A Tribute To John H Emerson

Jack Emerson: Notes on His Life and Contributions to Respiratory Care

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If you have had the pleasure of attending the annual meeting anytime in the last couple of decades, you undoubtedly caught a glimpse of a tall, aristocratic figure hovering around the Emerson booth. That distinctive, New England, Ichabod Crane-like frame belonged to John Haven Emerson (Fig. 1). Better known as “Jack,” Emerson was a pioneer in biomedical device development, with a particular emphasis on respiratory equipment. His death in February 1997 at the age of 91 brought to close a remarkable, storied, yet surprisingly quiet career in ingenious innovation.

Emerson was born February 5, 1906, in New York City to a scholarly family. He was educated in private schools. As a youngster he attended the Ethical Culture School and graduated despite lacking a few of the required studies. His son George remembers that Jack would often quip, “I never graduated from high school.” Attending an Ivy League school was a tradition for Emerson children. Jack’s father, Haven Emerson, was a Professor of Public Health at Columbia University in New York. In fact, I came across a manuscript by Haven Emerson, regarding artificial respiration for resuscitation.* Apparently the apple did not fall far from the tree. Jack, however, was not interested in a higher education and preferred to tinker and attempt to solve problems with the materials ready at hand.

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*Emerson HA. Artificial respiration in the treatment of edema of the lungs: a suggestion based on animal experimentation. Arch Intern Med 1909;3:368-371. Reprinted on Pages 583-584 in this issue, with permission.

Despite protests from his family, at the age of 22, Emerson purchased the rudiments of a machine shop from the estate of a local inventor. His father refused to aid in this folly, but his mother arranged for the $1,600 necessary for the purchase. He moved this equipment to a small warehouse at 15 Brattle Street in Harvard Square and set up shop. There Emerson built research apparatus to order for professors and researchers at the prestigious schools of medicine and physiology in the

Fig. 1. John Haven ‘Jack” Emerson, February 5, 1906 – February 4, 1997

Boston area It is interesting that many of his early clients were relatives who had more closely followed the Emerson family traditions.

In 1928 Emerson designed a Barcroft-Warburg apparatus for tissue respiration studies. These devices were used for studies of photosynthesis and in later years for cancer research. Essentially, this device used tissue cultures in small flasks that were agitated in a constant temperature waterbath. Gases generated during growth were measured in U-shaped manometers.

Emerson designed, in 1930, a micromanipulator for the precise movement of instruments under a microscope. This device proved invaluable in early physiology research including cell manipulation and injection. Decades later the same device would find use in the assembly of electronic parts. Emerson designed this device for his older brother Robert, who was a faculty member of the Botany Department at Harvard.

In 1931 Emerson built an oxygen tent that included an improved system for cooling the patient's s environment. Antibiotic therapy was not yet available and oxygen therapy was the mainstay of treatment. Previous devices were prone to rust and failure.

Emerson is best known for the development of the iron lung during the polio epidemic of the 1930s. According to David Garrison (one of Jack's relatives and a co-worker), Emerson's father, then Health Commissioner of New York City, began to notice the escalating number of polio cases. Haven took his son aside and suggested, "If you are ever going to make an artificial respirator, now is the time." Evidently, the two had previously discussed the possibility, unbeknown to others.

At the time Drinker was the leading manufacturer of iron lungs, but Emerson's improvements to the design were classic examples of his work to come—simple, functional, and cost effective. The Drinker iron lung was developed by Philip Drinker, Louis Agassiz Shaw, and James Wilson at Harvard. Upon hearing of Emerson's dalliance into making respirators, Drinker warned Jack that he owned the patents on these devices and to expect litigation if Emerson continued to pursue this technology. What followed represents the spirit of Jack Emerson, perhaps as well as any other event. He ignored Drinker's warning and went about producing iron lungs that were quieter, more reliable, and cheaper than Drinker's. When the lawsuit arrived, Emerson and his colleagues began an exhaustive search of the engineering and medical literature from Europe and the United States. The result of that research is contained in a bright yellow pamphlet[1] available from the J H Emerson Company, containing photographs and drawings of negative pressure ventilation devices preceding Drinker's by decades. Drinker's patents were declared invalid, for want of an invention. The resourcefulness of Emerson and company produced prior artwork that proved that although Drinker may have had some excellent ideas, others had them earlier.

