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Part of the furniture– Part 1. The contribution of pioneering anaesthetist Henry Edmund Gaskin Boyle 1875–1941

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After a long day in theatre many of us dream of escaping to a warm climate for a relaxing holiday, but did you know that the anaesthetic machine you have been using all day and the Caribbean have more in common than you may think? This is because the Caribbean's eastern most island, Barbados, is the birthplace and childhood home of one of the important pioneers of anaesthesia – Henry Edmund Gaskin Boyle (**Figure 1**). Boyle is responsible for the basic design of the anaesthetic machines we use in veterinary practice today. Like all good designs, it has stood the test of time and, amazingly, has not significantly altered since its invention in 1917 (Watt, 1968).

Henry Edmund Gaskin Boyle was born in Barbados on 2 April 1875. His father, Henry Eudolphus Boyle, was the immigrant manager of two sugar plantations who had married the daughter of Benjamin Law Gaskin, a Member of the Barbados House of Assembly (Wilkinson, 1996). Boyle was educated locally at Codrington and later at Harrison College. His childhood coincided with a time of decline in the prosperity of the island due to a long period of adverse weather conditions and a reducing demand for cane sugar in favour of European beet sugar (Hoyos, 1978). Possibly influenced by this economic decline, or perhaps on advice from his uncle, who was a local surgeon, he left his exotic place of birth at the age of 19 to follow a career in medicine at St. Bartholomew's (Barts) in London, qualifying in 1901.

His first appointment was as a casualty officer at the Bristol Royal Infirmary before returning to St. Bartholomew's as a Junior Resident Anaesthetist. More senior posts followed and in 1907 he authored a textbook, *Practical Anaesthetics*, which became a popular text for medical students and which ran to three editions (Wilkinson, 1996).

At the turn of the century, the science of anaesthesia, both human and veterinary, had not progressed significantly beyond the basic open-drop techniques developed in the mid-nineteenth century. This involved ether or chloroform being administered by dripping them onto a cloth, which was then held to the face using a mask. Some attempts to improve safety for both the patient and the anaesthetist had been made, and several designs of 'inhaler' were available, however both the dose administered and the level of drug exposure to the operator were liable to be significant. There were often unwanted fluctuations, with the potential for disaster, as both drugs are irritant and have serious side-effects. Additionally ether is highly flammable.

The few specialists in the field of human anaesthesia had started to explore administering compressed gases stored in iron cylinders. In addition, methods of controlling the proportions and flow rate were developed and it became obvious that a portable machine, to incorporate the gas cylinders and other components required by the new methods, would be a considerable advance (Metcalf, 2007).

Boyle mixed with the most eminent anaesthetists of the era and extended his

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Figure 1. Henry Edmund Gaskin Boyle 1875–1941 (Wilkinson, 1996)

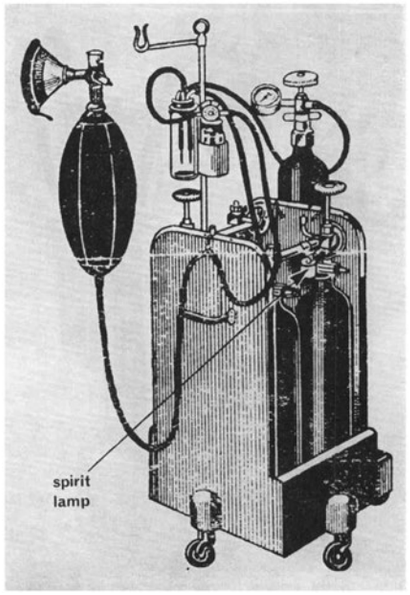


Figure 2. The 1917 Boyle machine. Note small spirit lamp for preventing freezing in the nitrous oxide valve (Watt, 1968)

knowledge during visits to North America where, amongst others, James Gwathmey was developing devices for the delivery of anaesthetics, and, in 1912, had produced one of the first continuous-flow anaesthetic machines (the Roth-Dräger Apparatus was another early machine, being commercially available in 1913). This development clearly made an impact on Boyle and he imported Gwathmey machines into England for use under his direction at Barts and other hospitals (Watt, 1968).

