Adolf Busemann: a giant in the field of aerodynamics

Carol White honors the pioneer scientist who died this month.

On Nov. 10, Adolf Busemann, one of the pioneers in the field of supersonic flight, died. He was 85 years old, and during his lifetime he made significant contributions to the field of space flight, he designed the sabre jet airplane, and he contributed major insights into the field of magnetohydrodynamics.

He was born in Lübeck, Germany, and worked on airplane and rocket design in Germany in the 1930s. He trained with Ludwig Prandtl, the leader of the German hydrodynamic school, and he passed this tradition on to a generation of American scientists and engineers, when he came to the United States in 1947. In the United States, he worked for the National Advisory Committee for Aeronautics, which later became the National Aeronautics and Space Administration (NASA), in Langley, Virginia, on problems concerned with the aerodynamic forces and surface heating involved in starting and landing space vehicles.

Busemann was responsible for redesigning airplanes capable of efficiently and safely flying at speeds beyond the speed of sound. He developed the design for the Busemann biplane, which would have had a double wing configuration that would have completely eliminated drag at supersonic speeds. While this plane was never built, it was used as a theoretical model by the aircraft industry.

He invented the swept-wing, streamlined design familiar today. In 1945, many tragic accidents occurred because airplanes were not being streamlined. Only after Busemann's discovery was applied after the war, were American jet planes redesigned to conform to Busemann's discovery.

Some years ago, my colleague, Uwe Parpart, attended a scientific conference in Moscow. He was shown a design by Busemann which the Soviets had appropriated at the end of the Second World War. It was identical with the Concorde!

But his greatest contributions were in the field of methodology, where he applied the hydrodynamic method of Leondardo da Vinci and Bernhard Riemann, to the problems of aerodynamics.

On Nov. 6, 1981, he was honored at the second annual award dinner of the Fusion Energy Foundation, which he attended. It is fitting that we reprint here excerpts from remarks made by speakers at that dinner, about his contributions to their own research and the development of science as a whole.

Dr. Karl Guderley, another leading scientist in the study of shock-wave phenomena, had this to say about him: "Busemann possesses, of course, very extensive knowledge ranging from engineering (including the repair of an outdated television set) through physics (including quantum mechanics and plasma physics) to mathematics (including little known facts of geometry). But this knowledge goes beyond facts and technical details or logical proofs. It comes alive as an insight into the essence of the subject, an insight frequently formulated in a very striking original manner. Problems of aerodynamics may appear in an easily visualized form.

". . . It has frequently been observed how much Ludwig Prandtl liked to play with things.
of him at a dinner table captured his attention and led to an impromptu lecture. I believe that Busemann plays in a similar manner, but with ideas and perhaps more mathematical toys, until he arrives at a very vivid picture of the essence of a problem. This, then, may lead to the recognition of new facets which someone who just knows the facts, as you find them in a textbook, is unable to recognize. Strangely enough, some of the insights are so simple that in retrospect one does not realize how novel they were at their time. He proposed the swept wing in a lecture at the Volta Congress [a seminal aerodyamics meeting in Volta, Italy] in 1935. The concept was overlooked in the U.S.A. According to von Karman, it came as quite a surprise when in 1945 one suddenly recognized its importance. . . .

"Another striking example of an unconventional approach is the problem of changing the elliptical orbit of a satellite into another one. Each possible orbit is described by a point in a three-dimensional space. The fuel consumption needed to change an orbit into a neighboring orbit is taken as distance definition. The fact that the distance figure determined by this definition has concave parts shows immediately that sometimes discontinuous maneuvers in which one uses temporarily an auxiliary orbit may be optimal from the point of view of fuel consumption."

Dr. William Grossman, a leading theorist in plasma physics, described his days as a student of Busemann. He noted that many of the things Busemann discovered were not recognized until 30 years later, such as a pump system which he proposed in the 1930s, which was only developed in 1962.

The late Krafft Ehricke not only was an expert in rocket design, but was one of the seminal planners of industrialization of the Moon. He said at this dinner: "Busemann was one of my childhood and young-year heroes. When I was studying aerodynamics at the Technical University of Berlin, Dr.

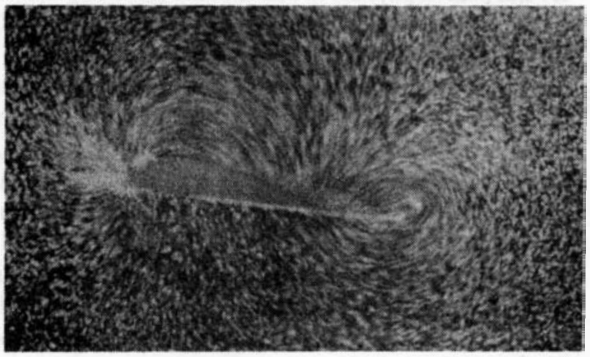
Busemann made me sweat!" Ehricke described how, as early as 1935, Busemann had calculated the pressure and force coefficients of various types of wing shapes which were impressively accurate when they were confirmed by wind tunnel tests at Langley Field.

