■ SPECIAL ARTICLE

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Richard von Foregger, Ph.D., 1872–1960

Manufacturer of Anesthesia Equipment

Richard Foregger, M.D.

THIS article examines Richard von Foregger's contributions to the development of anesthesiology during the first half of the 20th century (fig. 1). Foregger participated in and contributed to numerous practical and scientific endeavors that have benefitted the development of anesthesiology in the United States and throughout the world.

In 1914, when Foregger[a] began to manufacture anesthetic equipment, four inhalation anesthetic agents were in common use: nitrous oxide, ether, chloroform, and ethyl chloride. Flowmeters indicated only a rough approximation of gas flow; the carbon dioxide absorption method was not yet employed in clinical practice; apparatus for vaporizing liquid anesthetic agents was crude and inexact, so that measurement of dosage was imprecise; the special instruments for the endotracheal technique were primitive in comparison to those of today; and mechanical ventilators were not yet developed for anesthetic practice.

By the time of his death in 1960, all this had changed. Many agents requiring precision flowmeters and vaporizers had been introduced. Apparatus for the carbon dioxide absorption method had been developed, along with numerous devices for laryngoscopy and varieties of endotracheal tubes, each requiring different and expensive molds in their manufacture. Advanced instruments for the vaporization of liquid anesthetic agents, capable of precise measurement, were available. Many devices to meet the needs of individual anesthesiologists were constructed, some of lasting use, some not. The upright stand anesthetic machine was largely replaced by today's cabinet/table models, and the metric system of measurement had been introduced into anesthesia practice. Richard von Foregger participated in this period of design and development from 1914 to 1960. Working closely with many anesthesiologists, he assisted in new designs and built many devices for anesthesia during his productive years (appendix 1).

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[a] The author was never employed by or affiliated with the Foregger Company.

Early Years

Richard von Foregger, chemist and manufacturer, was born in Vienna, Austria, June 27, 1872, the son of Richard and Elise von Etlinger. His father, trained as a lawyer, was a judge and later a senator in the Austrian Parliament. His mother was born and lived her early years in Odessa, then part of the Russian Empire. From her, he acquired some knowledge of the Russian language. He was fluent in French and English; German was his native language. He had an intense lifelong interest in oxygen, awakened, he said, when, as a boy, he trained in athletics by running through the Vienna woods near the family home in Grinzing, a suburb of Vienna.

After attending school in Vienna, he studied at the University of Munich, where he joined one of the student corps. He participated in fencing in the corps, and those who knew him will remember the large scar across the face and bridge of the nose, received in a dueling match from those student days.

When he finished at the University of Munich, he went to the University of Stuttgart and then to the University of Bern, where, in 1896, he obtained the degree of Doctor of Philosophy in chemistry.

After his studies in Bern, he went to Russia while working for a British company on the construction of the Trans-Siberian Railway.

In 1898, he came to America and served under the electrical engineer Karl Steinmetz (1865–1923) at the General Electric Co., in Schenectady, New York. In 1900, he was sent as a representative of the General Electric Co. to the International Universal Exposition in Paris. After the exposition closed down, he lived and worked in Berlin.

Development of the Oxygen Generator and Early Anesthetic Apparatus

Foregger returned to America in 1902 and worked for the Medical Dioxide Co., in New York, where he introduced a process for making peroxides of magnesium and zinc. His publications during 1905–1906, revealed his interest in the alkaline metal and alkaline earth metal peroxides that he soon came to employ for the generation of oxygen. At this time, he became a member of the American Electrochemical Society, the American Chemical Society, and the Society of Chemical Industry. In 1905, while employed by the Roessler and Hasslacher Chemical Co., in New York,[b] he began experiments to produce oxygen by the action of water on fused sodium peroxide, trademarked "oxone,"[c] which he demonstrated at a meeting of the Electrochemical Society, in Bethlehem, Pennsylvania, in September 1905.[1]

In the following year, 1906, at a meeting of the same society in Ithaca, New York, Foregger presented results

Fig. 1. Richard von Foregger, 1956.

of observations of a man sealed in a box with the oxygen generator for nearly 6 h. In other experiments, six rabbits were able to remain in the same box for 15 h before the carbon dioxide content began to increase. He and coworker George Brindley calculated that 18 kg sodium peroxide would supply nine men in a submarine for 14 h. The same paper was presented at the Sixth International Congress of Applied Chemistry, April 27, 1906, in Rome.[2,3,d]

At the latter meeting, Dr. Herbert Philip, of Perth Amboy, New Jersey, in a paper on fused sodium peroxide, said, "A very neat apparatus for the generation of oxygen gas from fused sodium peroxide has been devised by Dr. R. von Foregger." He described the oxygen generator in detail[4] (fig. 2).

In 1907, Foregger first met the well known anesthetist James Tayloe Gwathmey. In his memorial to Gwathmey, he described how he and Gwathmey, on more than one night at Madison Square Garden, administered oxygen from the generator to relay teams of 10-mile runners as well as 6-day bicycle

[b] The Roessler and Hasslacher Chemical Co., founded in 1882, manufactured speciality chemicals, with works at Perth Amboy, New Jersey, and a subsidiary, the Niagara Electrochemical Co., at Niagara Falls, New York. It was acquired by E. I. duPont & Co. in 1930. The Medical Dioxide Co. was located at 90 William Street and Roessler and Hasslacher Co. at 100 William Street, New York City, the heart of the chemical district at that time. For history, see Williams Haynes, Chemical Pioneers, 1939, pages 209–24, and Mechthild Wolf, Degussa, International History of Company Histories, 4:69–72, 1991.

[c] Oxone is the trademark of I. E. duPont de Nemours & Company. It is fused sodium peroxide and liberates oxygen when in contact with water. It is used as a source of oxygen. From the Handbook of Material Trade Names by Oswald T. Zimmerman and Irvin Lavine, 1953. Sodium peroxide was first made in this country by the Niagara Electrochemical Co., Niagara Falls, New York.

[d] For a survey on air regeneration by the alkali metal peroxides and superoxides, see R. Foregger, Bibliography on the Use of the Alkali Metal and Alkaline Earth Peroxides and Superoxides for the Control of Atmospheres in Closed Spaces, Toxicilogical and Environmental Chemistry (in press).

