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(b. Orekhovo, Vladimir province, Russia, 17 January 1847; *d*. Moscow, U.S.S.R., 17 March 1921)

mechanics, mathematics.

The son of a communications engineer, Zhukovsky completed his secondary education at the Fourth Gymnasium for Men in Moscow in 1864 and graduated in 1868 from the Faculty of Physics and Mathematics of the University of Moscow, having specialized in applied mathematics. In 1870 he began teaching at the Second Gymnasium for Women in Moscow, and at the beginning of 1872 he was invited to teach mathematics at the Moscow Technical School, at which he also lectured on theoretical mechanics from 1874. Two years later he defended a dissertation at the Technical School on the kinematics of a liquid and was awarded the degree of master of applied mathematics; a separate chair of mechanics was subsequently established for him at the school. In 1882 he defended his doctoral dissertation, on the stability of motion, at Moscow University and four years later became head of the department of mechanics there. In 1894 he was elected corresponding member of the St. Petersburg Academy of Sciences, and in 1900 he was promoted to member. Unwilling to leave his teaching posts in Moscow and undertake the requisite move to St. Petersburg, however, Zhukovsky withdrew his candidacy. A member of the Moscow Mathematical Society, he also served as vice-president from 1903 to 1905, and as president from 1905 until his death he proved to be an outstanding administrator.

Zhukovsky’s approximately 200 publications in mechanics and its applications to technology reveal the wide range of his interests. Several works are devoted to the motion of a solid around a fixed point, in particular, to the case of Sonya Kovalevsky, for which he gave an elegant geometrical interpretation. He also wrote on the theory of ships, on the resistance of materials, and on practical mechanics. From the beginning of the twentieth century his interest focused primarily on aerodynamics and aviation, to which he devoted himself exclusively in his later years.

In his clear and well-organized lectures Zhukovsky made extensive use of geometric methods, which he valued highly. His lectures on hydrodynamics were standard works for many years, and his course on the theory of regulation of mechanical action (1908-1909) was the first rigorous presentation in Russian of the fundamentals of that subject. His lectures at the Moscow Technical School on the theoretical basis of aeronautics (191 1 -1912) were the world’s first systematic course in aviation theory and were based largely on his own theoretical research and on experiments conducted in laboratories that he had established. During World War I Zhukovsky and his students taught special courses for pilots at the Technical School.

Instrumental in the development of Soviet aviation, Zhukovsky was named head of the Central Aerohydrodynamics Institute, established in 1918. The school of aviation that subsequently developed from it was based on his teaching and became the N.E. Zhukovsky Academy of Military and Aeronautical Engineering in 1922.

Zhukovsky is considered the founder of Russian hydromechanics and aeromechanics. In his master’s thesis (1876) he made extensive use of geometric, as well as analytic, methods to establish the kinematic laws of particles in a current. In 1885 he was awarded the N. D. Brashman Prize for a major theoretical work on the motion of a solid containing a homogeneous liquid. The methods that he developed in this memoir made it possible to solve certain problems of astronomy, concerning the laws of planetary rotation, and of ballistics, on the theory of projectiles having liquid cores. In a work dealing with a modification of the Kirchhoff method for determining the motion of a liquid in two dimensions with constant velocity and an unknown line of flow (1890), Zhukovsky used the theory of functions of a complex variable to elaborate a method for determining the resistance of a profile having any number of critical points. In addition to solving the problems studied by Kirch-hoff, he resolved others, the solution of which had been extremely complicated with the use of existing methods. A memoir written with S. A. Chap-lygin (1906) gave a precise solution to the problem of the motion of a lubricant between pin and bearings, and stimulated a number of other investigations.

In hydraulics, Zhukovsky in 1888 undertook theoretical research on the movement of subsur-face water and studied the influence of pressure on water-permeated sand, establishing the relation between changes in the water level and changes in barometric pressure. Showing that the variation in the water level depends on the thickness of the water-bearing layer, he introduced formulas to determine the undergound water supply, using experimental data extensively. This research was summarized in a work on hydraulic shock in water pipes (1898), in which Zhukovsky established that the reason for damage to water mains was the sudden increase in pressure that followed the rapid closing of the valves. Extensive experiments enabled him to present the physical nature of hydraulic shock, to give a formula for determining the time needed for safe closing of the mains, and to elaborate a method for preserving them from damage effected by hydraulic shock. Zhukovsky acquired an international reputation for this theory, which has remained fundamental to problems of hydraulic shock.

Zhukovsky's other works in hydrodynamics concern the formation of riverbeds (1914) and the selection of a river site for constructing dams and for withdrawing water used to cool machines at large power stations (1915).

Known as "the father of Russian aviation," Zhukovsky became interested in the late 1880's in flight in heavier-than-air machines, a basic problem of which was lift . The experimental data that had been obtained proved useful only in particular cases ; attempts to determine lift on the basis of theoretical premises -especially existing theories of jet stream-yielded results that differed considerably from experimental findings .

