

# George I. Finch and his pioneering use of oxygen for climbing at extreme altitudes

**John B. West**

*Department of Medicine, University of California San Diego, La Jolla, California 92093-0623*

**West, John B.** George I. Finch and his pioneering use of oxygen for climbing at extreme altitudes. *J Appl Physiol* 94: 1702–1713, 2003; 10.1152/jappphysiol.00950.2002.—George Ingle Finch (1888–1970) was the first person to prove the great value of supplementary oxygen for climbing at extreme altitudes. He did this during the 1922 Everest expedition when he and his companion, Geoffrey Bruce, reached an altitude of 8,320 m, higher than any human had climbed before. Finch was well qualified to develop the oxygen equipment because he was an eminent physical chemist. Many of the features of the 1922 design are still used in modern oxygen equipment. Finch also demonstrated an extraordinary tolerance to severe acute hypoxia in a low-pressure chamber experiment. Remarkably, despite Finch's desire to participate in the first three Everest expeditions in 1921–1924, he was only allowed to be a member of one. His rejection from the 1921 expedition was based on medical reports that were apparently politically biased. Then, following his record ascent in 1922, he was refused participation in the 1924 expedition for complex reasons related to his Australian origin, his forthright and unconventional views, and the fact that some people in the climbing establishment in Britain saw Finch as an undesirable outsider.

Everest; hypoxia; mountaineering; oxygen equipment; record ascent

AT THE END OF 1920, a telegram arrived in the India Office in London to say that the Tibetan government had given the long-awaited permission to explore the Everest region from Tibet, and the Alpine Club and Royal Geographical Society (RGS) in London lost no time in planning a reconnaissance expedition. In fact, there were three expeditions in the space of four years, the reconnaissance in 1921 and the attempts to reach the summit in 1922 and 1924. In thinking about the best people to make a summit bid, J. P. Farrar, the influential President of the Alpine Club, consulted widely and came to the conclusion that George I. Finch and his brother Maxwell “were two of the best mountaineers we have ever seen” and that they would be his first choice for the summit party (2).

At about the same time, the issue of climbing oxygen was discussed at length, and George Finch took a leading role. This was natural because he was an eminent physical chemist with a special interest in properties of gases. Furthermore, in experiments carried out in a high-altitude chamber in Oxford, Finch demonstrated an extraordinary tolerance to acute severe hypoxia during exercise. In fact, his performance in the low-pressure chamber in 1921 has apparently not yet been surpassed.

From all this, it might be expected that Finch would play a key role in the first three Everest expeditions. However, this was not to be, although during the 1922 expedition he and his companion Geoffrey Bruce reached the altitude record of 8,320 m and in the process clearly demonstrated the great value of supplementary oxygen at extreme altitude. By an extraordinary series of events, Finch was first invited to join the 1921 expedition and then the invitation was withdrawn after he was declared unfit by two physicians whose reports were apparently politically influenced. Even more remarkable was that, after his great success on the 1922 expedition and after being asked to modify the oxygen sets for 1924, he was not invited to be a member of that expedition.

The story is a fascinating one of personality conflicts and how Finch, an Australian who was educated in Europe, did not fit well with the English climbing establishment in the early 1920s to the great disadvantage of everyone concerned.

## USE OF OXYGEN AT HIGH ALTITUDE BEFORE 1921

The beneficial effects of inhaling oxygen at high altitude were predictable when Paul Bert proved that low partial pressure of oxygen was responsible for

Address for reprint requests and other correspondence: J. B. West, UCSD Dept. of Medicine 0623A, 9500 Gilman Dr., La Jolla, CA 92093-0623 (E-mail: jwest@ucsd.edu).

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physiological impairment (3). Indeed, Bert showed that inhaling oxygen dramatically reduced the symptoms of hypoxia when he exposed himself to a low barometric pressure in a pressure chamber. For example, in one experiment, he reduced the barometric pressure to 418 mmHg, equivalent to that on the summit of Mont Blanc, and showed that breathing oxygen immediately relieved his nausea and reduced his pulse rate. In another remarkable experiment, the chamber pressure was reduced to as low as 248 mmHg, equivalent to that on the Everest summit, and Bert demonstrated that he could remain conscious by breathing supplementary oxygen. Bert also recommended that oxygen be taken on the famous but ill-fated flight of the Zénith balloon in 1875, but unfortunately too little oxygen was carried and the equipment made it difficult to inhale, resulting in two of the three balloonists dying from hypoxia.

