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BRIAN O'BRIEN
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A Biographical Memoir by

C. R. STROUD JR.

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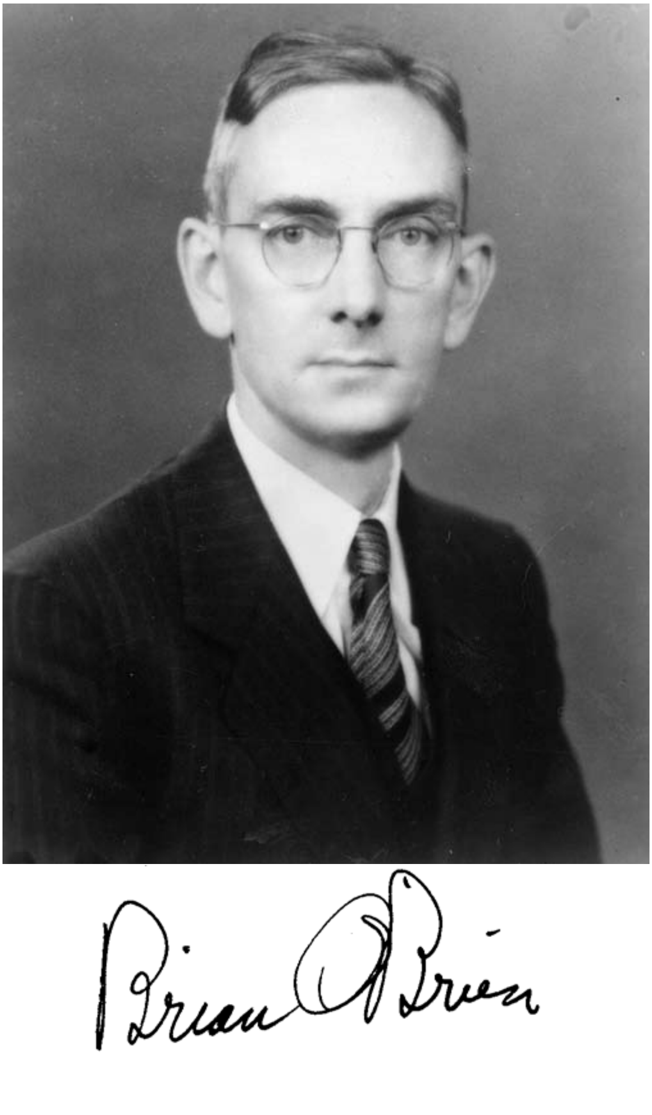

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BRIAN O'BRIEN

January 2, 1898–July 1, 1992

BY C. R. STROUD JR.

BRIAN O'BRIEN WAS A BIOPHYSICIST, an optical engineer, an educator, an inventor, and a patriot. Already in the 1930s he was studying the absorption of solar ultraviolet radiation by the earth's ozone layer, and developed the technique for vitamin D fortification of milk by use of ultraviolet light. He was the first permanent director of the Institute of Optics of the University of Rochester, and in less than a decade led that department to become the principal academic center of optical engineering during World War II, developing a series of optical instruments that were important to the war effort, including night vision devices, antivibration optical mounts, aerial cameras, and high-speed streak cameras. It was his suggestion that led to the development of optical fibers using low-index cladding. This suggestion was an outgrowth of his work on demonstrating that the Stiles-Crawford effect in physiological optics was due to waveguiding of light in the cones in the retina of the eye. He later moved to the American Optical Company where he was responsible for developing the Todd-AO motion picture process. Through all of this, up until his death, he served important roles on many governmental commissions and advisory groups.

Brian O'Brien was born in Denver, Colorado, in 1898 to Michael Phillip and Lina Prime O'Brien. His education started in the Chicago Latin School and continued at the Yale Sheffield Scientific School, where he earned a Ph.B. in 1918 and a Ph.D. in 1922. He did additional course work at MIT and Harvard. In 1922 he married Ethel Cornelia Dickerman with whom he had one son, Brian Jr. After Ethel died, he married Mary Nelson Firth in 1956.