Considering it necessary to first establish a physical picture of lift, Zhukovsky in 1890 considered the possibility that it can result from certain vortical motions caused by the viscosity of the surrounding medium. His subsequent experiments with disks rotating in an air current (1890- 189 I) anticipated his concept of bound vortices, the basis of his theory of lift. In 1891 Zhukovsky began studying the dynamics of flight in heavier-than-air machines, theoretically substantiating the possibility of complex motion of an airborne craft, in particular the existence of loops. In 1890-1891 Zhukovsky undertook experiments designed to study the changing position of the center of pressure of a wing with the simplest profile, a flat disk. By that time he had already turned his attention to the question of stability and was conducting tests of gliders and kites. In studying propeller thrust, Zhukovsky considered heavier-than-air craft powered by flapping wings, multipropellered helicopters, and screw propellors. In 1897 he presented a method of computing the most efficient angle of attack of a wing.

Zhukovsky's works on the motion of a substance in a liquid, published in the 1880's and 1890's, included a memoir on the paradox of Du Buat (1734-1809), for which he gave a physical explanation. In 1779 Du Buat had shown experimentally that the resistance of an immobile disk in a moving liquid is greater than the resistance of a disk moving at the same speed in a stationary liquid-a phenomenon that seemed to contradict the general laws of mechanics . Zhukovsky explained the discrepancy by the fact that, in practice, turbulence always occurs on the walls and the free surface of a liquid . To support his explanation he constructed a small device by means of which he showed that when there is no turbulence the pressure remains the same in both cases.

Zhukovsky established that lift results from the flow in an airstream of an immobile bound vortex (or system of vortices) by which the object can be replaced. From this starting point, he derived a formula for lift, equal to the product of the density of air, the circulation velocity of the surrounding airstream, and the velocity of the body . The theorem was confirmed in experiments with rotating oblong disks, conducted in 1905-1906 at the Aerodynamics Institute at Kuchino, near Moscow.

The formulation in 1910 of the Zhukovsky-Chaplygin postulate, concerning the determination of the rate of circulation around a wing, made it possible to solve the problem of lift, to determine its moment, and to develop a profile for airplane wings. Zhukovsky also investigated the profile of resistance of a wing and established the existence of resistance caused by the flow of turbulence from the wing's sharp leading edge.

In high-speed aerodynamics, Zhukovsky in 1919 presented a theory of the distribution of high-velocity plane and spherical waves, and demonstrated its possible application to determine the resistance of projectiles . His work in airplane stability included a major monograph (1918) in which he considered the construction of airplanes on the assumption that the longerons bear uniform loads arising from the weight of the wings and from the air pressure.

Zhukovsky initiated the study in Russia of the theory of bombing from airplanes. In 1915 he offered a method of determining the trajectory and bomb velocity when the air resistance is proportional to the square of the velocity ; he provided a method of calculating the change of air density from a given altitude ; and he examined various practical methods for using bombing and sighting apparatus .

S. A . Chaplygin was the most distinguished member of Zhukovsky's school, which included A . I. Nekrasov, L. S. Leybenzon, V. P. V etchinkin, B. N. Yuriev, and A. N. Tupolev.

BIBLIOGRAPHY

I. Original Works. Zhukovsky's complete collected works were published as *Polnoe sobranie sochineny*, **9** vols . (Moscow-Leningrad, 1935-1937) . Other collections are *Izbrannve sochinenia* ("Selected Works"), 2 vols. (Moscow-Leningrad, 1948); and *Sobranie sochinenv* ("Collected Works"). 7 vols. (Moscow-Leningrad, 1948-1950).

II. Secondary Literature. On Zhukovsky and his work, see V. A . Dombrovskaya, *Nikolav EgoroivichZhukovsky* (Moscow-Leningrad, 1939), with bibliography of his writings: V. V . Golubev, *Nikolay Egorovich Zlnrkovsky* (Moscow, 1947); A . T. Grigorian, *Ocherki istorii mekhaniki* v Rossü ("Sketches of the History of Mechanics in Russia"; Moscow, 1961); "Vklad N. E. Zhukovskogo i S. A . Chaplygina v gidro-dinamiky i aerodinamiku" ("The Contribution of Zhukovsky and Chaplygin to Hydrodynamics and Aerodynamics"), in *Evolvutsia mekhaniki v Rossü* ("Evolution of Mechanics in Russia"; Moscow, 1967); and *Mckhanika of anticlrnosti do nashikh dney* ("Mechanics From Antiquity to Our Time"; Moscow, 1971); A. A

.Kosmodemyansky, “Nikolay Egorovich Zhukovsky,” in *Lyudi russkoy nauki* (“Men of Russian Science”; Moscow, 1961), 169-177; and L. S. Leybenzon, *Nikolay Egorovich Zhukovsky* (Moscow-Leningrad, 1947).

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