Bert did not carry out any experiments on mountains; in fact, one of the first proposals to test the effects of inhaling oxygen at high altitude in the field preceded Bert's experiments by ~50 years. A Russian, Joseph Hamel (1788–1862), was probably the first person to suggest the use of supplementary oxygen when he made an attempt on Mont Blanc in 1820 with the intention of using compressed oxygen, although in the event suitable equipment was not available (27). His expedition was also ill-fated because of an avalanche that killed three guides.

The first use of supplementary oxygen in the Himalayas was apparently in 1907 when A. L. Mumm, Thomas Longstaff, and Charles Bruce went to the Garhwal and made the first ascent of Trisul (7,127 m), which remained the highest summit to be climbed for 21 years. Small oxygen generators were taken along on this expedition, which was partly done to celebrate the Golden Jubilee of the Alpine Club (25). However, no serious assessment of the value of oxygen was possible.

By far the most important forerunner in the use of oxygen at extreme altitudes was Alexander Mitchell Kellas (1868–1921). He carried out the first rigorous tests of the value of supplementary oxygen during climbing at high altitude on Kamet in the autumn of 1920 (19, 20). He arranged for 74 tanks of oxygen to be sent to him, and each of these weighed nearly 9 kg with its regulator. Kellas carried out a series of preliminary experiments at an altitude of ~6,400 m on Kamet and more systematic studies at ~5,500 m on the Bagini glacier. His conclusion was that the cylinders were “too heavy for use above 18,000 ft [5,486 m], and below that altitude they are not required. They would be quite useless during an attempt on Mt. Everest” (20).

Fortunately, Kellas also took along rubber bags and Oxylithe (sodium peroxide), an oxygen generator suggested by Prof. Leonard Hill of University College in London. In one set of experiments, he breathed oxygen from a bag and timed an ascent of ~10 min while breathing air and then compared this with another done without previous oxygen breathing. He stated “the times were practically identical” and that “the excess amount [of oxygen] in the lungs at starting was of negligible value in promoting ascent.” Kellas then

pointed out that this conclusion could have been predicted based on the very small oxygen stores of the body. Nevertheless, it is interesting that this technique has been repeatedly used, for example by the Swiss in their attempt on Mt. Everest in 1952 (6).

Kellas then carried out a third set of experiments using oxygen from the Oxylithe bag while climbing. He carried the bag under the arm, which he stated was inconvenient. However, the results were dramatic, and Kellas stated that “the gain while using oxygen was quite decisive, the advantage being up to 25%. This again was to be expected, and clearly indicates that the light oxygen cylinders suggested above might be of considerable value as regards increase of rate of ascent at high altitudes” (20).

The first expedition to Mt. Everest took place only a few months later in the spring of 1921. Kellas was a member of this expedition, but although oxygen tanks were taken in, they were never used (30). The main reason for this was that Kellas died during the approach march, and there was insufficient interest on the part of the other members of the expedition. An additional reason was that the tanks were heavy because there was not enough time to prepare new equipment, mainly because Kellas did not return to England between his tests on Kamet in 1920 and his joining the Everest expedition in the spring of 1921.