Calling Busemann one of the century's outstanding scientists, Ehricke noted: "A great mind has indeed as little limit as a field of gravity. It reaches into infinity and eventually affects every mind. . . . The greater the mind, the more penetrating its effect in all areas of our reasonable understanding of the universe."

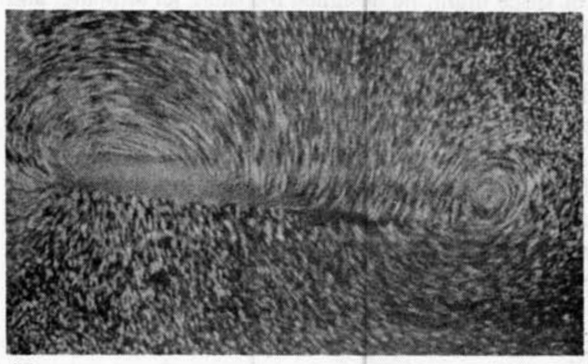
Dan Wells, a plasma physicist who has applied Busemann's insights into his own work on plasma vortices, described how he had been influenced by him. Wells spoke of his early work at the Princeton Plasma Physics Lab, generating vortex structures with a plasma gun that made balls of

FIGURE 1

Busemann's teacher Prandtl's theory of lift



(a)



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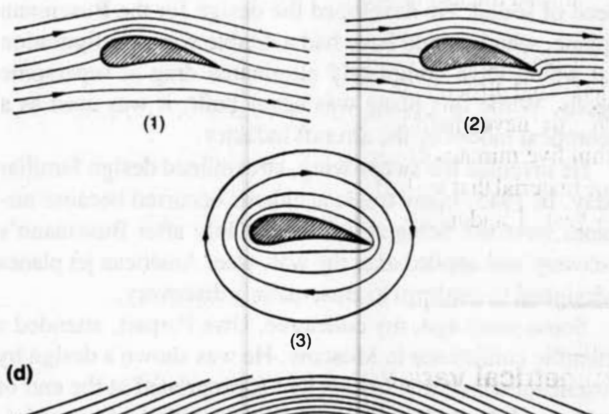
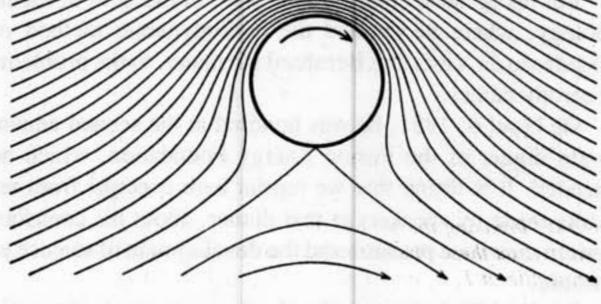


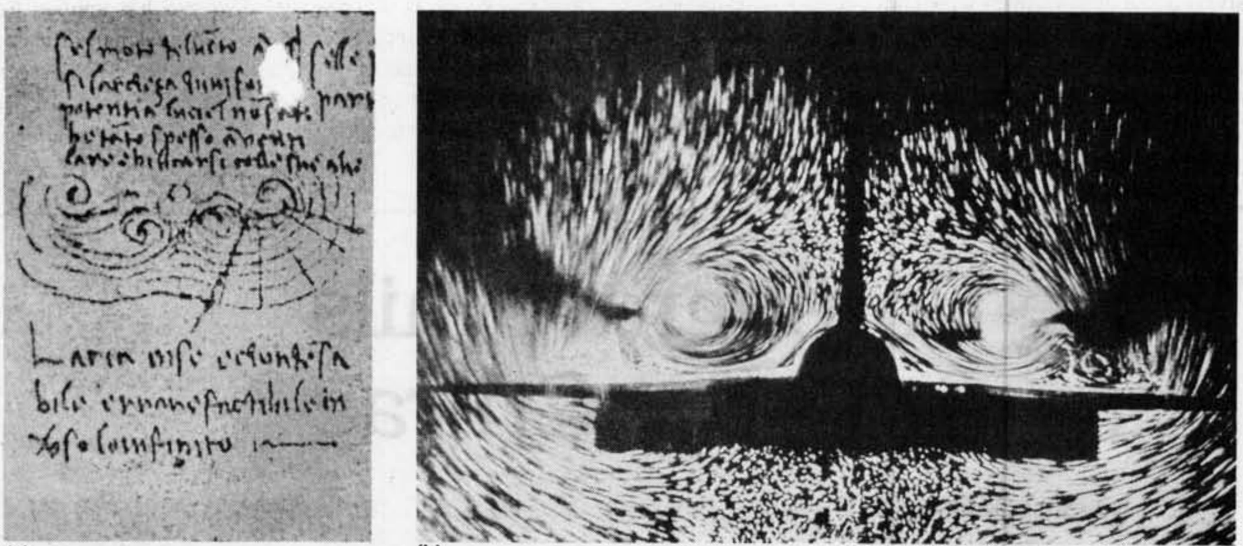
(d)



