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(*b*. Paris, France, 21 April 1774; *d*. Paris, 3 February 1862)

physics.

Biot's father, Joseph, was of Lorraine peasant stock; he had risen on the social scale and held a post in the treasury. Jean-Baptiste attended the Collège Louis-le-Grand in Paris and distinguished himself in the classical curriculum. About 1791, he left the school and took private lessons in mathematics. His father intended him to have a career in commerce, but Biot rebelled and, taking an opportunity provided by the Revolutionary Wars, volunteered for the army, enlisting as a gunner in September 1792. Biot, who had not abandoned mathematics, took the entrance examination for the École des Ponts et Chaussées and was accepted in January 1794. Shortly afterward, the École Polytechnique was founded; Biot transferred to it, and was appointed section leader of a group of students in November 1794. At the École Polytechnique, Biot's outstanding ability drew the attention of the director, Monge.

Under the influence of the ideas of the Revolution, and later of Laplace, Biot became skeptical of all belief in a personal God. Yet in 1825, in Rome, he sought and obtained a personal audience with Pope Leo XII and he became increasingly attracted to the religion of his childhood. In 1846 he made a formal return to the Roman Catholic Church. In 1797 Biot married the daughter (then aged sixteen) of Antoine François Brisson of Beauvais, *inspecteur général* du commerce et des manufactures, whose son was Biot's friend at the École Polytechnique. Biot instructed his wife in science and mathematics, and since she was a competent linguist, she was able to collaborate with him in a translation into French of E. G. Fischer's physics textbook.

Biot was closely associated with many of the institutions for education and research that were a prominent feature of France after the Revolution. On graduation from the École Polytechnique in 1797, he was appointed professor of mathematics at the École Centrale of the Oise department at Beauvais. From 1799 he was entrance examiner for the École Polytechnique, a post he retained when, in 1800, he was appointed professor of mathematical physics at the Collège de France. Under the patronage of Laplace, Biot was given the post of assistant astronomer at the Bureau des Longitudes in 1806. When the University of France was established by Napoleon in 1808, Biot was appointed professor of astronomy at the Paris Faculté des Sciences. From 1816 to 1826, however, while retaining the official title of professor of astronomy, he agreed to teach physics related to his own research and gave courses on light, sound, and magnetism. From 1840 until his retirement in 1849, Biot was dean of the Faculty.

Biot joined the Société Philomathique in Paris in 1801. His association with Laplace and Berthollet at about this time qualifies him for consideration as one of the original members of the Société d'Arcueil. In 1800 he was elected a nonresident member of the First Class of the Institute, and when, in 1803, a vacancy for full membership in the mathematics section occurred, he was elected. Biot was unsuccessful in his candidature for the post of permanent secretary of the Académie des Sciences on the death of Delambre in 1822, but was elected vice-president of the Academy in 1835. By virtue of his research on Egyptian, Babylonian, and Chinese astronomy, Biot was elected a member of the Académie des Inscriptions et Belles Lettres in 1841. In 1856 he received the honor, unusual for a man of science, of election to the Académie Française. Biot, who in his youth had detested the Jacobins, also had little sympathy for Napoleon. Upon the restoration of the Bourbons in 1814, Biot was awarded the Legion of Honor (*chevalier*) for his services to science and education, and was successively promoted to officer (1823) and commander (1849) of the order. Unlike many of his contemporaries in France, Biot took no part in politics, living a long and active life devoted almost entirely to scientific research.

Throughout his life Biot made contributions to literature beyond those expected of a man of science. His *Essai sur l'histoire générale des sciences pendant la révolution française* was published in 1803. When in 1812 the Académie Française proposed the subject of Montaigne for a prize, Biot's essay received an honorable mention. He was commissioned to write a hundred-page biography of Newton for the *Biographie universelle*. Biot was well known as an ardent follower of Newton. In 1813, in the *Journal de physique*, he described Newton as a person "whose conceptions seem to have surpassed the limits of thought of mortal man" (p.131). Biot continued: "Words fail to convey the profound impression of astonishment and respect which one experiences in studying the work of this admirable observer of nature." In the biography, Biot's solution to the problem of the interrelation of Newton's natural philosophy and his theology was to suggest that all the original scientific work had been completed early in Newton's life and that he had become seriously interested in theology only after mental illness. Biot later took issue with Brewster's interpretation of Newton. In the last years of his life, Biot wrote appreciations of Gay-Lussac and Cauchy.