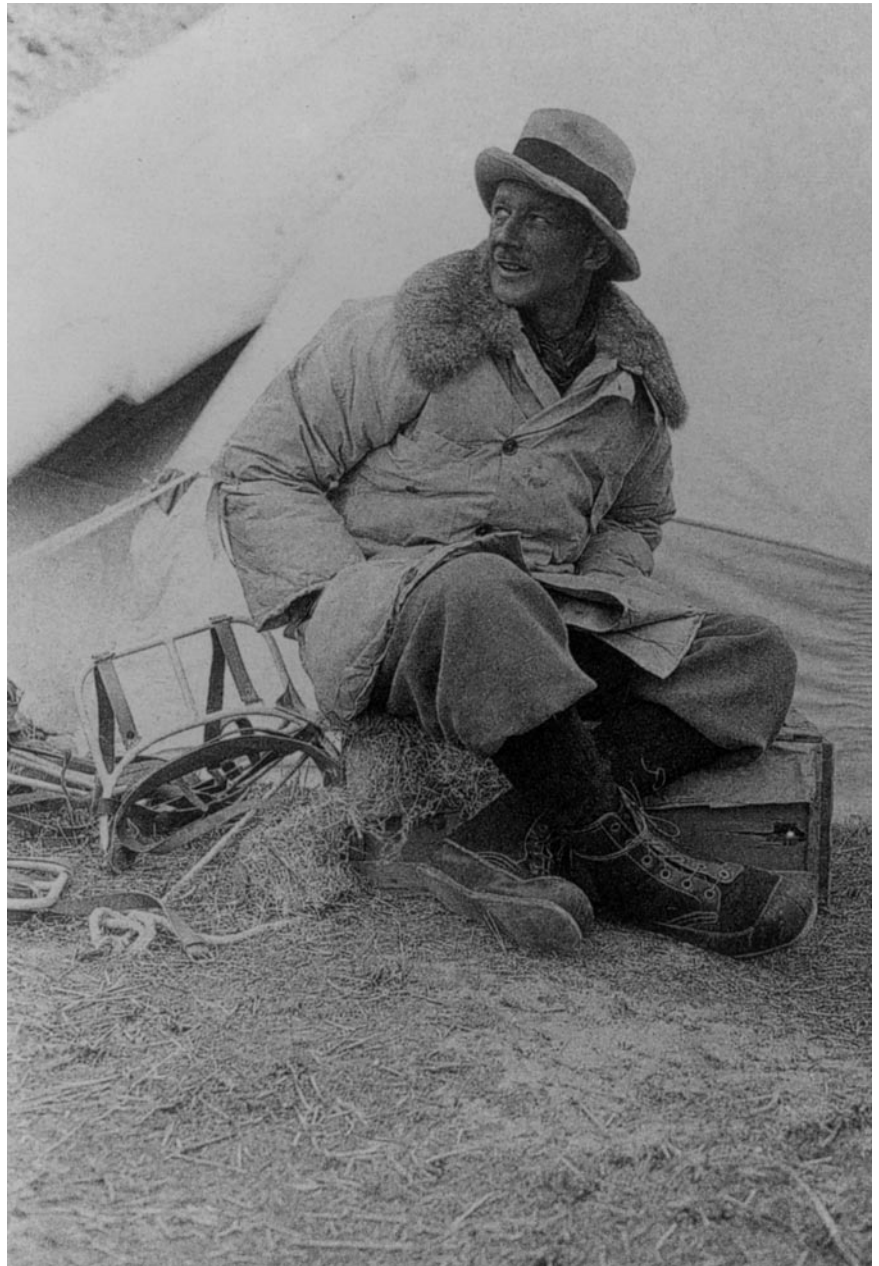
As discussed below, the first extensive use of supplementary oxygen for climbing at high altitude took place on the second Everest expedition in 1922. Curiously, the pioneering experiments of Kellas were virtually ignored, partly perhaps because Kellas was a very private person and usually climbed on his own, except for a few native porters accompanying him. An exception to this was his expedition to Kamet in 1920 when he was accompanied by Major H. T. Morshead. The fact that his results were published in the *Geographical Journal* in February 1921 (20) should have made them available; remarkably, however, in the preparations for the use of oxygen in 1922 his name was hardly mentioned.

#### EARLY HISTORY OF G. I. FINCH

George Ingle Finch (1888–1970) (Fig. 1) was born in Orange, New South Wales, Australia, then a small country town ~200 km west of Sydney. He was the eldest son of Charles Edward Finch (1843–1933) who owned a sheep and cattle property. Scott Russell, son-in-law of G. I. Finch, wrote a memoir about him (14) and made the point that Charles Finch had been born in Australia only 6 years after Queen Victoria had ascended to the British throne and that he regarded himself as entirely English. The emergence of Australian nationalism lay far in the future. Charles Finch was very interested in local affairs, and his legal training made him a suitable chairman of the district Land Board Court. George had a brother Maxwell, about one year younger, and also a sister, Dorothy.