(a) Flow around an airfoil, with the "starting vortex" emphasized. The camera is at rest with respect to the airfoil. The surface of discontinuity around the wing creates a vortex at the back of the wing.
(b) Now the camera is at rest with respect to the undisturbed fluid, revealing circulation equal and opposite to the "starting vortex."
(c) Pradtl explains what is occurring: The flow around an airfoil (1) may be represented by "superposing" the "ordinary irrotational flow" (2) without circulation, and the circulatory flow of (3). Irrotational flow means that the particles in any local region of the fluid do not undergo any rotation with respect to the median line of the flow. Thus, the resulting flow also exhibits circulation, which is very closely related to the occurrence of a lifting force: the circulatory flow acts with the irrotational flow of (2) above the airfoil and against it below. By Bernoulli's theorem, this means that the pressure is diminished above the airfoil and increased below it; that is, there is a lifting force.
(d) The lift phenomenon is analogous to the Magnus effect involved in flow around a rotating cylinder. On the side where the two velocities are in the same direction, the speed of flow is greater. On the opposite side, where the two velocities oppose each other, it is less. A force at right angles to the flow results (upward in the diagram). This explains why a baseball to which a high spin is imparted will "pop up."

Source: (a)(b)(d) L. Prandtl, Applied Hydro- and Aeromechanics (New York: Dover, 1957), pp. 299, 300, 83; (c) L. Prandtl, Essentials of Fluid Dynamics, p. 70.

FIGURE 2



(a) (b)

Leonardo studies vortices around a bird's wing (a). Compare this to vortices around airplane wings (b).

Source: Institut de France Ms. E 47v.

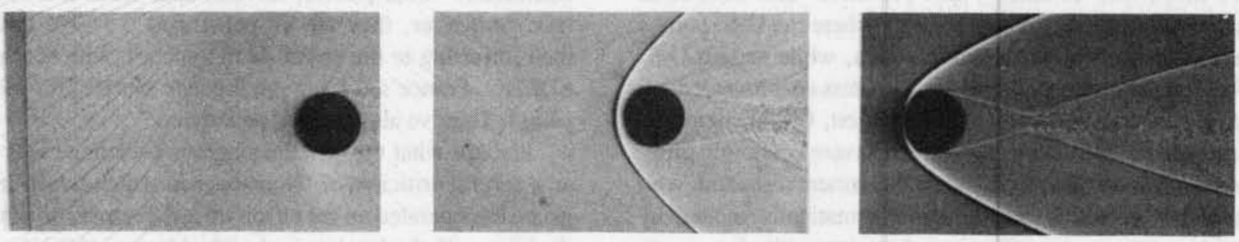
plasma move down a magnetic guide field. The field acted like railroad tracks guiding the donut-shaped plasma projectiles.

"It was very hard to understand physically," Wells recalled, "and difficult to connect the mathematics of Hamilton with this never-before-observed nonlinear structure. Yet, within five minutes of seeing the Busemann approach to the same material that we had been struggling over for six months to a year, I understood exactly what was going on. In one simple diagram and three or four paragraphs, Busemann had clarified the whole formation for us.

"With that beginning, we carried the experiments forward. Using the techniques described by Busemann, we can now generate very hot, very dense plamsa structures. . . . In the future, the real value of this work with hydrodynamic forces will play a major role in both experimental and theoretical research with magnetic fusion devices. The real value of Busemann's contributions will only be seen in the future."

FIGURE 3

Geometrical variation in shock waves at different speeds



The term "breaking the sound barrier" is a misnomer. Actually, increases in speed produce geometrical variations in the same type of singularity, as these photographs of an object at different speeds show. Above, sound wave silhouettes for a 9/16-inch diameter spherical projectile at 1, 2, and 4 times the speed of sound.

Source: Rouse, Elementary Mechanics of Fluids, p. 345.