In 1914 the world changed dramatically with the outbreak of the First World War. Almost immediately, large-scale land battles were being fought in France and Belgium and there was an urgent need for speedy and effective treatment of the vast numbers of wounded troops. After emergency treatment at a field dressing station, casualties were initially evacuated by ambulance to clearing stations in huts or tented camps, set some miles back from the front line, for assessment and treatment.

Although the clearing stations were generally well equipped for their day, the mortality rate amongst the more serious cases was very high, not least as a result of surgical shock resulting from major surgery. This was a particular problem in the amputation of limbs, often carried out long after the initial injury, when the patient was suffering from blood loss and hypothermia. Although the relatively new technique of blood transfusion was introduced, mortality rates using ether or chloroform anaesthesia were still high (Metcalf, 2007).

In the Ypres salient, which was the scene of some of the biggest battles of the war, a young respiratory physiologist from Guys Hospital, Geoffrey Marshall, was working in a casualty clearing station researching the increasing problem of surgical shock. It became clear to him that the concurrent use of gas and oxygen anaesthetic mixtures, rather than ether or chloroform alone, resulted in vastly improved outcomes. In the absence of any method of delivering gas mixtures on a continuous basis he designed and built his own machine, based on the Gwathmey model, for use in the casualty clearing station. This was subsequently developed and constructed by the medical apparatus manufacturers Coxeter & Sons. Geoffrey Marshall found that, following the use of reliably delivered gas and oxygen mixtures, mortality rates fell from about 90% to something like 25% (Evans, 1982; Metcalf, 2007).

Although Boyle did not serve overseas during World War I he was commissioned as a Captain in the Royal Army Medical Corps and continued his research whilst working with the RAMC in London, caring for wounded soldiers and documenting many cases of the use of anaesthesia. He was later awarded an OBE for his war service (Wilkinson, 1996). Boyle was dissatisfied with certain aspects of the imported Gwathmey machines and, using his own research and ideas from Geoffrey Marshall, he developed the concept for his first machine, which was also built by Coxeter in 1917, under the direction of Lord George Wellesly. Boyle subsequently presented his design to the Royal Society of Medicine in 1918 (**Figure 2**).