In his beautifully written and influential book *The Making of a Mountaineer*, George Finch described how

Fig. 1. George I. Finch during the 1922 expedition. He is wearing a jacket of his own design filled with eiderdown. This was ridiculed by A. R. Hinks as a “patent climbing outfit” but in fact was the forerunner of the down clothing that is now standard for high-altitude climbing. (From Ref. 9.)



at the age of 13 he found himself on the summit of a hill outside Orange entranced by the view and that “after this, my first mountain ascent, I had made up my mind to see the world; to see it from above, from the tops of mountains” (9). The family moved to Europe in 1902 when George was only 14 and spent some time in England and France. George’s mother Laura was more cosmopolitan than her husband and, it is said, was bored by the country life in England that her husband so much enjoyed. In Paris, Laura had a large and interesting circle of friends, including Charles Richet, a Nobel laureate for his work on anaphylaxis, and Sir Oliver Lodge, an eminent physicist. Something of a crisis occurred when George’s education was being planned. It would have been natural for him to go to an English public school, but there was a feeling that the

discipline and restrictions were too repressive. Instead, Laura arranged for the boys to be privately tutored in Paris, and Charles Finch returned to Australia without her. It is said that Charles Finch never saw his wife again, but his daughter Anne disputes this.

George and his brother wasted no time in testing their climbing abilities when they reached Europe. The following two extracts are from *The Making of a Mountaineer*.

My brother Maxwell and I, now proud possessors of Edward Whymper’s *Scrambles in the Alps* emulated our hero’s early exploits by scaling Beachy Head [a steep cliff in southern England] by a particularly dangerous route, much to the consternation of the light-house crew and subsequent disappointment of the coast guards who arrived up aloft with ropes and rescue

tackle just in time to see us draw ourselves, muddy and begrimed, over the brink of the cliff into safety. . . . A few weeks later, an ascent of Notre-Dame [the cathedral in Paris] by an unorthodox route might well have led to trouble, had it not been for the fact that the two gendarmes and the kindly priest who were the most interested spectators of these doings did not lack a sense of humour and human understanding.

George spent a short period at the *École des Médecine* in Paris and became fluent in French. However, he felt that he would be more comfortable in a more exact science and soon switched to the physical sciences. At the suggestion of Laura's friend, Sir Oliver Lodge, George moved to the Eidgenössische Technische Hochschule in Zurich and soon became fluent not only in proper German but also the in Swiss dialect. He was at the Eidgenössische Technische Hochschule from 1906 to 1911 and was awarded the Gold Medal at the end of his course for the diploma in technical chemistry. The weekends and summer vacations were spent climbing extensively in the Alps, and George became an outstanding mountaineer and president of the prestigious Zurich Akademischer Alpen Club.

In 1912, he returned to England and in the following year became associated with the Imperial College of Science and Technology in London, which remained his scientific base for the next 40 years. During the First World War, he served with the Royal Field Artillery in France and was later attached to the Ordnance Corps and worked on explosives in Salonica. He was awarded the Military M.B.E., was mentioned in dispatches, and was demobilized with the rank of captain. He then returned to Imperial College. He was married briefly in 1916 and there was a son, Peter Finch, who became a successful actor. The paternity of Peter Finch has been the subject of much discussion (7, 8). A second marriage in 1921 was very happy, and there were three daughters, one of whom, Anne, married Scott Russell.

#### PREPARATIONS FOR THE EXPEDITION OF 1921

Although, as indicated above, Kellas' experiments with oxygen equipment on Kamet in 1920 were subsequently ignored, another of his observations was responsible for a renewed interest in oxygen equipment in 1921 and 1922. In discussing the reasons for their failure to reach the summit of Kamet, Kellas and Morshead referred to the difficulties with stoves at high altitude. Morshead wrote, "I was unaware until too late that the large Primus stove, on which I had been relying, would not work in the rarified atmosphere of 20,000 feet, beyond which point methylated spirit is the only possible fuel; while Dr. Kellas had only one small spirit stove which took an hour to thaw sufficient snow to fill a teapot" (20).