Fig. 2. Showing the airtight box in which a man was sealed for 6 h during experiments using fused sodium peroxide to generate oxygen and absorb carbon dioxide. Dr. Foregger in center. These experiments were conducted at the Niagara Electrochemical Co., a subsidiary of Roessler and Hasslacher Chemical Co. Bryant Library Archives, Roslyn, New York.

racers. As a result of their relationship, the oxygen generator was later modified to become an ether-oxygen outfit[5,e] (fig. 3).

In 1909, Foregger met Dr. William Anderson, a friend of Gwathmey and Director of Physical Education at Yale University.[f] In a report on the oxygen generator, which he had used for mountain climbing in Mexico, Anderson wrote, "Dr. R. von Foregger has invented a small oxygen generator. Foregger uses what he terms 'Oxone.' I carried the generator about my neck and breathed the gas almost constantly for three hours. It was like water to a thirsty man."[6]

In 1913, Foregger returned to the study of fused sodium peroxide for the purification of air, this time with Lt. (later Captain) Ernest W. Brown, MC, U.S. Navy.

Fig. 3. The Autogenor. The description reads, "An efficient, practical substitute for the oxygen tank. Generating pure oxygen from 'Oxone'-fused sodium peroxide. Furnished with single ether attachment. Capacity 85 liters oxygen." Foregger Co. catalog 1942.

[e] For life and complete biography, see Pittinger C: James Tayloe Gwathmey: Pioneer Anesthesiologist. Nashville, Vanderbilt University School of Medicine, 1989. Gwathmey (1863–1944) had been a member of an acrobatic team in a traveling circus and was later Director of the Gymnasium at Vanderbilt as a medical student. In addition to his many publications in anesthesiology, including his textbook *Anesthesia* (1914, 2nd edition 1924), he was the author of a book on gymnastics. For an informative account of the history of the Gwathmey apparatus, see Cope DK: James Tayloe Gwathmey: Seeds of a developing specialty. Anesth Analg 1993;76:642–647, and Cope DK: The international medical congress of 1912: World War I and the transatlantic triangle, History of Anesthesia. 3rd International Symposium, Park Ridge, Wood-Library Museum of Anesthesiology, 1992.

[f] Anderson founded the American Association for the Advancement of Physical Education. Like Gwathmey, he learned gymnastics from a traveling circus. Gwathmey said in his book, *Tumbling for Amateurs,* 1919, "I am also indebted to Dr. William Anderson of Yale University for many valuable suggestions." For biography, see National Cyclopaedia of American Biography 1950; 36:325–6.

Ten respiratory apparatuses were tested, and experiments were carried out in a sealed room at Harvard University Medical School.[g]

A later model of oxygen generator with increased capacity and increased pressure, patented by Foregger in 1908, was named the Autogenor. The Autogenor, including attachments for delivery of ether vapor, was manufactured while he was an employee at Roessler and Hasslacher. The firm was a manufacturer of specialty chemicals, and thus manufacture and sale of anesthetic apparatuses was outside their interests.

In 1914, Foregger left Roessler and Hasslacher to set up a workshop in a barn at Roslyn, Long Island, New York, for the manufacture of the oxygen generator and anesthetic equipment with funds supplied by my mother, Dorothy Ledwith.[h] The Foregger Company was incorporated on May 26, 1914. The Gwathmey apparatus was built there for many years, commencing in 1914[i] (fig. 4). This apparatus was constructed without reducing valves but with control valves for oxygen and nitrous oxide. Each gas was led into a tube calibrated with a succession of openings, which allowed the gas to bubble separately through water into a glass mixing chamber so that the anesthetist could visually regulate the flow.

The sight-feed method had been introduced by Walter M. Boothby (1888–1953) and Frederick Cotton (1869–1938)[7,8] and later used in the Gwathmey-Woolsey gas machine.[9,j]

How the Gwathmey Apparatus Became the Prototype for the Boyle Apparatus

When Gwathmey attended the 17th International Medical Congress in London in August 1913, he demonstrated the Gwathmey apparatus during the symposium on anesthesia at which the London anesthetist Henry E. G. Boyle was present.[10] Boyle (1875–1941) was impressed and arranged to have two Foregger-Gwathmey apparatuses imported from New York, one a portable, the other a hospital model.[11] In 1917, at a meeting before the Medical Society of London, Boyle said, "The machine which I use is Gwathmey's. . ."[12] In a report to the St. Bartholomew's Hospital staff, Boyle recorded that "soon after this it became apparent that there was a need for a machine with which English cylinders could be used, and so at the suggestion of Messrs Coxeter & Son, and with their assistance, I devised the machine now known as 'Boyle's Nitrous Oxide Oxygen Ether Outfit.'"[11]

The Gwathmey apparatus undoubtedly influenced the design of the Boyle machine, as Boyle stated. Various authorities in anesthesia equipment design concur. Thompson and Wilkinson stated, "Boyle had described his apparatus which was purely an English modification of Gwathmey's."[13] Rendell-Baker said, "This apparatus is important because it was the prototype for the British Boyle machine."[14] The Synopsis of Anaesthesia stated, "The original Boyle machine was an adaptation of the American Gwathmey apparatus," and "Boyle in 1917 got Coxeter, the instrument maker, to copy James Tayloe Gwathmey's gas-oxygen machine which became the first Boyle apparatus."[15]

Professor Dennis Jackson (1878–1980) reported that, at the Detroit AMA Convention in June 1916, he was assigned exhibit space not far from where Foregger was showing the oxygen generator. Jackson called it the "oxydonor" and described it as "looking like a rather tall nickel-plated, old fashioned coffee pot" containing sodium peroxide, which generated pure oxygen when water was added. Jackson said, "This was a splendid

[g] The oxone, fused sodium peroxide, experiments comprise a nine-page section and 17 charts of a report by Lt. Ernest William Brown, "Final Report of the Board on Investigations and Experiments on the Air Supply in Submarines: Regeneration and Purification of Air in Submarines, Bureau of Construction and Repair, U.S. Navy, Washington, D.C., March 1914, no. 14512-A-43, no. 108. (National Archives, Record Group 19, Bureau of Construction and Repair, general correspondence, 1912–1925, box no. 815.) According to Roman R. Miller and V. R. Piatt, in the Present Status of Chemical Research in Atmosphere Purification and Control on Nuclear-powered Submarines (Washington, D.C., U.S. Naval Research Laboratory, 1960, NRL report 5465, page 1), this work was the first detailed research on air purification in submarines for the U.S. Navy. For obituary on Ernest William Brown, M.D. (1878–1960), see JAMA 1962; 176: 740.