On completion of his doctorate he began his professional career as a research engineer with the Westinghouse Electric Company where he developed, along with Joseph Slepian, the autovalve lightning arrester, which is still in use today. In 1923 he moved to the J. N. Adam Memorial Hospital in Perrysburg, N.Y., a tuberculosis sanitarium run by Buffalo's Public Health Department. Prior to the advent of antibiotics the primary treatment for tuberculosis was fresh air and sunshine. There was some evidence that sun tanning did help in the remission of the disease. However, Perrysburg—40 miles south of Buffalo—had very little sunshine in the winter. Therefore, O'Brien, as physicist on the staff, developed carbon arcs with cored carbons that very closely matched the solar spectrum. With this development the patients could have sun therapy year-round. Due to a general interest in the biological effects of solar radiation, he published some of the early work on the ozone layer and erythema caused by the sun.

The educational and research requirements of the rapidly growing optics industry in the United States led two Rochester companies, Eastman Kodak and Bausch and Lomb, to underwrite a new Institute for Applied Optics at the University of Rochester. The institute was looking for a professor of physiological optics. O'Brien's presentation of his studies of ultraviolet radiation at a meeting of the Optical Society of America held at Cornell University attracted the attention of the search committee for the new institute. O'Brien accepted an offer to move to the University of Rochester in

1930 to hold the chair of physiological optics. He was to be responsible for teaching physiological optics, visual sensitometry, and colorimetry.

His continuing interest in the biological effects of solar radiation led to research in vitamin chemistry. The need for vitamin D, especially in the diet of children, had been recognized for preventing the disease rickets. At that time there was no synthetic vitamin D, but the dehydrocholesterol in milk can be converted to vitamin D by irradiation with ultraviolet light. The carbon arcs developed at Perrysburg were an ideal source of ultraviolet, but for proper irradiation the milk had to be in a very thin film. Flowing down a solid cylinder produced a suitable film, but the flow volume was much too low to be practical. Free flow from an annular slit might work, but surface tension would collapse the film shortly after leaving the slit. If by suitable vanes the milk were given an angular velocity prior to leaving the slit, centrifugal force would counteract the surface tension and a thin free-flowing film would be produced. Thus, a film of high enough flow volume for commercial application was produced, and vitamin D-fortified milk became widespread.

In 1934 O'Brien became director of the Institute of Optics. Under his leadership the institute, which was founded in 1929 shortly before he arrived, became one of the principal academic centers in the world for studying basic and applied optics. In 1935 he undertook a series of ultraviolet spectroscopic experiments measuring the vertical distribution of ozone in the atmosphere with instrumentation on the stratospheric balloon *Explorer II* which ascended to a record 72,000 feet over the Black Hills of South Dakota. Most importantly, by the late 1930s he realized that the United States would soon be entering the war in Europe and that there would be an enormous need for optics research and development to support the war effort. A similar realization of the importance optical instrumentation for national defense had earlier led to the founding in France of the Institute d'Optique and in England of the Optics Section at Imperial College. He prepared for this anticipated wartime need by expansion of instrument shop facilities, and stocking up on potentially scarce materials such as high-strength aluminum.

Shortly before the war the Office of Scientific Research and Development was formed, headed by Vannevar Bush, reporting directly to the White House. Under the OSRD the National Defense Research Committee was formed with various subdivisions. Section D, handling instrumentation, was formed under George Harrison, and Section D6 was headed by O'Brien. The work of the OSRD during the war is recorded in a volume edited by C. G. Suits and George Harrison (Suits and Harrison, 1948). That book describes the work that was carried out in the Institute of Optics by a wartime professional staff of approximately 50.

Perhaps the most important development to come out of Rochester was the metascope. These were a series of infrared telescopes with Kellner-Schmidt optics, using an infrared phosphor in the image plane. When O'Brien began work developing such a night-vision device he soon encountered the problem of obtaining the requisite phosphor. It was rumored that an Austrian named Franz Urbach had developed an appropriate phosphor, but his whereabouts after the war started were unknown. Through the various intelligence services O'Brien tried to trace him but with little success. Some time later Lee Dubridge, head of the Physics Department, came into O'Brien's office and told him that a refugee physical chemist had shown up in his department, and he had given him some laboratory space, but he really didn't know what to do with him. His name was Franz Urbach—and he had escaped the Nazis.

Urbach had indeed developed a phosphor-like material that could convert infrared radiation into visible light without violating the laws of physics. By doping sulfide phosphors with rare-earth elements, primarily europium, many possible meta stable states are generated. If electrons are bumped up into these states by high-energy radiation (initially ultraviolet light, but later alpha particles from radium), they will stay there until triggered out by infrared, then fall back to the ground state and in so doing emit visible light.