With the aim of improving the Primus stoves for the 1921 expedition, Finch went to Oxford in March 1921 to see G. M. B. Dobson, a lecturer in meteorology, who was carrying out tests in a low-pressure chamber in the laboratory of Georges Dreyer, F.R.S., the professor of pathology. Finch was accompanied by P. J. H. Unna,

another member of the Oxygen Subcommittee set up by the main Everest Committee and who wrote an informative account of the visit (29). Dreyer (1873–1934) had been educated in Copenhagen and obtained his medical degree there in 1900. He subsequently worked as a bacteriologist and virologist and co-authored a report with the physiologist Mabel FitzGerald (15). Dreyer had been a consultant to the Royal Flying Corps (to become the Royal Air Force) during World War I and had probably carried out more research with oxygen for aviators than anyone else in the United Kingdom. His design of oxygen equipment for aircraft was very successful and was used, for example, by the Air Service, U.S. Army (1). Dreyer's low-pressure chamber was a steel cylinder 2.1 m in diameter with glass windows and was evacuated by means of an electric pump.

The stoves were duly modified for high-altitude use, and then Finch and Unna switched their attention from the effects of oxygen on the stoves to the possible value of oxygen for climbers. Dreyer had strong views on this, stating "I do not think you will get up [Everest] without it [supplementary oxygen], but if you do succeed you may not get down again" (29). Finch, Unna, and J. P. Farrar, former President of the Alpine Club, went to Oxford on March 25, 1921, to see the tests on the stoves, and Dreyer convinced Farrar that the question of oxygen for climbers should receive serious consideration. Dreyer's contributions to the use of oxygen on the 1922 expedition were therefore considerable. Finch stayed in Oxford overnight, and Dreyer carried out experiments on him in the low-pressure chamber the next day. The simulated altitude of the chamber was set at 21,000 ft (6,400 m), and Finch stepped up on a chair, first with one foot and then with the other, 20 times in succession while carrying a load of 35 lb. (16 kg) slung over his shoulder. The stepping rate was chosen to correspond to a fairly rapid climbing pace.

The results showed that while Finch was standing still and holding the load at the simulated altitude of 6,400 m his pulse rate was ~104 beats/min. Immediately after the exercise during which he stepped up onto the chair 20 times in 2.5 min, the pulse rate was 140 beats/min. However, when Finch breathed supplementary oxygen, the pulse rate while standing was only 77 beats/min, only slightly more than his normal pulse rate of 68 beats/min while standing at sea level. Immediately after the exercise, which this time was accomplished in only 2 min, his pulse rate was not above 100 beats/min. As Dreyer stated, "The striking effect of taking oxygen is obvious from these figures." Dreyer went on to add, "Apart from the effect upon pulse, there was a marked change in his whole condition and appearance shortly after he began to breathe oxygen. His expression and colour became normal, and his elasticity of movement returned, as shown by the fact that although he attempted to maintain the same rate for his exercises in both cases, he unconsciously shortened the time from 2½ to 2 min" (29).

Dreyer reported his medical examination of Finch and the results of the low-pressure chamber studies in

a four-page letter to Farrar dated March 28, 1921, which is in the archives of the RGS. Part of the summary reads as follows (26)

1. Captain Finch is slightly under weight at present, otherwise his physique is excellent.
2. He has an unusually large vital capacity. This indicates a high degree of physical fitness, and he should therefore be able to stand great exertion at high altitudes better than most persons.
3. Furthermore, the tests in the low pressure chamber proved that Captain Finch possesses quite unusual powers of resistance to the effects of high altitudes. Among the large number of picked, healthy, athletic young men which we have examined, more than 1,000 in all, we have not come across a single case where the subject possessed the resisting power to the same degree.
4. The administration of oxygen to Captain Finch at 21,000 feet at once restored him to normal, as measured by colour, expression, pulse and elasticity of movement.

The improvement shown by Finch while breathing oxygen was impressive, but even more remarkable was his ability to do this large amount of work at this very considerable simulated altitude of 6,400 m while breathing air. An analysis of the exercise test is given in APPENDIX 1. This extraordinary demonstration of fitness by Finch contrasted greatly with subsequent events in 1921.

All members of the 1921 expedition were required to have a routine medical examination, and on March 17 and 18, just 1 wk before his exemplary performance in the low-pressure chamber in Oxford, Finch was examined by two London physicians. Amazingly, they concluded that he was unfit, and soon after this his invitation to join the expedition was rescinded by the selection committee less than 1 mo before he was scheduled to sail! The medical reports are in the archives of the RGS and make astonishing reading today. They are reproduced in Fig. 2; a transcription is given in APPENDIX 2 (Table 1) because the handwriting is difficult to read. Additional information about the authors of the two reports and the expedition doctor, A. F. R. Wollaston, is in APPENDIX 3. The role of Wollaston in the decision to reject Finch is not spelled out, although Mallory stated in a letter to Winthrop Young that "Wollaston told me that there could be no question of taking Finch after the doctors' report" (26). This statement suggests that Wollaston was biased toward excluding Finch in that he was willing to ignore Dreyer's report.