[h] Dorothy Ledwith Foregger (1891–1981) was educated at the Academy of the Sacred Heart, New York City, and married my father in 1911. They were divorced in 1927.

[i] According to Thomas Keys, in *History of Surgical Anesthesia,* New York, Schuman, 1945, page 85, the original Gwathmey-Woolsey apparatus was made by Joseph Langsdorff in 1912. Foregger did not commence to make the apparatus until 1914. Langsdorff, Jersey City, New Jersey, and Louis Krug, Windfield, Queens, New York, received U.S. Patent no. 1,068,909 on July 29, 1913, for the oxygen control valve used on the machine.

[j] William Caven Woolsey (1875–1919) was a member of the original Long Island Society of Anesthesists (1905–1911) and the first Secretary of the American Association of Anesthetists, elected in 1912. For obituary see JAMA 1919; 73:127. For further details, see *The New York Times,* June 25, 1919, page 19, and June 26, 1919, page 9.

idea but it shows the status of oxygen supplies and anesthesia in 1916." Foregger, he says, was much impressed with Jackson's anesthesia apparatus, which was equipped with a device for absorbing carbon dioxide.[16,k]

Active Years in the Development of Anesthetic Apparatus

In 1923, Dr. Ralph Waters (1883–1979), then in private practice in Sioux City, Iowa, introduced the closed system of carbon dioxide absorption into clinical practice.[17,l] He gave the design of the to-and-fro filter to Foregger with a request to construct the device, which, at first, was used with the Gwathmey apparatus. However, the closed absorption system required an oxygen delivery of fine adjustment, for which there had to be an improvement in the rather coarse sight-feed method of measurement. Also, in 1923, the introduction of ethylene as an anesthetic agent led to the need for more accurate methods of delivery. To improve the sight-feed flowmeter, Foregger, in 1924, designed and developed a flowmeter based on the principle of depression of a column of water (figs. 5 and 6). In his paper describing the method, delivered at the 6th Annual Congress of Anesthetists, in 1927, he was frank to say that there was nothing new in this principle but that its practical application for anesthetic gases and the form in which it was done was novel.[18,m] Flowmeters were made during this period for acetylene and propylene. Professor Yandell Henderson (1873–1944), at Yale University, and Dr. Howard Haggard (1891–1959) helped to develop a method of calibrating the flowmeter.

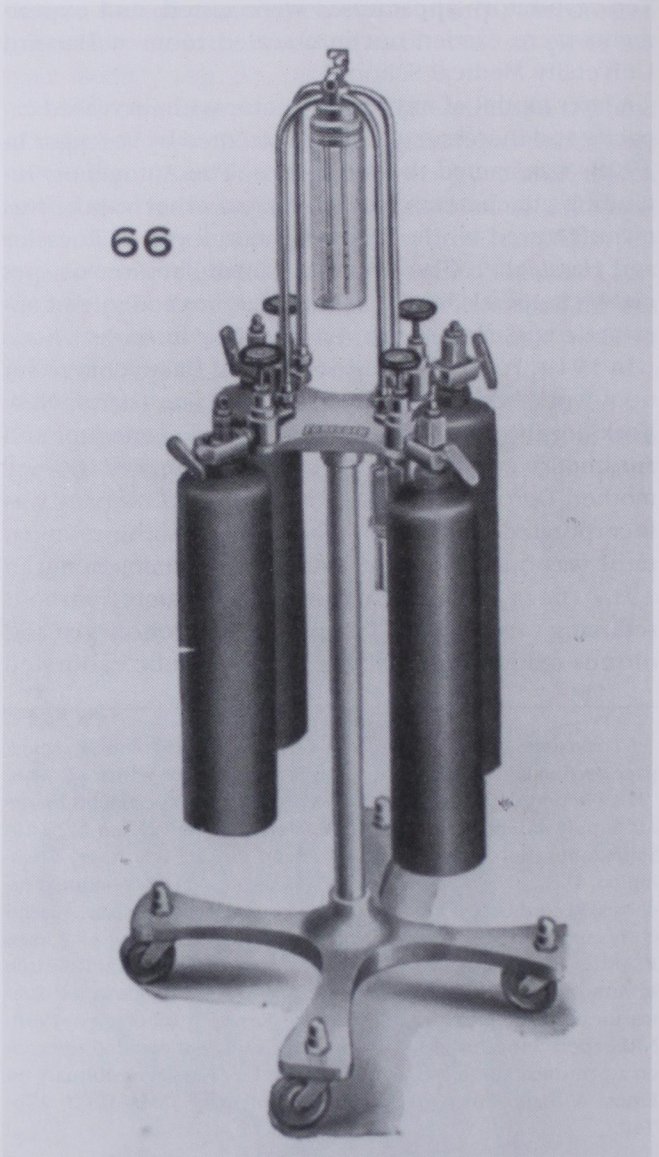

Fig. 4. Gwathmey apparatus. This was the standard hospital unit for nitrous oxide, oxygen, and ether with two sight-feed tubes. Foregger Co. catalog 1926.

Strange as it may seem to the current generation of anesthesiologists, the metric system of measurement was not widely used in medicine or in engineering at that period of time. The traditional apothecary or troy system was used for weight and gallons per minute for gases, although there was some use of the metric system. Foregger was, however, a vigorous proponent of the metric system. He carried out a continuing educational effort through correspondence, the biennial catalog of the company, and advertisements. His work

[k] Jackson's work in the development of apparatus for carbon dioxide absorption during anesthesia is reviewed by John Stetson in Dennis Emerson Jackson (1878–1980), pages 564–71, and by Leslie Rendell-Baker, Development and Function of Anaesthesia Breathing Systems, pages 301–19, History of Anaesthesia. Edited by Atkinson RS, Boulton TB. Park Ridge, Parthenon Publishing Group, 1987. The 1916 meeting of the American Medical Association, held in Detroit, was the first time the Foregger Co. is listed as an exhibitor.