Immediately laboratory space was set up for him in the basement of Dewey Hall and a crew of assistants was provided. With the spherical image plane of a Kellner-Schmidt optical system coated with this material and an eyepiece system arranged to view it one had an infrared viewing telescope. The code word "metascope" was applied to these devices to hide their true nature. A series of these instruments was developed, with several going into large-scale production for use during the war. For example, the Sampson United Co. in Rochester was contracted to produce the type A metascope, but the company had trouble ramping up to the needed production in time for a planned invasion. To solve this, classes were canceled at the Institute of Optics. The undergraduates were put on a three-shift-a-day basis in the institute optical shop grinding and polishing the flats on Kellner-Schmidt corrector plates. The faculty went on three shifts at the Sampson United assembly line, and the required number of units was produced for the battle of Okinawa, on which their impact was significant. This can-do spirit as illustrated by the joint faculty and student effort to solve a manufacturing problem is a good example of the sort of atmosphere O'Brien's leadership inspired.

Many other devices were developed for the war effort, including the "seebackascope" to align a dive bomber between the sun and a target; the "Icarascope" to reduce the brightness of the solar disc to the point where an attacker coming out of the sunlight could be seen; and anti-oscillation mounts for binoculars to increase the range that night fighter aircraft pilots could identify enemy aircraft.

Civilian transportation was problematic during the war, but there was need for quick trips to various military bases and to companies that were collaborating in various projects of the National Defense Research Committee; the Institute of Optics had its own small airplane used for these trips and for various research projects, often piloted personally by Brian O'Brien. One of the most remarkable uses of the plane was to test a system by which a pilot was able to land on a moonless night on a darkened landing strip using only a small flashlight attached to his head. Just such a landing was performed one night at the Rochester city airport after it had been closed for the night. The runway was lined with a number of small triple mirrors which reflected the dim light directly back to the pilot's eyes so that the strip was clearly outlined by the images of his flashlight. The retroreflection was sufficiently accurate that no one but the pilot could see the reflected light. The mirrors were small enough to be carried in the lining of an overcoat to mark clandestine landing strips behind enemy lines. Other versions of these reflectors were used by the navy to mark friendly ships so that they were not strafed, and to communicate at night between surfaced submarines and observers hidden in mountain jungles in the South Pacific.

Before the war O'Brien had set up a vacuum metallic thin film evaporator. This was used extensively during the war. A particularly important use of it was the development of the cube polarizing beamsplitter that is a familiar staple in every optics lab today. It played an important role in various bomb sights and heads-up displays. All of this optical work was performed under O'Brien's section D6 of the National Defense Research Committee.

O'Brien also developed before the war the first of a series of high-speed cameras to study the reciprocity effect in silver halide emulsions. The type I was a streak camera with an equivalent speed of 11 million frames per second. In 1946 when the military was setting up Joint Task Force One to test nuclear explosives on Bikini atoll in the Pacific (termed "Operation Crossroads"), they asked O'Brien and the Institute of Optics to participate with his cameras. It was obviously important to have some idea of the expected fireball brightness to determine exposure. The only source of this was a roll of 16 mm motion picture film taken at the original Trinity test at Alamogordo. Little or no information was available as to film processing conditions, but with microdensitometry and some assumptions an approximate value was obtained. The military wanted much more quantitative information from the new tests. Since the camera used a continuous loop of film, a very-high-speed capping shutter was required. Because the light went through a single slit at one point, it was only necessary to cut off the light at this point. To do this a heavy current was run through a loop of soft aluminum wire stretched on either side of the slit. The magnetic field generated by the current attracted the two wires together and shut off the light.

At this time O'Brien's son, Brian Jr., was serving in the navy and was stationed at the Bureau of Aeronautics in the Navy Department, and because of his familiarity with the equipment (he had studied optics in Rochester himself) his father requested him as navy liaison officer for the project. He was reassigned to Rochester to help with the preparations and later to operate the camera on an observation ship, the USS *Barton*, the ship closest to the blast. Brian Jr. describes his experience:

On D-day all was set. I was perched on the gun director with earphones, the camera control box, and a stopwatch. At the minus two-minute signal I started the camera drum spinning, listened to the bombardier's tone and when it stopped, started the stopwatch. Five seconds before detonation I opened the capping shutter, and closed it immediately after detonation. On looking up it seemed that the mushroom cloud was leaning over toward us. Fearing radiation fogging of our film, I frantically unbolted the camera from the antenna, wrapped it in black cloth and rushed it, still spinning, down to the wardroom, hoping that the steel hull of the ship would absorb any radiation. Our fears turned out to result from only an illusion—the cloud had gone essentially straight up.