By any reasonable assessment, the two medical reports are totally inadequate and cannot possibly justify rejecting Finch at this stage. The surgeon's report is absurdly short and replete with vague terms, such as *sallow*, *nutrition poor*, *spare*, and *flabby*. The medical report (that is, by an internist) is a little longer but contains no convincing data for rejecting Finch. The only positive findings were a mild degree of anemia (now known to be a frequent finding in athletes), some missing teeth, and apparently some glucosuria as indicated by the positive Fehling test. This last finding is

curious and suggests that the test should have been repeated immediately by Larkins. When Dreyer performed the same test 1 wk later, it was normal; when it was repeated in November (later that year) by Larkins it was also normal. The contrast between these two inadequate medical reports and the remarkable performance recorded by Dreyer in the low-pressure chamber 1 wk later is dramatic indeed.

How is it possible to explain Finch's rejection on such flimsy grounds? The Everest Committee, as it was known, consisted of representatives from the RGS and the Alpine Club. Finch had strong supporters, such as John Percy Farrar (1857–1929), former President of the Alpine Club, but powerful enemies, including Arthur Robert Hinks (1873–1945), Secretary of the RGS (28). There had been several instances in the past where Hinks' animosity toward Finch had been demonstrated, and it seems likely that he was looking for an excuse to reject Finch. In fact, it is natural to wonder whether the opinions of the two physicians who provided the medical reports were influenced by Hinks or some other member of the Everest Committee.

There may have been other reasons for the antipathy of some members of the Everest Committee. A photograph of Finch had been published in an illustrated paper with some information about the forthcoming expedition, and this annoyed Hinks who had a great dislike of publicity in the press. And there may have been other factors, too. The 1921 Everest expedition, and indeed the subsequent ones for the next 30 years, were dominated by men who had been to English public schools and were educated in the Oxford and Cambridge universities or who had a military background. The elitist character of the Alpine Club was amusingly referred to by Scott Russell when he described his first visit to the Club shortly after he had been elected a member. He met Sydney Spencer, one of the vice presidents, who remarked, "I hope your proposers told you that in addition to being the oldest mountaineering club in the world, the Alpine Club is a unique one—a club for gentlemen who also climb." Then, pointing out of a window at a street sweeper in Savile Row where the club was then situated he added, "I mean that we would never elect that fellow even if he were the finest climber in the world" (14). Naturally, such an attitude would not set well with the Australian Finch who had been educated in Europe, was not part of the English establishment, and was a great believer in each person's right to determine his own destiny.

The old-fashioned views of some members of the Alpine Club were highlighted in an anecdote related by C. J. Morris, who was also a member of the 1922 expedition. Col. E. L. Strutt was the deputy leader of the expedition and a power in the Alpine Club. As stated by Morris, Strutt was aware that Finch (24)

had been educated in Switzerland and had acquired a considerable reputation for the enterprise and skill of his numerous guideless ascents [many members of the Alpine Club were against ascents without guides]. Besides, he was by profession a research chemist and therefore doubly suspect, since in Strutt's old-fashioned

**A** TELEPHONE PADD. 5042. 3/3/10 75, HARLEY STREET, W.1. 17. 3 19.21


Surgical Report on  
 Capt. G. I Finch

Altitude Test = 58 Seconds = good.  
 Saliv. nutrition. poor. - spare. glabrous.  
 Pupils react. knee jerks present.  
 Coordination. active. - mentality good.  
 - a determined type =

|| but his physical condition at present is poor.

No Valvular lesion. No Hemis. No Hæmorrhoids  
 Involvements of all joints free & good.

H. Graeme Anderson  
 M.D. C.B. F.R.C.S.



**B** TELEPHONE, PADDINGTON ROAD. 75, HARLEY STREET, W.1. March 18. 1921

Medical report on Capt. G. I. Finch.