[l] According to Noel Gillespie (Ralph Milton Waters: A brief biography. Br J Anaesth 1949; 21:197–214), Waters was aware of the researches of Brindley and Foregger on the use of sodium peroxide for purification of the atmosphere of submarines when he became interested in carbon dioxide absorption during anesthesia.

[m] Also see Richard Foregger, U.S. Patent 1,778,716, October 21, 1930, with specifications showing flowmeters with metric scale.

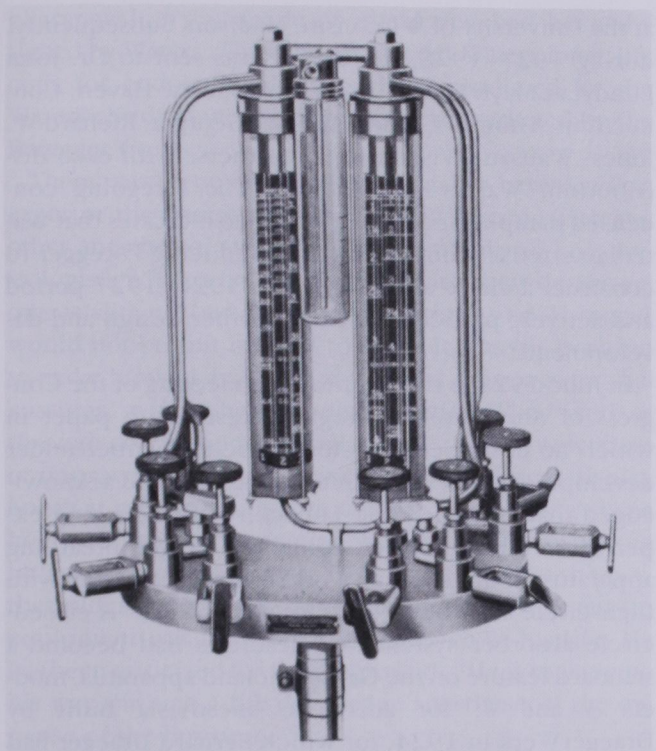

Fig. 5. Head of early metric gas machine showing water depression flowmeter with metric system scale for measurement of flow rates. This early model also had a Gwathmey sight-feed attached to make the gas flow doubly visible. Foregger Co. catalog 1926.

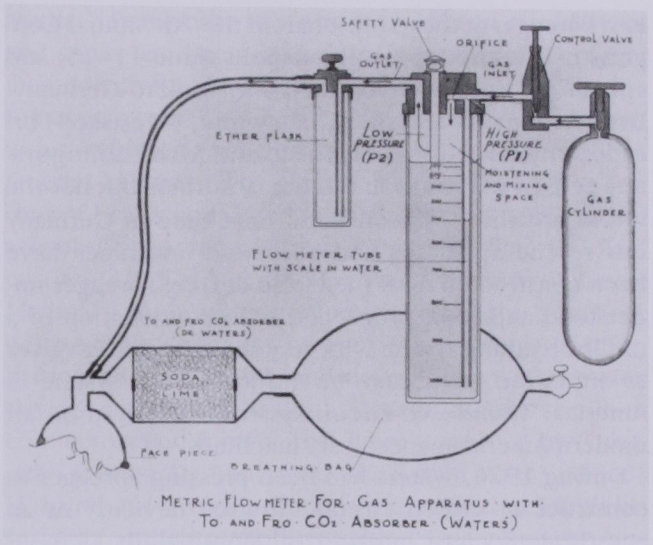

Fig. 6. Diagram of flowmeter for gas apparatus with metric scale. Foregger Co. catalog 1942.

to apply the metric system of measurement for use on anesthetic apparatus was a genuine pioneering effort and may have been his major achievement.[n]

How Foregger Came to Make the Circle Absorber

In early 1927, he designed and constructed a carbon dioxide absorber with unidirectional valves to be used in a closed respiratory circuit on an anesthetic apparatus, for which he was later granted a U.S. patent[19–21] (fig. 7).

When Helmut Schmidt (1895–1979) and Hans Killian (1892–1982) came to America in 1928, they vis-

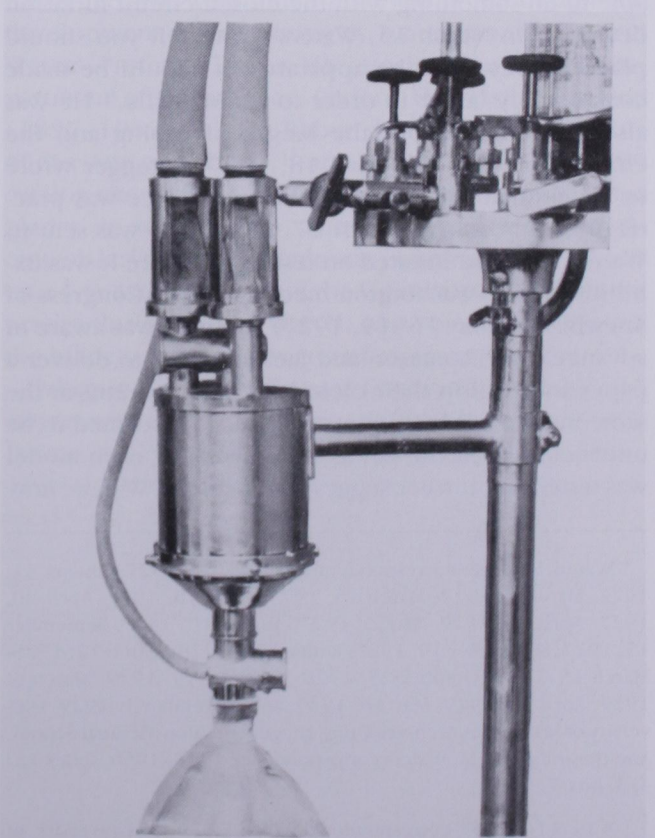

Fig. 7. Early circle respiration carbon dioxide absorber. Foregger Co. catalog 1929. ANESTHESIOLOGY 1946; 7:550.