Biot was the author of several important textbooks. His *Traité élémentaire d'astronomie physique* was the source from which Sir George Airy, later British astronomer royal, learned his basic astronomy; and he claimed that he had acquired his interest in the subject through Biot's work. Biot's *Traité de physique* (1816) constitutes a comprehensive account of contemporary physics, including not only recent original research by himself (e.g., on polarization) but also the recent and often unpublished work of his associates, particularly Laplace, Gay-Lussac, and Dulong.

Although Biot's first publications were in mathematics, he soon came strongly under the influence of Laplace, whose advice he followed in the application of analysis to physical problems. In 1802 Biot demonstrated that the attraction of an ellipsoid at an external point might be deduced by simple differentiations from a particular expression, which is theoretically known when the attraction is known for all points situated in the plane of one of the principal sections. Biot's memoir, however, constituted little more than a commentary on the earlier writings of Legendre and Laplace. His introduction to Laplace had come about through his offer to read the proofs of Laplace's *Mécanique céleste*. Laplace encouraged Biot to undertake experimental investigation of a wide range of problems, many of which constituted a deliberate extension of the Newtonian framework of science. This can be seen particularly in Biot's research on refraction, polarization of light, and sound. If we were to select any one branch of physics to which Biot made the most important contribution, the choice would be the polarization of light, but, since none of his contributions in this field occurred before 1812, it will be convenient to deal first with his varied contributions to other branches of physical science.

An unusual piece of research at the beginning of Biot's career was concerned with a meteorite said to have fallen from the sky at l'Aigle in the Orne department on 26 April 1803. Biot was ordered by Chaptal, minister of the interior, to confirm the report. Shortly before, M. A. Pictet had called attention to reports of meteorites—reports that many rationalists had dismissed as superstitious. Biot questioned people in the locality where the meteoric stones had fallen. Various specimens were examined and compared with the composition of the ground from which they had been taken, and some were subjected to chemical analysis. Biot's report, read to the First Class of the Institute on 18 July 1803, marks the beginning of a general recognition in France of the reality of meteorites.

In the years 1804–1809 Biot undertook several scientific projects in collaboration with other men, notably fellow members of the Arcueil group or the Bureau des Longitudes. On 24 August 1804, Biot made a balloon ascent with Gay-Lussac. The ascent was notable in that it was undertaken entirely for purposes of scientific research and had the approval of the French government. The primary purpose was to find whether the magnetic intensity of the earth decreased at great altitudes, as had been suggested by Horace de Saussure's experiments in the Alps. From their experiments, in which they timed the oscillations of a magnetized needle at various altitudes, Biot and Gay-Lussac concluded that up to 4,000 meters there was no change.

Biot undertook further work on magnetism in collaboration with Humboldt, who furnished much of the data used in their joint memoir (1804). Biot attempted to derive general laws governing inclination, using as a basis the hypothesis of an infinitely small magnet situated at the center of the earth and placed perpendicular to the magnetic equator. The theoretical values for the inclination agreed well with Humboldt's readings, particularly in the northern hemisphere. Anomalies were attributed to purely local factors.

Biot collaborated with Arago in 1805–1806 in research which, in a typically Newtonian spirit, they presented with the title "Mémoire sur les affinités des corps pour la lumière, et, particulièrement sur les forces réfringentes des différents gaz" (1806). The accurate determination of the refractive indices of various gases and vapors at different pressures was a legitimate subject of study for two members of the Bureau des Longitudes who were concerned with astronomical observations. In another memoir, Biot reported on the refraction of light rays near the horizon. He made a full study of mirages, taking the subject beyond Wollaston's work of 1803. In later years, in a succession of memoirs, Biot made further contributions to the subject of atmospheric refraction. As regards the joint work with Arago, however, not the least important part of Biot's research was the accurate determination of the densities of gases weighed in glass globes. The values obtained were part of the data used by Gay-Lussac to establish his law of combining volumes of gases. When Gay-Lussac and the chemist Thenard carried out combustion analyses of organic compounds, they calculated their results with atomic weights for carbon and hydrogen deduced from the density measurements of Biot and Arago. Prout also used the data of Biot and Arago to support his hypothesis.