The streak photograph of the blast was recorded and provided a crucial diagnostic in determining the early evolution of the fireball. This story well illustrates the zeal and dedication of the O'Briens in the war effort. In 1948 President Truman recognized this contribution by awarding Brian O'Brien the Medal of Merit, the highest civilian award given by the government.

After World War II, O'Brien could return to his interests in basic research in physiological optics and sensors. He undertook a major study in the behavior of lead sulfide as an infrared detector. He also returned to the study of the distribution of the ozone layer in the lower stratosphere, work he had begun in the 1930s in conjunction with the National Geographic U.S. Army Air Corps high-altitude balloon ascents. In fact, the spectrographic apparatus and even the wicker basket used to carry it into the stratosphere are still preserved at the Smithsonian Institution's Air and Space Museum. With the development of lightweight unmanned plastic balloons by 3M Company, it was now possible to reach altitudes above 100,000 feet, 30,000 feet higher than before the war.

These tests were made in 1949, and although the spectrograph fell into a Minnesota lake, the film was retrieved intact, analyzed, and found to have reached only the lower reaches of the ozone layer. It was not until rocket probes were developed that the ozone layer was fully characterized, but this work was a precursor of current studies of humanity's effect on the atmosphere.

O'Brien enjoyed solving the unexplained riddles of human vision. One of them was the Stiles-Crawford effect (Stiles and Crawford, 1933). In the 1930s Stiles and Crawford observed that light entering the eye at the edges of the pupil produced a lower brightness sensation than light entering at the center of the pupil. This went unexplained for many years. O'Brien postulated that because of the structure of the retina, light entering the retinal cones at the base travels down the cone by multiple total internal reflections since the cone is immersed in a transparent medium of a lower refractive index than the cone itself. Because of the shape of the cone, light entering off-axis would tend to reach critical angle and be lost sooner than light entering on-axis. Histological measurements on rabbit retinas confirmed this possibility, but any direct photometric measurements would be extremely difficult.

By scaling up the system by a factor of 6×10^4, 3 cm X-band microwave radiation could be used and easily measured, if only a scaled-up retinal cone could be produced. A material, new at the time, made of expanded polystyrene (now called Styrofoam) had just become available. It had the right refractive index characteristics for X-band radiation against air. A system was set up using a surplus X-band military radar transmitter, and the results exactly matched the observed results of Stiles and Crawford. As a result of the work on the Stiles and Crawford effect it occurred to O'Brien that a low-refractive-index cladding on a high-index core glass would provide insulation from adjacent fibers while giving extremely high-efficiency reflections by total internal reflection. Thus, a glass fiber could transmit light over long distances without large losses, and fibers bundled together could transmit images. Preliminary experiments with glass fibers and an ultraviolet polymerized plastic coating showed this to be the case.

This study was completed at just about the time when, on a visit from Delft in Holland, Professor A. C. S. van Heel confided to O'Brien that he had been attempting to produce light-transmitting glass fibers for a classified government project. His results from coating glass fibers with silver to enhance their transmission and prevent crosstalk between fibers in a bundle had failed, and the project was in jeopardy. O'Brien pointed out to van Heel that a low-refractive-index cladding provided the right solution, which van Heel, of course, then recognized immediately. When van Heel applied this he got the results he needed and went on to other things but not before publishing the results in the Dutch journal *de Ingenieur*. This meeting between O'Brien and van Heel is dramatically described in a comprehensive history of the field of fiber optics (Hecht, 1999).

When O'Brien went from the University of Rochester to the American Optical Co. he gave the company the fiber-cladding concept and the company patent department began preparing a patent application. In their pre-application search they found van Heel's publication of the concept. However, they misread the publication date (in the European sequence), and their filing date was beyond the one-year allowance under U.S. patent law; the most important concept of the patent was invalidated by van Heel's prior publication.

It was perhaps inevitable that O'Brien would move from academia to industry following the war. The large staff and funding of the National Defense Research Committee vanished after the war, and although the government began direct funding of scientific research in universities through the new National Science Foundation as well as military agencies, the focus was much more on nuclear and particle physics than applied optical engineering, at least prior to the development of the laser in 1960. There was no way in the university setting that he could operate with the scale and resources he had enjoyed during the war. Industry offered an attractive alternative, and in 1954 he moved to become vice president for research at American Optical Company in Southbridge, Massachusetts.