[n] Not until 1947 did the U.S. Pharmacopoeia, in its 13th revision, discontinue the apothecaries' and avoirdupois systems in favor of the metric system. It did not go unnoticed by Foregger. It was not until 1973 that JAMA and the AMA specialty journals began to publish weights and measures solely in the metric system.

ited Foregger at the exhibit hall of the 7th Annual Congress of Anesthetists in Minneapolis, June 11–15, and at his New York office on their way back to Germany. In reporting on the visit, Killian wrote, "We asked Foregger why in America only the to-and-fro breathing system is used with carbon dioxide absorbers but not the circle breathing system. For a long time in Germany our rescue apparatus and anesthesia machines have been constructed with the circle device. Foregger understood and soon proceeded with construction of a circle breathing system with very sensitive flutter valves to direct the gas stream; he introduced the system in America. The closed-circuit system is featured on all modern American anesthesia machines."[22]

During 1926, Waters had been pressing Foregger to construct a "closed circuit filtration device." At an anesthesia society meeting in Montreal in October 1926, Foregger had taken occasion to carefully study for the second time several metabolism apparatuses on exhibit with flutter valves. On January 31, 1927, Waters wrote again stating, "I shall be very glad when you are able to do something with the closed circuit filtration device." On March 15, Waters wrote, "If you should place the filter on the apparatus, it should be made considerably larger in order to avoid refills." He was also concerned about the length of tubing and the chance for leaks. On April 18, 1927, Foregger wrote to Waters that the new closed-circle device was practically ready, and on April 27, the device was sent to Waters who had insisted on testing it before it was exhibited at the Washington meeting of the Congress of Anesthesists, May 16–19, 1927. Foregger was aware in advance that Thomason and Jackson were to deliver a paper and exhibit their closed-circuit apparatus at the same meeting.[23] In a letter to Waters, he seemed to be unconcerned. As the device was modified, each model was tested and further suggestions made by Waters, now at the University of Wisconsin, Madison. Subsequently, during 1927–1928, the device was sent to Dr. John Lundy, at Mayo Clinic; Brian Sword, New Haven, Connecticut; Thomas Collier; Atlanta, Georgia; Richard W. Jones, Wausau, Wisconsin; and others. With each distribution, Waters was notified. The foregoing condensed paraphrased correspondence indicates that Waters exerted a prominent role in inducing Foregger to construct a circle absorber in the 1926–1927 period and actively participated in its further design and development.[o]

In June 1928 at the Minneapolis meeting of the Congress of Anesthetists, Foregger presented a paper in which he described the closed-circle absorber under development in several different designs and acknowledged that DraegerWerk, Lubeck, with their long experience in building self-contained oxygen breathing apparatus for mine rescue work, had preceded him with their circle absorber system for anesthesia.[24] A closed-circle absorber system for anesthesia had become a standard feature on the Gauss-Wieland apparatus, models 3 and 4, for acetylene anesthesia built by DraegerWerk in 1924, for which Bernard Draeger had been granted a German patent in 1927.[25,26] In the aforementioned paper,[24] presented in June 1928, at the Minneapolis meeting of the Congress of Anesthetists, Foregger considered the method to be in its early experimental stage. By the time of the Congress in October 1929, Dr. Brian Sword was able to report on the use of the closed-circle carbon dioxide absorption apparatus in about 1,200 cases.[27]

Helmut Schmidt, who accompanied Killian on the trip to America and attended the Congress of Anesthetists meeting at Minneapolis in June 1928, reported that, "as a forthcoming method, gas anesthesia with to-and-fro or circle breathing and CO_2 filtration were exhibited. A neat little inexpensive apparatus for nitrous oxide with circle breathing similar to the Draeger portable apparatus was shown."[28]

When Schmidt returned to Germany, he brought one of these Guedel-Foregger Midgets with him.[p]

The development of the closed system of carbon dioxide absorption required a close working relationship between Waters and Foregger which lasted for many years. The advent of cyclopropane required continued and more exacting flowmeter precision. Other devices were improved, including the change from the base and upright stand models to the current combined anesthesia table and apparatus. Foregger also manufactured and distributed an anatomically improved oro-

[o] Waters-Foregger correspondence: January 27, 1927; January 31, 1927; March 8, 1927; March 15, 1927; April 18, 1927; April 20, 1927; April 25, 1927; May 2, 1927; August 10, 1927; September 15, 1927; September 19, 1927; January 26, 1928; March 12, 1928; March 15, 1928; October 25, 1928; February 19, 1929; March 6, 1929; April 30, 1929; May 16, 1929; and November 1, 1929. University of Wisconsin Archives Division, general files, Medical School, Anesthesiology, R. M. Waters correspondence 1928–1950, series 12/4/3, box 7.

[p] Waters-Foregger correspondence: July 9, 1928. University of Wisconsin Archives Division, general files, Medical School, Anesthesiology, R. M. Waters correspondence 1928–1950, series 12/4/3, box 7.

pharyngeal airway made of metal that had been designed by Waters. The original Guedel-Waters inflatable cuffs for endotracheal tubes, hand-produced by the Waters children in earlier years, were marketed by the Foregger Co.[29]

There was no commercial relationship between Foregger or the Foregger Co. and Dr. Waters or with any other anesthesiologists, as far as I am aware. Anesthesiologists who came to my father with their design requests did not ask for compensation, and Foregger would not permit himself to offer. It was his position to make himself available at medical meetings for discussions, which he thoroughly enjoyed, as well as through correspondence. He would discuss new ideas or improvements in equipment at the Foregger display booth at medical conventions or in the evening at the hotel. He was very exacting and punctual, answering letters within a few days. His relationship with anesthesiologists interested in design and improvements in equipment was the overriding essence of his life. He has been criticized for this; some said, "He is romancing his way through a life devoted to anesthesia at the expense of the business."[q]

Saturday mornings in a group meeting at the factory, all the ideas gathered at medical meetings or accumulated during the week's correspondence were discussed at length by those responsible for equipment development.

