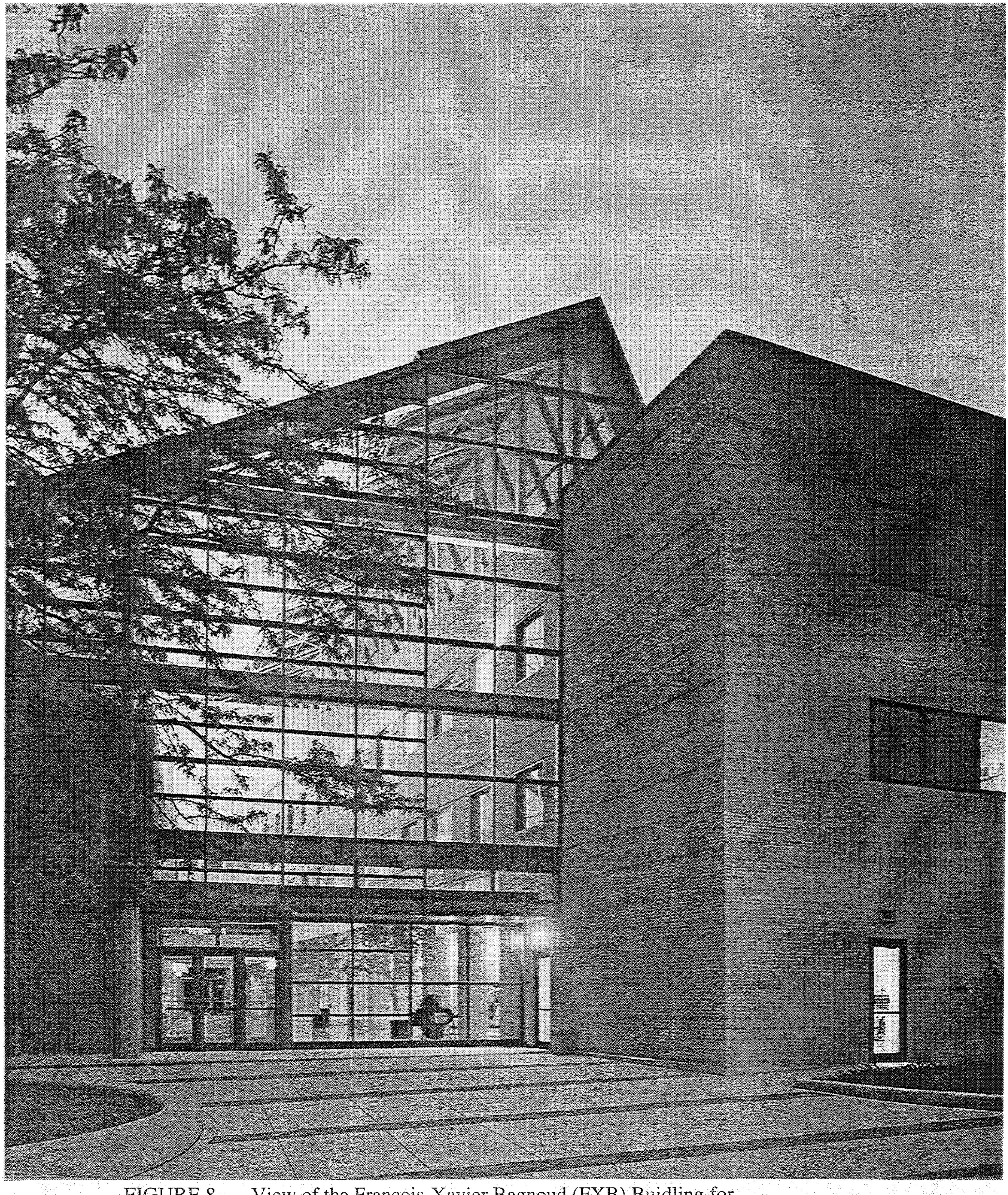


FIGURE 8 View of the François-Xavier Bagnoud (FXB) Buidling for Aerospace Engineering at the University of Michigan.