In 1807 Biot collaborated with Thenard in a thorough comparative study of rhombic aragonite and hexagonal calcite. Apart from obvious chemical tests, they compared the refractivity not only of the crystals but also of their solutions in hydrochloric acid and of the carbon dioxide evolved from each. They concluded that aragonite and calcite were composed of the same chemical elements in the same proportions, but with a different arrangement of the molecules, which resulted in physically different substances. This was one of the earliest examples of what was later called dimorphism.

Biot made a number of contributions to the determination of the velocity of sound. His first memoir in 1802 mentions that he had undertaken this research at the instigation of Laplace. Biot was not then able to measure directly the tiny temperature changes produced by sound waves, although Laplace believed that this was the key to solving the discrepancy between Newton's formula for the velocity of sound and the value obtained in practice. In 1807 Biot carried out more experiments at Arcueil on the transmission of sound through vapors. In 1808 the extensive laying of water mains in Paris gave Biot the opportunity of carrying out further experiments on sound. With cast iron pipes forming a continuous length of 951 meters Biot determined, by repeated experiments, the time interval between transmission and reception of sound through the pipe and through the air. Knowing the velocity of sound in air under the temperature and pressure conditions of the experiment, Biot was able to compare the two velocities. One factor limiting the accuracy of the experiments was the presence of lead, used to join the iron pipes. Biot therefore did not give an explicit value for the velocity of sound in cast iron, but concluded that it was 10.5 times that in air—a value that was long considered authoritative because of the difficulty of direct determination.

In 1806 Biot and Arago were sent by the Bureau des Longitudes to determine the arc of the meridian in Spain and the Balearic Islands, a task begun by Méchain but left incomplete at his death in 1804. The post-Revolution metric system was based on the idea of a "natural" unit, the meter, which was supposed to be exactly one ten-millionth of a meridian quadrant of the earth. Méchain and Delambre had made measurements over a meridian arc of 10° stretching from Dunkirk to Barcelona, and from their readings the length of the standard meter was obtained. It was proposed that this should be redetermined with greater accuracy by extending measurements farther south to the Balearic Islands. Special difficulties in triangulation were encountered because of the distance of the islands from the mainland, but these difficulties were eventually overcome. Biot presented a report on this expedition to the Institute in 1810. Meanwhile, in the company of Mathieu, Biot measured the length of the seconds pendulum at Bordeaux and at Dunkirk. In 1817, Biot took part in another expedition, this time to Scotland and the Shetland Islands in order to confirm the geodesic work that had recently been undertaken by the British under Colonel Mudge. In 1818, Biot was again in Dunkirk; in 1824 and 1825 he went to Italy and Sicily with his son, and then revisited Formentera and Barcelona to correct his earlier geodesic measurements. From a comparison of his determinations, Biot concluded that the weight of a given body is not the same on all points with the same latitude, nor is its variation uniform along a particular meridian. This work established the necessity of revising the generally accepted simple ellipsoid theory of the earth.

During Biot's visit to Spain in 1806 and 1807 for geodesic work, he carried out other experimental work which is not generally known. He made a special study of the composition of the air contained in the swim bladders of fish found off the islands of Ibiza and Formentera. He can claim credit for recording the extremely high proportion of oxygen in the swim bladders of certain fish which live at great depths. He found a maximum of 87 percent oxygen, a figure that agrees well with the modern value. Another series of experiments that he carried out in the Mediterranean on the compression of gases (published in 1809) is of some theoretical interest. He lowered mixtures of gases, in appropriate proportions, to great depths to see whether they would combine to form the corresponding compounds. Combination did not take place up to pressures of about thirty atmospheres, and he was able to conclude that even when the pressure was increased thirty times and the distance between the molecules was correspondingly reduced, the molecules were still too far apart to exercise their chemical affinity.

In 1804 Biot carried out an experimental investigation of the conductivity of metal bars by maintaining one end at a known high temperature and taking readings of thermometers placed in holes along the bar. He was able to report the significant result that the steady-state temperature decreased exponentially along the length of the bar. He saw that this could be explained in terms of a balance of loss of heat at the surface and transfer of heat along the bar, which he analyzed in terms of adjacent pairs of cross-sectional areas. Unfortunately he was unable to present the differential equation corresponding to his physical model because of his inability to find plausible physical reasons for dividing a second difference of temperatures by the square of the infinitesimal element of length. Hence he could not convert his second difference into a second derivative. This was later achieved by Fourier. (I owe the above analysis of Biot's work on conductivity to Dr. J. R. Ravetz.)