Other Working Relationships

During the 1940s, Foregger worked with Dr. John Adriani (1907–1988) to improve the design of carbon dioxide absorbers. Dr. Arthur Guedel (1883–1956) of Santa Barbara, California, working with cadavers, designed and constructed a series of different-sized oropharyngeal airways made of rubber, later of plastic, intended for use in the smallest infants to the largest adults.[30] Previous to this, airways had been cast of metal and some had been anatomically incorrect. Foregger manufactured and marketed these nontraumatic airways for many years. This may be an exception to my previous statement concerning financial relationships. Guedel had ceased to practice anesthesiology for reasons of health and relied in part upon income from the sale of the pharyngeal airways. Professor Emery A. Rovenstine (1895–1960) at New York University-Bellevue Medical Center, was a frequent visitor to the New York office of the Foregger Company for exchange of information on new designs and development. Rovenstine devised an endotracheal tube set-up, angular slip-joint connectors and forceps that were produced by Foregger. Likewise Dr. Vincent Collins, then at St. Vincent's Hospital, New York, often visited, sometimes with his resident students. Collins said, "The company was ready to make and supply new instruments and anesthesia accessories, and the tooling skill of the company has been appreciated by inventive anesthesiologists for many years."[20]

Foregger was very much involved in the design and development of laryngoscopes, working with Guedel,[r] Waters, Professor Robert Macintosh, of the Nuffield Department of Anesthetics, Oxford University, England (1897–1989).[31,32] Dr. Robert A. Miller (1906–1976) of San Antonio, Texas,[33] and many others. The 1959 catalog shows some 20 different shaped laryngoscope blades, in several sizes. The development of the Macintosh laryngoscope blade was completed while I was on a 1-yr assignment from the U.S. Army at Oxford University during World War II, and Macintosh gave me the blade to ensure it was sent to America safely.

Others with whom Foregger worked to design and improve anesthetic equipment included Dr. Wesley Bourne (1886–1965) and Dr. Harold Griffith (1896–1985), for both of whom he developed the Montreal Model gas machine. Dr. Paluel Flagg (1886–1970) lived and practiced in the New York City area, and my father produced more than 15 devices for anesthesia and resuscitation designed by Flagg, including the Flagg laryngoscope, Flagg infant resuscitator, the Flagg inhaler for administration of anesthesia, and a tube insufflator to put oxygen directly into the lungs of a patient. Many of these are illustrated in Flagg's books, *The Art of Anaesthesia* and *The Art of Resuscitation*.

At the request of Dr. Gilbert Troup (1896–1962), Perth, Western Australia, who had made an anesthetic study tour of North American in 1935, Foregger designed and constructed a small portable gas machine

[q] Personal communication from Reginald Bates, Vice President, J. Sklar Manufacturing Company, Long Island City, New York, 1956.

[r] The Guedel Blade Laryngoscope was the standard issued to the U.S. Armed Forces Medical Corps during the Second World War. The large orders received for their Military Endotracheal Set kept the Foregger Company factory employed at full capacity during the war years. U.S. Patent no. 2,289,226 for the Guedel laryngoscope was issued to Richard von Foregger on July 7, 1942. The U.S. Patent for the Macintosh laryngoscope was held by R. R. Macintosh, of Oxford, and assigned to the Foregger Co. Macintosh refused any remuneration for the patent.

dubbed the "Australian Midget." Likewise, a similar portable apparatus with slightly different specifications, the "Chilean Midget," was designed and constructed for Dr. Ernesto Frias (1908–1977), of Santiago, Chile, who also had come on an extended visit to the United States in 1938. Subsequently, anesthesiologists in Chile, Argentina, Mexico, and Brazil found the portable Chilean Midget to be helpful in an itinerant type of practice. The original midget gas machine was built at the request of Dr. Arthur Guedel.

Besides anesthetic gas machines, carbon dioxide absorbers, equipment for oxygen therapy, and resuscitation, Foregger manufactured an entire series of accessories; pharyngeal airways in various sizes, endotracheal tubes, forceps, connectors, adapters, slip joints, pediatric nonrebreathing valves, and laryngoscope blades in several sizes and in numerous varieties.[s] The 1959 catalog, the last published by him before his death in 1960, consists of 167 pages, each page containing illustrations and descriptions of several devices.

The liquid anesthetic vaporizer invented by Dr. Lucien Morris in 1952, then at the University of Wisconsin, and manufactured by the Foregger Company as the Copper Kettle, was one of the last major appliances my father assisted in developing.[34]

Final Years

In the summer of 1940, Dr. Clayton Wangeman (1909–1975), resident anesthesiologist at the University of Wisconsin and Major in the US Army Medical Corps Reserve, reported to the Department of Anesthesiology that, while on recent Second U.S. Army maneuvers, a Foregger Military Model anesthetic apparatus that he had been using had tipped over and could not be used because of the resulting malfunction of the water flowmeter. The report was also sent through Army channels.

Largely as a result of this report, Foregger sold very few machines to the U. S. Armed Forces and none in the European theater of operations that I was aware of. All suggestions to change to a dry flowmeter were resisted by him. In England the rotameter, a variable area type flowmeter, accurate, durable, free from the need for repairs, and capable of indicating small changes in flow rates, had been in use since 1937.In Germany, they had been used in 1910, and again in 1923 when DraegerWerk had employed the rotameter in the Gauss-Wieland acetylene apparatus.[35,t]

After the Wangeman report, through correspondence to Foregger and in a paper at the 1941 annual session of the American Medical Association, Waters suggested that the rotameter should be studied.[36] In 1946, the advantages were pointed out, and a further recommendation was made in the U.S. anesthetic literature to change to the rotameter.[37] There was continued resistance by Foregger for several more years. In response to demands by an increasing number of anesthesiologists, in 1950, 10 years after Wangeman had made his report, the rotameter was placed on the American market.

Dr. James Elam had established an anesthesia research center devoted to equipment design and testing at Roswell Park Memorial Institute, Buffalo. Elam and Dr. Elwyn Brown, chemical engineer and anesthesiologist, were the designers and proponents of the large capacity canisters for carbon dioxide absorption. In his published studies, Brown found that all the canisters made by Foregger were inadequate in size.[38] Several other manufacturers had already increased canister capacity and efficiency based on features of design proposed by Elam.[39] In the 1950s, after success with the innovation of the large canister, Elam was anxious to develop a mechanical ventilator to be combined with an anesthetic machine, but when he approached Foregger the suggestion was rebuffed.