The Emerson design replaced blowers and valves with a flexible diaphragm. The flexible diaphragm was fashioned from elk hide in a dual layer. In this fashion, if one layer became torn, the second redundant layer would continue operation. Emerson also improved the shape and size of the chamber by having it manufactured by a boiler company in Boston (Market Forge). The result was a quieter, simpler, lighter, and less expensive device. Although difficult to source, the Emerson device was said to cost half the price of the Drinker device. Emerson's first device was used for a polio patient at Chapin Hospital in Providence, Rhode Island. The patient had been given last rites, but survived the illness. This iron lung, affectionately referred to as "Old No. 1," now resides in the Smithsonian Institution. Emerson's improvements to the iron lung continued, and he added a quick opening and closing function, an improved pressure gauge, and emergency hand operation. Emerson's design was innovative and yet so simple, it was copied by others. His final development of the iron lung was the creation of a transparent positive pressure dome to allow ventilation when the body compartment was opened for patient care.

Like other ventilator entrepreneurs of his time (Forrest Bird and V Ray Bennett), Emerson was involved in the development of demand valves for high altitude flight and SCUBA (self-contained underwater breathing apparatus) for the Navy. In 1942 Emerson developed an automatic resuscitator, which provided alternating positive and negative pressure along with delivering oxygen. His interest in resuscitation techniques led to his formulation of the Emerson method of artificial respiration for drowning victims. This technique placed the patient in the prone position and alternately raised and lowered the patient's hips. The hipbones were grasped and lifted upward to create inspiration and drainage of fluid out of the lungs. When the hips were lowered, exhalation occurred. This method was widely used, replacing the Shafer prone pressure technique, until the introduction of mouth-to-mouth resuscitation.

In 1949 Emerson turned his attention to positive pressure devices and created a mechanical assistor for anesthesia. Using the bag-in-the-box technique, Emerson's device was triggered by patient effort, and the ventilator compressed the bag, ventilating the patient. This device was developed in concert with the anesthesia department at Harvard.

Emerson developed equipment for intermittent positive pressure breathing (IPPB), cardiopulmonary bypass equipment, hospital beds, negative pressure ventilators (pneumo-wrap), and body positioning devices. In 1955 Emerson introduced a pleural suction pump that provided continuous low-pressure suction for thoracostomy tubes in postoperative thoracic surgery. These devices were on wheels, utilized a large glass jar and a quiet, effective pump. These devices continue to be widely used and are well known as Emerson Postop Pumps in surgery departments around the world.

In 1957 Emerson built a volume plethysmograph for Dr Jere Mead at Massachusetts General Hospital for the measurement of residual lung volume. Mead was a preeminent pulmonary physiologist of his time. This device was later adapted for the measurement of other lung volumes. At Mead' s encouragement, Emerson also developed the first "deep breath" modification for negative pressure ventilation, a predecessor of the sigh breath. Mead's idea was first suggested by Visscher, who believed a periodic deep breath would restore lung compliance.

In 1964 Emerson built one of the early volume ventilators. This simple device resembled a green washing machine and used a piston to deliver precise volumes. Oxygen was added into a 'trombone-shaped' accumulator connected to the intake of the piston for delivery of elevated F_{IO2}. The tidal volume was changed by a crank on the front of the machine, which controlled the stroke of the piston. Respiratory rate and inspiratory-to-expiratory-time ratio (I:E) were adjustable. The humidifier was a modified pressure cooker and was known as the Emerson Hot Pot. A belt, connected to a DC motor and pulley wheel, served to move the piston. In case of failure of the existing belt, a spare was hung inside each cabinet. The belts were similar to those used to circulate air in forced air gas furnaces in homes. On numerous occasions I have heard the story of the belt becoming loose or breaking and the spare found to be missing. Under these circumstances, the resourceful respiratory therapist would run to the parking lot and obtain the belt from a Volkswagen Beetle (the old one) and place it in the Emerson to restore it to working order. I've never looked to see whether the two belt sizes are compatible because it's such a good story. In any event, the Emerson Postop Volume Ventilator was reliable and would allow ventilation of patients when other devices failed. Emerson's device was not the first of the piston ventilators (Morch and Engstrom preceded him), but it was the first device to allow independent control of I:E.