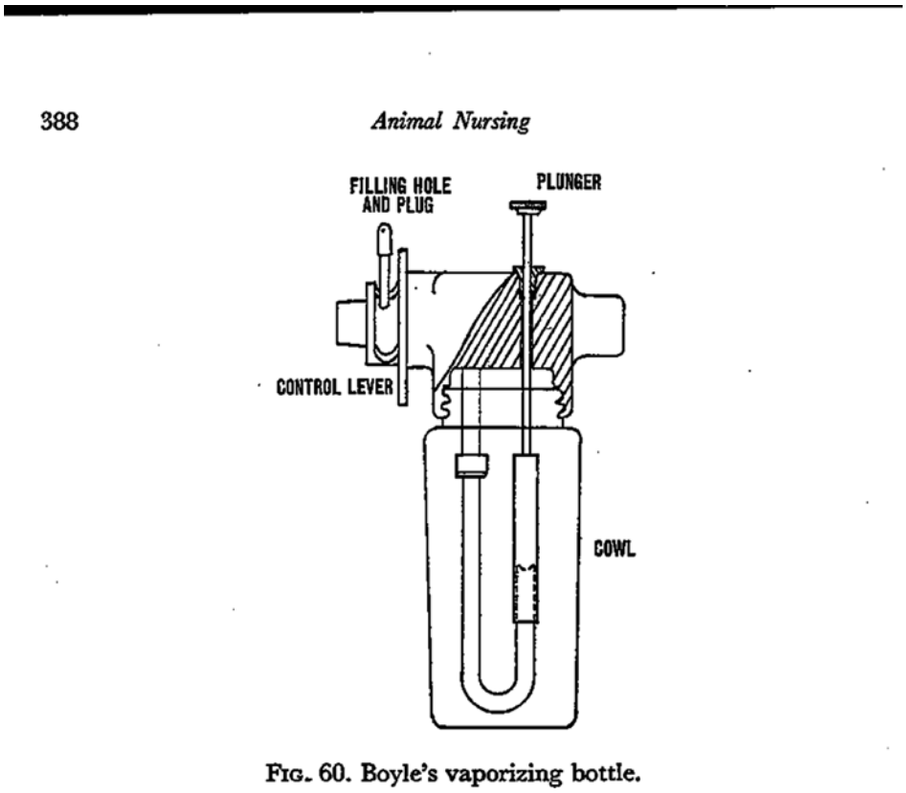


Figure 3. Boyle's bottle (Jones, 1966)

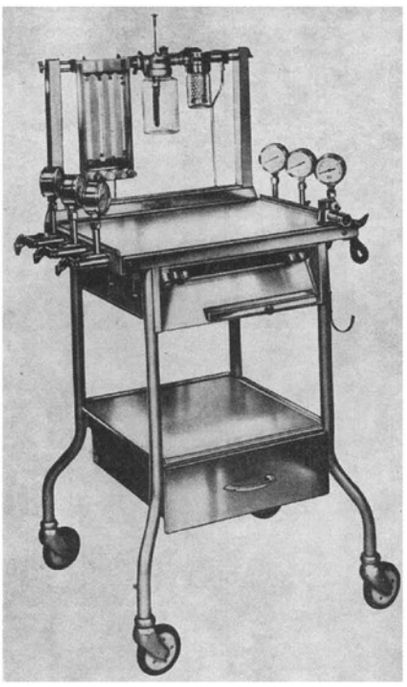


Figure 4. The stainless steel model of the Boyle apparatus (c.1965), incorporating a halothane vaporiser and with a 'take-off' mount transposed to the front of the table (Watt, 1968)

This machine incorporated water sight flow meters that enabled more accurate control of the flow of gases to the patient, as well as an innovative ether vaporiser, which became known as 'Boyle's bottle' (**Figure 3**). In the later stages of the war, the British army used a portable version of Boyle's apparatus at clearing stations (Wilkinson, 1996; Gurudatt, 2013).

The original machine contained the five elements, which are still present in all modern machines, albeit in an altered form, namely:

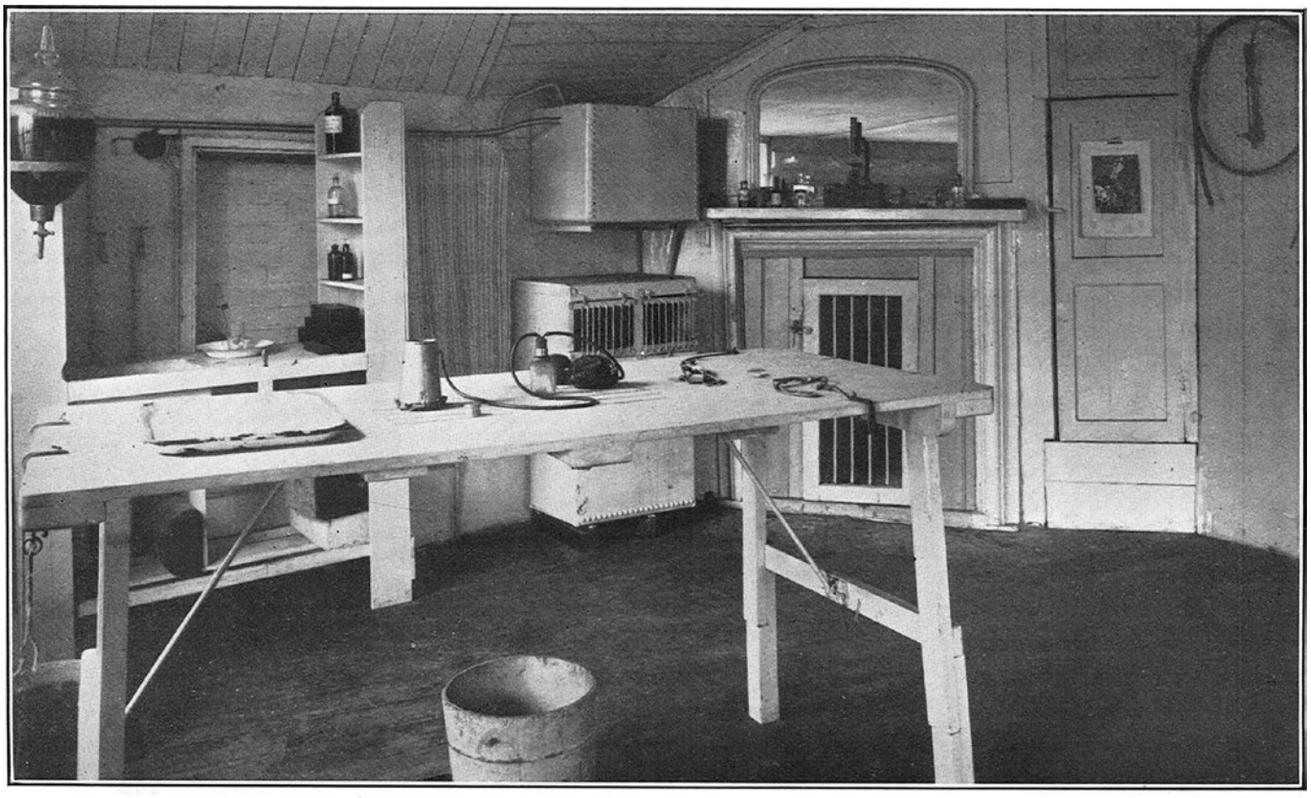
- a high pressure gas supply
- pressure gauges and adjustment valves to control gas pressures
- flow meters to control the rate and proportions of gas delivery
- a vaporiser for volatile anaesthetic liquid
- a breathing system

After the war, Boyle continued to develop his apparatus and, between 1920 and 1965, numerous additions and improvements were made, including the addition of reducing valves, improved vaporising methods and refinements to the flow metering system (**Figure 4**).

The British Oxygen Company bought out Coxeter & Sons in 1939, and named their machine the Boyle Machine in honour of its inventor. From that time this became a protected trade name and, until fairly recently, was adopted by the medical profession as the generic term for the continuous-flow anaesthetic machine (Gurudatt, 2013).

Interestingly, Boyle was left handed and, until the 1950s, anaesthetic machines based on his original apparatus and in use all over the world were designed with controls for left-hand use, with the oxygen flowmeter and adjustment knob on the left hand side. Many later machines were re-designed to suit right handers (Gurudatt, 2013).

Human and veterinary anaesthetic advances are closely linked, with innovations in one usually triggering advancement in the other. This has been



Arthur Hands, Wanstead.

CANINE OPERATING THEATRE, WITH TABLE, HOBBLES FOR RESTRAINT, HOT WATER TANK, SINK WITH HOT AND COLD WATER, CHLOROFORM APPARATUS, ANTISEPTIC SOLUTIONS, ETC.

Figure 5. Canine operating theatre circa 1937 (photo courtesy of Canine Nursing) (Wilkinson, 1937)