The delay in the manufacture of the rotameter, delay in marketing a large capacity carbon dioxide absorber, and failure to develop a respirator cost Foregger and the company the loss of competitive leadership.

Tragic Ending

The last 14 yr of his life were surrounded by turmoil of his own making, not being able to deal with and

[s] According to the testimony of Burton A. Dole, Jr., President of Puritan-Bennett Corp., Foregger anesthesia machines represented 15% of anesthesia machines in U.S. hospitals. See Anesthesia Machines Failures: Hearings before the Subcommittee on Oversight and Investigations, Committee on Energy and Commerce, House of Representatives, 98th Congress, 2nd session, September 24, 1984, serial no. 98–188, U.S. G.P.O. 1985, p. 264. See page 95. However, with a 60–75% share of the market, Foregger always exceeded all other firms in accessories.

[t] For a detailed history of the rotameter in anesthesia, see H. Kronschwitz, 50 Jahr Rotameter für Narkoseapparate, Der Anesthesist 1961; 10:97–9, with correspondence by R. R. Macintosh 1961; 10: 213, and H. Kronschwitz 1961; 10:214. E. A. Pask, in Modified Flowmeters for Anaesthetic Gases, Lancet 1940;2:680–681, summarizes the disadvantages of wet flowmeters.

control his private life. This interfered with his business life and no doubt had a devastating effect on him.

I was notified in 1958 by several attending physicians, including a board-certified psychiatrist, of my father's deteriorating mental condition. There was a diagnosis of paranoid psychosis. A visit and examination confirmed the foregoing. I reported to my father's long-time attorneys, and I commenced a competency hearing that was bitterly contested by my father's third wife in a widely publicized trial reported in the Long Island newspapers.[u] A jury of 12 declared my father incompetent. A very capable Long Island attorney was appointed by the Court to supervise the management of the Company.

My father died at the age of 87 on January 18, 1960. At autopsy there was cerebral arteriosclerosis, extensive cystic degeneration of the brain and congestive heart failure.

In the ensuing years, the Foregger Co. was acquired by a series of companies, but the loss of the founder's knowledge, along with long-standing, valued employees, had destroyed institutional memory. In time the Foregger Company disappeared (Appendix 2).

References

1. von Foregger R: Utilization of active oxygen electrically and chemically produced. Trans Am Electrochem Soc 1905; 8:141–60

2. Brindley GF, von Foregger R: Report on experiments with fused sodium peroxide on the regeneration of air for submarines. Trans Am Electrochem Soc 1906; 9:291–304

3. Brindley GF, von Foregger R: Report on experiments with fused sodium peroxide for the regeneration of air in submarine boats. Atti d VI Congr Int Chim Appl 1907; 1:737–47

4. Philipp H: Fused sodium peroxide. Atti d VI Congr Int Chim Appl 1907; 1:734–37

5. Foregger R: Gwathmey. ANESTHESIOLOGY 1944; 5:296–99

6. Anderson WG: Use of oxygen in mountain climbing. Am Phys Educ Rev 1909; 14:277–87

7. Boothby WM: Nitrous oxide-oxygen anesthesia, with a description of a new apparatus. Boston Med Surg J 1912; 166:86–90

8. Cotten FJ, Boothby WM: Nitrous-oxide-oxygen-ether anaesthesia: Notes on administration. A perfected apparatus. Surg Gynecol Obstet 1912; 15:281–9

9. Gwathmey JT, Woolsey WC: The Gwathmey-Woolsey nitrous oxide-oxygen apparatus. N Y Med J 1912; 96:943–6

10. Anaesthesia, general and local, Seventeenth International Medical Congress, Proceedings of Sections. Br Med J 1913; 2:478

11. Boyle HEG: Recent developments in gas and local anaesthesia. St Bartholomew's Hosp J 1919; 28:22–3

12. Boyle HEG: The use of nitrous oxide and oxygen with rebreathing in military surgery. Lancet 1917; 2:667–9

13. Thompson PW, Wilkinson DJ: Development of anaesthetic machines. Br J Anaesth 1985; 57:640–8

14. Rendell-Baker L: Development and function of anaesthesia breathing machines, The History of Anaesthesia. Edited by Atkinson RS, Bowlton TB. Park Ridge, Parthenon, 1987, pp 301–19

15. Atkinson RS, Rushman GB, Lee JA: Synopsis of Anaesthesia. 10th edition. Bristol, Wright, 1987, 18, 145

16. Jackson DE: Anesthesia equipment from 1914 to 1954 and experiments leading to its development. ANESTHESIOLOGY 1955; 16: 953–69

17. Waters RM: Clinical scope and utility of carbon dioxide filtration in inhalation anesthesia. Curr Res Anesth Analg 1924; 3:20–2

18. Foregger RV: Percentages and true flow of gases for gas-oxygen anesthesia. Anesth Analg 1927; 6:225–34

19. Richard von Foregger, The National Cyclopedia of American Biography. Clifton, James T. White, 1965; 48:406

20. Collins V: Principles of Anesthesiology. 2nd edition. New York, Lea & Febiger, 1976, p 15

21. Betcher AM: Anesthesiology in New York. N Y State J Med 1976; 76:1165–70

22. Killian H: Das Abenteuer der Narkose: Erfahrungen und Erlebnisse aus 40 Jahren Narkoseforschung. Tübingen, Grabert, 1966, p 71

23. Thomason H, Jackson DE: Carbon dioxide filtration method for general analgesia and anesthesia. Curr Res Anesth Analg 1927; 6: 181–3