For the intermittent mechanical ventilation (IMV) Emerson used continuous flow IMV and a unique water column PEEP (positive end-expiratory pressure) valve to allow successful use of IMV and a very low work of breathing. During the introduction of microprocessor ventilators with demand valves, numerous investigators compared the work of breathing of the new devices to the "Emerson" gold standard. In fact, the IMV champions of the 1970s were all great supporters of Emerson ventilators, because the work of breathing was low and the possibility of successful application of the technique maximized.

In 1954 Emerson was intrigued with the idea of a dog's ability to ventilate normally during panting. He developed a device for 'vibrating' the patient's airway. His patent[2] for this device, No. 2,918,917: *Apparatus for Vibrating Portions of a Patient's Airway,* issued in 1959 made several unique observations.

> This invention pertains to an apparatus for treating a patient by vibrating a column of gas which is in communication with his airway at a rate which is greater than the patients normal rate—from 100 to 1,500 vibrations per minute—vibrating the column of gas doubtless causes the gas to diffuse more rapidly within the airway and therefore aiding in breathing function by circulating the gas more thoroughly to and from the walls of the lungs.

The initial device used a reciprocating diaphragm, similar to the high-frequency oscillation devices used today. A continuous flow of air was provided from a blower and directed into the inspiratory circuit. The diaphragm was connected to a shaft, which was attached to a pulley. A second electric motor turned the pulley by means of a belt. As the pulley turned, the shaft 'vibrated' the diaphragm. In the 1970s Emerson experimented with a series of high-frequency devices, settling on a device that did not incorporate a diaphragm. The final high frequency device was simple and functional. A high-pressure gas source was delivered to a rotating ball. The ball had a hole drilled through the center to allow the passage of gas into the patient circuit. The faster the ball would spin, the higher the frequency. As the spinning speed was reduced, volume through the hole and duration of flow (% inspiratory time) increased. This device is frequently referred to as a High-Frequency Flow Interrupter (HFFI), owing to the mechanical design (Fig. 2).

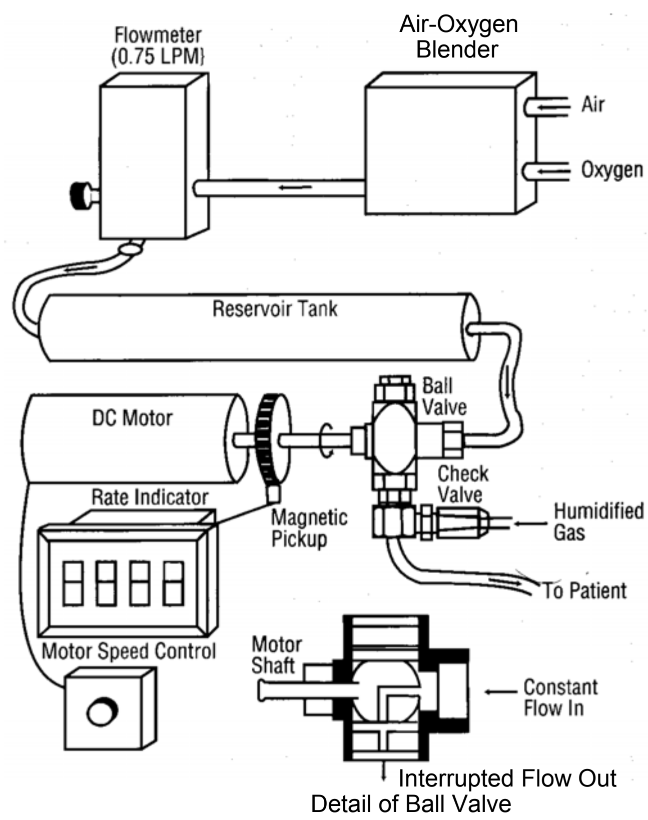

Fig. 2. Schematic of the Emerson High-Frequency Flow Interrupter used for high-frequency positive pressure ventilation.

Several authors reported successful use of this device in the 1980s.[3-7]

Throughout his lifetime, Emerson had long-standing relationships with the leaders in respiratory care, critical care, surgery, anesthesia, and pulmonary medicine. Alvin Barach was a close Emerson colleague and was instrumental in development of the "In-Exsufflator Cough Machine," a device gaining new acceptance now as a method of secretion removal in patients with neuromuscular disease. Many of you may recognize this device by its earlier name, the name given it upon its initial introduction, "The Cofflator." The Cofflator was Barach' s invention and, despite his influence, never really caught on with clinicians. The In-Exsufflator improved on the idea and provided the flows required to aid in secretion removal. Emerson also developed Barach' s walking cane, which contained 50 L of oxygen in an unobtrusive hollow cane.