One of the specific incidents that occasioned the move was a late-night visit by the movie producer Michael Todd. The Cinerama system of widescreen movie projection had just been developed and was acclaimed by audiences and critics, but it required movies to be simultaneously recorded with three cameras and projected with three projectors. Todd had been a principal in the development of this system but was unhappy with it because it was expensive and cumbersome. Todd wanted to have a system to film and project through "one hole," and he flew to Rochester and met O'Brien and his student, Walter Siegmund, in the airport bar to get advice on getting such a system built quickly. O'Brien told him that he thought that such a system could be built, but it was too big an effort for a university, and in fact that there were just three optical companies in the country that could do it: Eastman Kodak, Bausch and Lomb, and American Optical. Brian O'Brien Jr. tells what happened next.

Every other night for three weeks Mike would call my dad, usually after 10 pm; trying to persuade him to take the job personally (Mike's calls always came from his switchboard in New York even if Mike was in Belgrade or Los Angeles). Finally, he called one night and said "OK Doctor, I give up. I have been looking into the companies you mentioned and American Optical looks like the best bet. What do I do now?" "Fine," said my dad, "I am having lunch with Walter Stewart, President of AO (American Optical) next Tuesday. Why do you not come up to Southbridge and have lunch with us?" "I will be there," said Mike and hung up. The following Tuesday Mike showed up in Southbridge (AO headquarters). My dad introduced him to

Walter—Mike plunked a certified check for $60,000 down on Walter's desk and said, "Let's talk business." And that is how it all started (http://www.in70mm.com/index.htm).

The project was a success and the blockbuster production of *Oklahoma* was filmed using it. The entire faculty of the Institute of Optics, many of whom had consulted on the project, was invited to attend the grand opening with Todd and his wife, Elizabeth Taylor. Although the movie was a success, it did not really make good use of the new system. Close-up shots rather than the huge panoramas were now the fashion in movie making, so the capabilities of the new system were not appreciated and it was quickly dropped although there is still a very active group of aficionados who hold regular screenings of the old movies using the system.

In 1954 O'Brien was elected to the National Academy of Sciences and was active in the Physical Sciences Division of the National Research Council and its Undersea Warfare Committee. Shortly thereafter General Bernard Shriever, commander of the Air Force Systems Command, asked the Academy to set up a committee to advise the Systems Command on technical problems. This committee was later called the Air Force Studies Board and consisted of scientists and engineers from a wide variety of disciplines. In 1966 he chaired the Ad Hoc Committee to Review Project Blue Book. On the recommendation of this committee a university-based study, eventually directed by Edward U. Condon of the University of Colorado, was carried out to carefully analyze UFO sightings. Their findings led to publication of a book and the cessation of the Air Force Project Blue Book (Condon, 1969).

James Webb, then head of NASA, requested that O'Brien set up an Academy committee to advise NASA on future programs. This was to be called the Space Projects Advisory Council and had a similar composition as the Air Force Studies Board. This was early in the space program when orbiting objects were measured in "beer-can units": it cost roughly $1 million to put a can of beer (one pound mass) into Earth orbit. One of the council's recommendations was that NASA develop a reusable shuttle, capable of orbiting objects at a much lower cost. The result, of course, was the Space Shuttle.

After retiring from American Optical, O'Brien continued consulting for various branches of the military and NASA as well as commercial concerns. When consulting for the government he always refused any compensation, considering it a patriotic contribution. He continued this until shortly before his death.

This memoir is for the most part derived from *A Jewel in the Crown* (Stroud, 2004), a collection of essays written in honor of the 75th anniversary of the founding of the Institute of Optics at the University of Rochester. The essays were written by various authors who were participants in the events described. We have extensively excerpted from essays written by Hilda Kingslake, Brian O'Brien Jr., Walter Siegmund, and the author of the current memoir. The entire volume, which gives a much more detailed biography of Brian O'Brien, can be obtained directly from the Institute of Optics (*http://www.optics.rochester.edu*).

An archive of the Brian O'Brien papers and artifacts has been established: D.340 Brian O'Brien Papers. Department of Rare Books and Special Collections, River Campus Libraries, University of Rochester. Erwin Loewen has cataloged those papers and administers the archive.

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