In 1813 Biot attempted to derive a general formula for the expansion of liquids, and in 1815 he made a critical examination of Newton's law of cooling. Biot's friend Delaroche had already shown that at high temperatures heat losses were greater than the simple proportionality suggested by Newton. Biot proposed the equation

$$t=aT + bT^3,$$

where t represents the heat loss, T is the difference in temperature between the hot body and its surroundings, and a and b are constants. While considering Biot's early work on heat, it will be convenient to mention two later contributions. Biot proposed a general formula for the pressure, p, of a saturated vapor:

$$\log p = a + b\alpha^{\theta} + c\beta^{\theta},$$

where a, b, c, α, and β are determined by means of five experiments and θ is the temperature measured from a convenient zero, such as the lowest temperature in the five experiments used to determine the constants. Biot's formula was a considerable improvement in generality and precision over the earlier formula of Delaroche. Biot also derived a formula (occasionally referred to as Biot's law) relating the intensity of solar radiation to the thickness of the atmosphere. If I is intensity of radiation of incident beam and I' is intensity of radiation transmitted through a thickness, t, of a medium whose coefficient of absorption is k, then

$$I'=Ie^{-kt}$$

In 1800, the announcement of the voltaic pile aroused general interest; and when Volta came to Paris in 1801, the official report of the committee appointed by the First Class to examine Volta's work was edited and presented by Biot. On 14 August 1801, Biot read a memoir to the First Class describing his study of the "movement of the galvanic fluid," based on the hypothesis of Laplace that it consisted of mutually repellent particles. In collaboration with Cuvier, Biot investigated the chemistry of the voltaic pile. Expanding the work of W. H. Pepys, they confirmed that the voltaic pile in action absorbed oxygen, which they measured. They found that as long as any oxygen remained to be absorbed, the voltaic pile was still active, but with decreasing intensity. Nevertheless, the pile continued to function in the exhausted receiver of an air pump.

In the first edition of his physics textbook, Biot adopted a theory of electrolytic decomposition that was substantially that of Grotthus, but he later suggested that the liquid undergoing decomposition is most positive at the positive pole and most negative at the negative pole. When a particle of a salt is decomposed at the negative pole, the latter communicates a strong negative charge to the acid part. By repulsion from the surrounding negatively charged particles and by attraction toward the positive pole, it moves toward the latter. Only at the poles does decomposition take place. Biot made a brief study of the distribution of electricity on the surface of irregular spheroids, an extension of earlier work by Laplace. By analysis, he also established that when a Leyden jar is discharged by successive contacts, the losses of electricity form a geometrical progression.

News of Oersted's discovery of the connection between magnetism and electricity was brought to Paris by Arago in September 1820. Immediately the Paris scientists, including Ampère, began to explore the subject. Biot was away at the time, but on his return he was said to be working day and night to make up for lost time. He presented the result of his research with Savart to the Academy on 30 October 1820. They had measured the rate of oscillation of a suspended magnet placed at various distances from a conductor carrying a current. They were thus able to show that the magnetic force acts at right angles to the perpendicular joining the point considered to the conductor, and that its intensity is inversely proportional to the distance (Biot and Savart's law).

After this review of Biot's miscellaneous contributions to science, we must turn to the field in which he did his most important work—the study of polarization of light, the research for which Biot was awarded the Rumford Medal in 1840 by the Royal Society of London. The polarization of light by reflection had been discovered by Malus in Paris in the fall of 1808. This was of fundamental importance in the history of optics, since it showed that a phenomenon that had previously been observed in a few crystalline substances, such as Iceland spar, was a general property of light. Malus's discovery opened up an entirely new field of research, and no one was stimulated more than his two associates in the Arcueil group, Arago and Biot. In August 1811, Arago announced that he had found that white light polarized by reflection could, on passing through certain crystals, be split into two differently colored beams.