General appearance - Tired. Sallow complexion  
 Nutrition. poor.  
 Physique. fair.  
 Height. 6' 0 1/2"  
 Weight. 11 3/4"  
 Previous illness. Maladant.

Heart - apex beat 1 1/2" + 4 3/4" = 6 1/4"  
 in 5th intercostal space  
 1/2" in axilla. normal.  
 40 cardiac murmurs, 2 in mitral area.  
 Pulse. 72.  
 Venous slightly thickened


Blood Pressure. 118.

Chest. measurements 34" - 58"  
 no impairment of expansion  
 Breath sounds. normal  
 V.R. + V.F. normal.

Blood examination H.C.C. 4500,000  
 W.B.C. 10500  
 Hb. 85%

Nervous system. all tests normal.  
 Conduction " "

Heavy. normal.  
 Light. normal.  
 Emulsion allowed. healthy



**C** TELEPHONE, PADDINGTON ROAD. 75, HARLEY STREET, W.1. Continued.

Medical report on Capt. G. I. Finch.

Urine. - 1022, acid  
 No albumin  
 Reduces Fehling

Alimentary system. 17 teeth remaining  
 No enlargement of liver,  
 Spleen, & stomach.  
 No tenderness of appendix.

This man is not at the moment fit. He has been losing weight. His urine reduces Fehling. He is slightly anæmic, and his mouth is very deficient in teeth.

He may improve considerably with training.  
 His blood ought to be tested once a week  
 as teeth deficiencies can be remedied with plates.

F. E. Larkins.  
 M.D.




Fig. 2. Copies of the original medical reports by Drs. H. Graeme Anderson and F. E. Larkins. The handwriting is transcribed in Table 1. The originals are in the archives of the Royal Geographical Society (reference RGS/EE3/14) and are reproduced with permission.

view the sciences were not a respectable occupation for anyone who regarded himself as a gentleman. One of the photographs which particularly irritated him depicted Finch repairing his own boots. It confirmed Strutt's belief that a scientist was a sort of mechanic. I can still see his rigid expression as he looked at the picture. "I always knew the fellow was a shit," he said, and the sneer remained on his face while the rest of us sat in frozen silence.

In spite of this, Finch and Strutt later became firm friends. Morris also remarked on the rigorous scientific approach of Finch, which contributed to other logistical aspects of the expedition. Finch's empirical attitude contrasted with the more romantic approach of other members of the expedition, for example, that of Mallory.

The allegation that the two medical reports were biased is of course a very serious one, and it is pertinent here to summarize the events in the decision to rescind Finch's invitation to be a member of the 1921 expedition. The responsibility for the membership of the expedition was vested in the Everest Committee, which was made up of four members of the RGS and four from the Alpine Club. Hinks was the Secretary of the RGS and became the main secretary of the Everest Committee. The other three members from the RGS were Sir Francis Younghusband, Col. E. M. Jack, and Edward Somers-Cocks. From the Alpine Club, there were J. E. C. Eaton, Norman Collie, Capt. J. P. Farrar, and C. F. Meade. The Everest Committee quite reasonably required that candidates for the expedition should undergo a medical examination. The two doctors who examined Finch were presumably chosen by Wollaston, the official expedition doctor. Details of these three people are in APPENDIX 3. The choice of Wollaston as expedition doctor might have raised eyebrows because his choice to study medicine was made reluctantly and, as pointed out in APPENDIX 3, he disliked its practice. On the other hand, he had been on several expeditions to remote areas and had distinguished himself as a surgeon in the Royal Navy during World War I when he was awarded a D.S.C.

His choice of Dr. Graeme Anderson as one of the physicians seems reasonable because Anderson had written the first book on the medical and surgical aspects of aviation and was interested in the selection of aviators. The reasons for the choice of Dr. F. E. Larkins are less clear because he was a pediatrician chiefly interested in the health of school children. It is possible that Wollaston asked Anderson's advice and he recommended Larkins. Larkins and Anderson had the same address and telephone number (APPENDIX 2) and presumably were partners in a practice. This raises the question of whether the two reports were independent.

The medical reports themselves (see Table 1 in APPENDIX 2) definitely seem to be biased in that the conclusions do not fit with the facts of the examination. Anderson's report states that Finch's "physical condition at present is poor," and Larkins' report concludes, "This man is not at the moment fit." However, nothing

else in the reports supports these conclusions with the possible exception of the positive Fehling test, which should have been repeated. The allegation of bias is based on the fact that the conclusions of the two medical reports are not consistent with the details of the reports.