I was introduced to Jack Emerson by Forrest Bird and enjoyed many conversations with Mr. Emerson over the past decade. Despite his advancing age, Emerson was always patient and willing to discuss any matter of interest. He would always surprise me by reaching into his worn briefcase and pulling out an original manuscript or conference proceeding from the 1940s or 1950s. These would often have his handwritten notes and those of others (Barach, Mead, and others) in the margin. He would often produce this as evidence that all the new techniques we were talking about at the meeting had been done many times before. In the last years of his life, he would frequently lament over the state of relations between the government, clinicians, and manufacturers. He would produce the 1955 proceedings[8] on the state-of-the-art conference on negative pressure ventilation and suggest that cooperation between the groups was a key to early success in mechanical ventilation. Emerson liked to reminisce about the days when a physician could call for a needed piece of equipment, and he could create the device in a couple of days and bring it in for a patient trial. In fact, the very first Emerson iron lung was never tested on anyone but Jack Emerson himself, before going on a patient. Perhaps this could be considered an Emerson innovation as well, true quality control.

This issue of RESPIRATORY CARE contains several pieces as a tribute to the life of a man who saved and changed the lives of others. I did not know Mr. Emerson well, but he usually remembered my name and was always congenial and enlightening. The respect he garnered from Forrest Bird—who called him Jack, but always answered his questions with 'sir'—provided me some insight into the magnitude of his stature. A lot can be learned about a person by observing the respect shown them by leaders in their field. I was fortunate enough to have a photograph taken with Jack Emerson and Forrest Bird during the American Association for Respiratory Care meeting in Las Vegas in 1994 (Fig. 3); an enlarged version graces the wall of my office.

I do not know how Mr. Emerson would have felt about this issue of the Journal. He was quiet and self-effacing. He didn't seem to care much for attention or honors. He was like his devices—simple, functional, and reliable. The role Jack Emerson has played in the history of biomedical engineering has touched the lives of hundreds of thousands of people on both sides of his equipment. His entrepreneurial spirit and simple, innovative genius will be sorely missed in this microprocessor world.

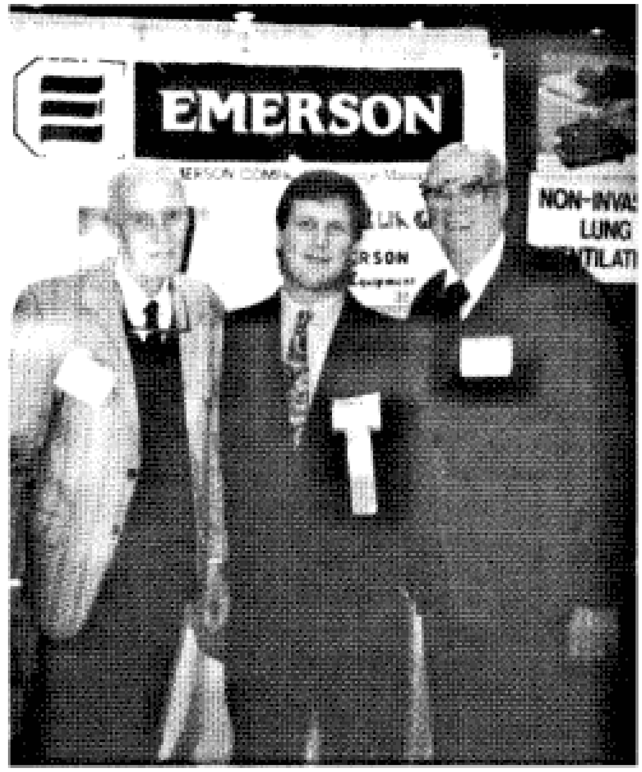

Fig. 3. From left: John Haven Emerson, Richard D Branson RRT, and Forrest M Bird during the 1994 American Association for Respiratory Care annual meeting in Las Vegas.

ACKNOWLEDGMENT

This piece could not have been written without the kind cooperation and assistance of George Emerson. I am grateful for his honesty and hope that this issue of the Journal will invoke fond memories of his father.

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