Biot repeated Arago's experiments and established the relationship between the thicknesses of the crystal plates and the colors produced. He observed that for perpendicular incidence, the colors seen correspond to those seen by reflection and transmission in thin films of air; and he concluded that the thicknesses at which the colors appeared were proportional to the thickness of the air gap that gave the same color on Newton's scale. These thicknesses depended on the nature of the crystal, but were always much greater than the thicknesses of thin films of air that gave the same tint. Biot found that the colors disappeared if the plate was extremely thin, and there was also an upper limit—for example, no colors would be seen if the thickness of a plate of gypsum was greater than 0.45 mm. In this research the exact measurement of the plate was of the utmost importance, and Biot was fortunate in being able to use the spherometer, newly invented by Cauchoix. He began his research by taking eleven plates of gypsum, varying in thickness from 0.087 mm. to 0.345 mm. He determined the color produced by each and compared it with the color on Newton's scale. For oblique incidence, Biot found that the color depended on the thickness of the crystal traversed by the refracted ray and varied as the square of the sine of the angle that the direction of the ray formed with the optical axis.

Biot's interpretation of his results was in terms of a repulsive force that caused polarization by acting on the particles of light. This conception was first worked out in detail in a memoir presented to the First Class on 30 November 1812. The discovery of polarization had greatly encouraged Laplace, Biot, and others who supported a corpuscular theory of light. Malus had been successful in deriving the fundamental cosine law of polarization on such a model. To explain the complementary polarization in crystalline plates, Biot developed a theory of "mobile polarization." The particles of a polarized ray were supposed to preserve their original polarization until they reached a certain depth in the crystal, when they began to oscillate around their center of gravity so that the axes of polarization were carried alternately to each side of the axes of the crystal. The period was considered to vary with the color (as in Newton's theory of fits). When the ray emerged from the crystal, oscillation stopped, and the ray assumed "fixed polarization," in which the axes of the particles were arranged in two perpendicular directions. The theory was plausible up to a point, but Biot had considerable difficulty in accounting for the difference in the effect of thin and thick plates on polarized light. In 1841 Biot considered that he had found a new phenomenon of polarization, which was dependent on the existence of different layers in the crystal and which he called lamellar polarization.

In 1812 Biot observed that the rotation of polarized light produced by a plate of quartz decreased progressively with change of color from violet to red. In a paper read to the Academy on 22 September 1818, Biot was able to announce what has become known as Biot's law of rotatory dispersion and would now be expressed by the equation

where α is the rotation and λ is the wavelength. For Biot, however, it was "la loi de rotation réciproque aux quarrés des longueurs des accès" (the law of rotation in inverse proportion to the squares of the lengths of the fits)—a reminder that Biot did not accept a wave theory, but followed Newton's theory of "fits." Biot also found that the amount of rotation is proportional to the thickness of the crystalline plate traversed by the ray and that the rotation effected by two plates is the algebraic sum of the rotations produced by each separately.

Biot deduced his law without the use of monochromatic light, and his wavelength values given in the graph (Fig. 1) are Newton's values for the boundaries of different colors.

The horizontal axis in Biot's graph represents the square of the wavelength of light, and the vertical axis denotes the thickness of the plates of quartz required to produce rotations of 180°, 360°, 540°, etc., in light of a given color. Biot found that the same law apparently applied equally to liquids. Later, when trying to compensate levorotatory turpentine against dextrorotatory oil of lemon, Biot observed that exact compensation of all rays was not possible. The amendment to the expression of Biot's law that this implied was not achieved until much later (Drude, 1898; Lowry and Dickson, 1913).

In 1814, Biot found that in certain crystalline substances the refractive index was less for the ordinary ray than for the extraordinary ray, unlike the standard doubly refracting substance calcite. Huygens had explained the formation of the extraordinary ray in calcite by the construction of an oblate spheroid. Biot modified this construction, drawing a prolate spheroid to describe the new phenomenon.

Tourmaline was known to be a doubly refracting substance. In 1815 Biot found that a plate of a certain thickness of tourmaline crystal cut parallel to the axis

had the property of transmitting only light polarized in one plane. If light was allowed to pass through two plates and the second was rotated until it was perpendicular to the first, the light would gradually be extinguished. Biot's difficulty in explaining the action of polarized light on certain crystals such as calcium sulfate was overcome only when Brewster distinguished biaxial crystals from uniaxial ones. Nevertheless, in 1818 Biot did clearly distinguish a uniaxial form of magnesia mica from the more common biaxial types, and his work is commemorated in the name biotite given to a type of mica by J. F. L. Hausmann in 1847.