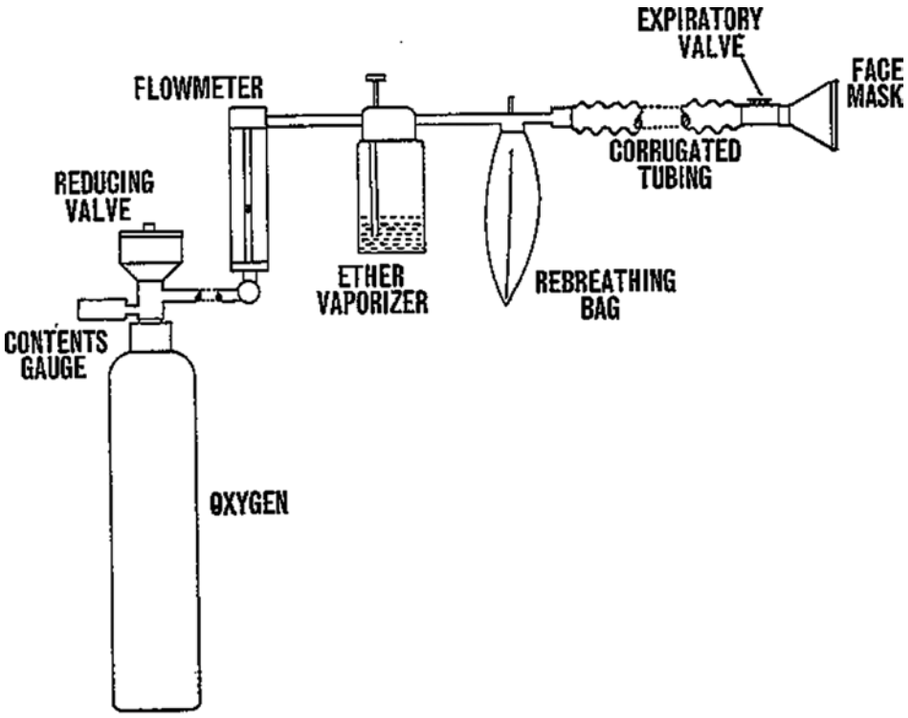


FIG. 62. A satisfactory method of administering ether.

Figure 6. "A satisfactory method of administering ether" (diagram courtesy of Jones Animal Nursing) (Jones, 1966)

Figure 7. Modern anaesthetic machine- similar machines are familiar sights in veterinary practice today (photo courtesy of Burtons Veterinary Products)

seen throughout history, and the Boyle Machine is no exception. It is likely that, as second-hand Boyle Machines became available from hospital surplus, they started to be purchased by veterinary practitioners, although they were absent from the 'modern canine operating theatre' in the 1930s (Wilkinson, 1937) (**Figure 5**). The first comprehensive veterinary nursing reference text, Jones Animal Nursing (1966), discusses both the 'Boyle's anaesthetic equipment' and the 'Boyle's ether vaporising bottle' in some detail (Jones, 1966) (**Figure 6**), so, clearly, by this time the equipment was being seen in small animal practice.

At a personal level, Boyle was a very sociable and popular figure. He was a keen sportsman and played both rugby and cricket for St. Bartholomew's Hospital. He was very active in the academic arena, being on the editorial board of the British Journal of Anaesthesia, an original member of the Association of Anaesthetists of Great Britain and a member of the Society of Anaesthetists. His academic contributions were recognised by the award of an Honorary Fellowship of the Royal College of Surgeons in 1935.

Boyle retired as a consulting anaesthetist in 1940 at the age of 65. He did not enjoy good health in his later years and, after a long illness, died in 1941. Sadly, like so many innovative scientists before and since, he did not benefit financially from his invention (Plarr et al., 1930; Watt, 1968; Wilkinson, 1996).

Although Boyle is sometimes credited with the invention of the first continuous-flow anaesthetic machine, Dräger and Roth, James Gwathmey and Geoffrey Marshall had developed machines before him, although Marshall did not publish details of his machine until 1919. This should not detract from Boyle's enormous achievement and the importance of his development of the safe delivery and control of anaesthetics. Since the year 2000, St. Bartholomew's has named its Anaesthesia Department the Boyle Department of Anaesthesia as a lasting and fitting tribute to a man who made a significant contribution to the advancement of this branch of medicine.

So, next time you are having a long day in theatre, spare a thought for the man who had the foresight, skill and determination to develop a reliable anaesthetic delivery machine that has stood the test of time and is literally 'part of the furniture' in so many veterinary theatres (**Figure 7**).

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