24. Foregger R: The position of the breathing bag. Curr Res Anesth Analg 1929; 8:34–9

25. Gauss CJ: Die Narcylenbetäubung mit dem Kreisatmer. Zentralbl f Gynakol 1925; 49:1218–26

26. Dräger-Apparat zur Sauerstoff-Narcylen-Betäubung nach Prof. Gauss/Prof. Wieland. Draeger-Hefte 1926; 112:1163–4

27. Sword BC: The closed-circle method of administration of gas anesthesia. Curr Res Anesth Analg 1930; 9:198–202

28. Schmidt H: Die Gasnarkose vom Standpunkt des Amerikanischen Narkosespezialisten. Narkose Anaesth 1928; 1:530–40

29. Guedel AE, Waters RM: A new intratracheal catheter. Curr Res Anesth Analg 1928; 7:238–9

30. Guedel AE: A nontraumatic pharyngeal airway. JAMA 1933; 100:1862

31. Macintosh RR: A new laryngoscope. Lancet 1943; 1:205

32. Jephcott A: The Macintosh laryngoscope. Anaesthesia 1984; 39:474–9

33. Miller RA: The development of the laryngoscope. Anaesthesist 1972; 21:145–7

34. Morris LE: A new vaporizer for liquid anesthetic agents. ANESTHESIOLOGY 1952; 13:587–93

35. Gauss CJ, Wieland H: Ein neues betäubungsverfahren. Klin Wchnschr 1923; 2:113–7, 158–62

36. Waters RM: Chemical absorption of carbon dioxide from anesthetic atmospheres. ANESTHESIOLOGY 1943; 4:596–607

37. Foregger R: Rotameter in anesthesia. ANESTHESIOLOGY 1946; 7:549–57

38. Brown ES: Voids, pores and total air space of carbon dioxide absorbents. ANESTHESIOLOGY 1958; 19:1–6

[u] In 1946, my father married his housekeeper, Mrs. Lillie Mae Holt (1900–1990). Supreme Court, Nassau County, Mineola, New York, Matter of the appointment of a Committee for Richard von Foregger (Incomp). Index no 3861/59, entered April 16, 1959, trial held September 10–23, 1959. Complete newspaper reports of the trial are on file at Wood Library-Museum of Anesthesiology, Park Ridge, Illinois.

39. Elam JO: The design of circle absorbers. ANESTHESIOLOGY 1958; 19:99–100

Appendix I

List of Major Advances Brought to Market by Foregger Company[v]

1. Oxone Generator and Autogenor: Two portable devices employing sodium peroxide to generate oxygen. 1906 and 1908. These devices were manufactured by Roessler and Hasslacher Chemical Co. from 1906 to 1914 and for many years by the Foregger Co. after 1914. The patents were held by Foregger.

2. Gwathmey Apparatus: 1914—Patent held by Foregger.

3. Construction of portable Seattle model anesthetic apparatus for nitrous oxide, ethylene, carbon dioxide, oxygen, and an ether bottle, at the request of Dr. John Lundy. 1923–.

4. Waters to-and-fro carbon dioxide absorber 1923–.

5. The Metric Gas Machine 1923 with flowmeters for nitrous oxide, oxygen, carbon dioxide, ethylene, propylene, individually calibrated with metric scale; later available for helium, cyclopropane. Patent held by Foregger.—

6. Circle breathing system with carbon dioxide absorber 1927/28. Patent held by Foregger.

7. Waters-Wisconsin metal pharyngeal airway, 1931/33–.

8. Guedel rubber/plastic pharyngeal airway 1933. Note: Foregger Co. had made pharyngeal airways since 1916, notably the Lombard and the Miller modification, Connell, Poe, Buettner, Flagg, and Branower.

9. Midget gas machine, Guedel 1928–.

10. Guedel, Flagg, Anesthesist's Laryngosopes 1935–. Manufactured by Welch-Allyn, marketed by Foregger.

11. Magill and other endotracheal tubes began to appear in the catalog at this time along with the laryngoscopes, 1935–.

12. Table model gas machines 1931–.

13. Foregger laryngoscope patent, assigned to Welch-Allyn, 1941–.

14. Foregger starts to manufacture laryngoscopes, 1941—Patent for folding detachable blade held by Foregger.

15. Foregger starts manufacture of Macintosh laryngoscope followed by about 16 other models, 1943—Total 20 models. U.S. patent for Macintosh laryngoscope held by Macintosh.

16. Manufacture and sale of complete apparatus models, carbon dioxide absorbers, accessories, endotracheal equipment, oxygen and resuscitation equipment, increased extensively during and after World War II.

17. Rotameter 1950–.

18. Copper Kettle Vaporizer 1952—Patent held by L. Morris.–

19. Enlarged capacity carbon dioxide absorber, 1959–.

[v] From List of Exhibitors, Technical Exposition, JAMA, 1916–1960; Foregger Co. catalogs.

Appendix 2

Chronology of Foregger Company

1. Foregger Co. incorporated May 26, 1914 Source: State of New York, Department of State, Division of Corporations.

2. Foregger, founder of the Company, died on January 18, 1960, but the Company probably had been run with an absent or diminished presence since 1958.

3. Purchased by Hillman Coal and Coke, a division of Hillman Corp., Pittsburgh, Pennsylvania, venture capitalists, on January 3, 1968. Source: *Surgical Business,* page 86, February 1968. At this time, the Foregger Co. was merged with the medical product line of Melchior, Armstrong, Dessau Company, in Ridgefield, New Jersey. George Lake became President of the merged entities, named the Foregger Co., which was moved to Smithtown, Long Island, New York, on February 8–13, 1968. Source: *Roslyn News,* February 15, 1968.

4. The merged companies, named the Foregger Co. were purchased by Air Products and Chemicals on December 1969. Source: *Moody's Industrials* 1970, page 455; also in *Chemical Week* 106: page 16, January 14, 1970.

5. The Foregger Division of Air Products and Chemicals was purchased by Puritan-Bennett Corp. in October 1978. Source: *Moody's Industrials,* page 11, 1979. Also in *Moody's OTC,* page 1209, 1979. Puritan-Bennett in *Moody's OTC* says the date of acquisition was November 1, 1978.

6. After a series of patient deaths and lawsuits, the Foregger Division of Puritan-Bennett was dissolved in May 1984. Source: *Anesthesia Machine Failures:* Hearing before the Subcommittee on Oversight and Investigations of the Committee on Energy and Commerce, House of Representatives, 98th Congress, 2nd session, September 26, 1984. Serial no. 98–188, Washington: U.S. G.P.O., 1985, page 264. See pages 94, 104–105.

According to the State of New York, Department of State, Division of Corporations, the Foregger corporation was legally dissolved on March 2, 1987.