Until 1815 it had been assumed that only in the solid state did substances have the effect of rotating the plane of polarized light. It was Biot who discovered that certain crystalline solids, which had no effect on polarized light, did have an effect when in solution. On 23 October 1815, Biot announced to the First Class that the property of rotating the plane of polarized light was shared by liquids. Turpentine placed in a long tube with plane glass at each end exhibited a similar property, although to a less marked degree. Within a week he found a similar effect with oil of laurel and oil of lemon. Biot appreciated the immense importance of his discovery—that since this was a property of liquids, it must be a property of the molecules. To confirm this, he demonstrated that the effect on polarized light applied equally to turpentine in the liquid and vapor states.

In 1811 Arago found that in plates of quartz, the colors polarized along the axis were different from those he had studied in other crystals. When they were analyzed through a prism of Iceland spar, he found that the two images had complementary colors and changed through the spectrum as the prism was rotated. Biot repeated these experiments and found that while in some quartz crystals the tints descended in the scale of colors by turning the analyzing prism from left to right, in others the same effect was obtained by turning the prism from right to left. He thus distinguished what he called right-handed and left-handed quartz. Biot found that liquids also had opposite effects on polarized light. If liquids that rotated the plane of polarization in opposite directions were mixed in suitable proportions, the effect was canceled out. For this effect, Biot introduced the term *compensé* ("compensated"). He found that the rotation of the plane of polarization for a given liquid was proportional to its concentration or, with a given concentration, to the length of the tube containing the solution. It was Biot who introduced the practice of denoting the effect of polarized light on a liquid or solution by the value of the rotation produced by a column of standard length. Biot's major contribution to instrumentation in polarimetry was to design one of the first polariscopes.

In 1816 Biot suggested that the equal effect of polarized light on respective solutions of cane sugar and beet sugar constituted an additional proof of their identity. After 1820 he put his optical research aside, and for the next twelve years his work was mainly in astronomy and electricity. From 1832 he resumed his optical research with renewed vigor, going back to his earlier work and carrying out comparative tests on sugars. In 1833, working with Persoz, Biot found that when cane sugar was heated with dilute sulfuric acid, a chemical change took place; this was revealed by the solution's rotating the plane of polarized light to the left instead of to the right. He described the effect as "inversion," a term which is still used. In further collaboration with Persoz, Biot studied the conversion of starch by dilute acids into sugar and a gum which, from its effect on polarized light, they named dextrine. Biot introduced the polarimetric method of quantitative estimation of sugar remaining in molasses.

In 1832 Biot recorded the property of a solution of tartaric acid of rotating polarized light, and he remarked on the anomalous dispersion it gave, the rotation being greater for "less refrangible rays." In 1836 he presented to the Academy a memoir devoted entirely to the study of the rotatory power of tartaric acid under different conditions. He stressed that tartaric acid constituted an outstanding exception to his law of inverse squares (of wavelength). Biot accordingly divided optically active substances into two classes, those that obeyed his law and those that did not. He observed the crystalline forms of some salts of tartaric acid, but it was left to Pasteur to show the relationship between the crystalline form and the effect on polarized light. Biot was, significantly, an ardent champion of Pasteur at the beginning of his career. Pasteur, for his part, felt that Biot's work on the rotation of polarized light by liquids constituted a valuable scientific tool that had been hitherto unjustly neglected by chemists.

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II. Secondary Literature. There is an anonymous biography of Biot in American Academy of Arts and Sciences, *Proceedings*, **6** (1862–1865), 16–23. Other works on Biot are D. Brewster, "Optics," in *Encyclopaedia Britannica*, 8th ed. (Edinburgh, 1858), XVI; M. P. Crosland, *The Society of Arcueil. A View of French Science at the Time of Napoleon I* (Cambridge, Mass. 1967); F. Lefort, "Un savant chrétien. J. B. Biot," in *Le correspodant*, n. s. **36** (1867), 955–995; T. M. Lowry, "Optical Rotatory Dispersion. A Tribute to the Memory of Jean Baptiste Biot (1774–1862)," in *Nature*, **117** (1926), 271–275; E. Mach, *The Principles of Physical Optics* (New York, 1926), ch. X; P. F. de Mottelay, *Bibliographical History of Electricity and Magnetism* (London, 1922); C. E. Picard, "La vie etl'oeuvre de Jean Baptiste Biot," in *Éloges et discours académiques* (Paris, 1931), pp. 221–287; D. Sidersky, "Le centenaire du premier polarimetre," in Association des Chimistes, *Bulletin de l'Association des chimistes* (Jan.-Feb.1940)

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