These internal inconsistencies are further highlighted by the enormous discrepancy between the medical tests and Finch's extraordinary demonstration of fitness 1 wk later in the low-pressure chamber (APPENDIX 1). Of course, Finch's performance during extreme hypoxia was far more relevant to his potential on Everest than the routine medical examinations and is an example of the value of "specificity of testing" now often applied to elite athletes. The results of these tests were sent by Dreyer to Farrar on March 28 only 6 days after the medical reports were received by Hinks. It is inconceivable that Farrar, who was a strong supporter of Finch, did not communicate this information to the other members of the Everest Committee. Yet, as indicated earlier, Wollaston apparently stated that there could be no question of taking Finch after the doctors' reports. The most likely scenario, unpleasant as it is, is that the wishes of the Committee to rescind Finch's invitation were made known to the two examining physicians and, furthermore, that the evidence from Dreyer's low-pressure chamber experiments was deliberately suppressed.

#### EXPEDITION OF 1922

In November 1921, Finch was reexamined by Dr. Larkins and declared fit (presumably to no one's surprise). The report read, "I have also reexamined G. I. Finch today. He is now absolutely fit and has lost his glucosuria. In my first report on him I stated that I thought all he needed was to get into training" (14). Presumably, Finch still lacked the 17 teeth. Do we detect a slightly defensive air on the part of the good Dr. Larkins?

In any event, Finch was selected for the 1922 expedition and on January 13, 1922, found himself in Oxford again with Farrar, Unna, and this time the surgeon T. H. Somervell. Another test was carried out in the low-pressure chamber, this time at the higher altitude of 23,000 ft (7,010 m). Finch with a 30 lb. (14 kg) load stepped on and off a chair 20 times without apparent difficulty at the rate of 8 s per step. Somervell, similarly loaded, started at 5 s a step, but was stopped after the fifth step, and oxygen was forcibly administered to prevent him from fainting (29). When the group returned to London, a detailed report was made to the Everest Committee who agreed that oxygen should be obtained for the expedition.

It is interesting that, although Finch visited Oxford on several occasions in 1921 and 1922, there is no mention of the eminent physiologist J. S. Haldane who worked in Oxford at the time. Haldane is famous as the leader of the 1911 Anglo-American Pikes Peak Expedition that laid the groundwork for much of the physiology of high-altitude acclimatization. Haldane was

certainly active in 1921–1922; in fact, the first edition of his influential book *Respiration* was published in 1922 (16). The explanation may be that, after Haldane was passed over in preference to C. S. Sherrington for the Chair of Physiology at Oxford in 1913, he left the department and built his own laboratory in the garden of his house in north Oxford. There is also evidence from correspondence of some tension between Haldane and Dreyer. Haldane did take part in a discussion of the physiological problems of extreme altitude after the return of the 1924 expedition (17) when he made some curious disparaging remarks about the “somewhat disappointing effects of oxygen on well-acclimated persons.”

Dreyer naturally had links with the Air Ministry who were the experts in supplying compressed oxygen in light cylinders. A series of steel tanks 0.53 m long and 7.6 cm in diameter were made that could safely contain oxygen at a pressure of 150 atm. Tests showed that dropping the charged bottles from a height of 9 m on to a concrete floor resulted in nothing more serious than leakage at the valve; however, to allow for a further margin of safety, it was decided that the pressure would be reduced from 150 to 120 atm. Because the water content of the tank was 2 liters, each held 240 liters of oxygen at normal temperature and pressure. The total weight including the valve was 2.6 kg, of which 0.36 kg was the oxygen. A drawing and photograph of the tanks are shown in Figs. 3 and 5.

Dreyer was insistent that the supply of oxygen, once started, should not be interrupted, and this meant that the line going to the mask was always connected to two bottles so that it was possible to switch from one bottle to another without stopping the supply. Subsequent experience has shown that this was a needless concern. The reducing valve, made by Siebe Gorman, was based on one used in high-altitude flying during the war. Two kinds of masks were designed, the “standard” and the “economizer.” The latter can be seen in Fig. 4 and

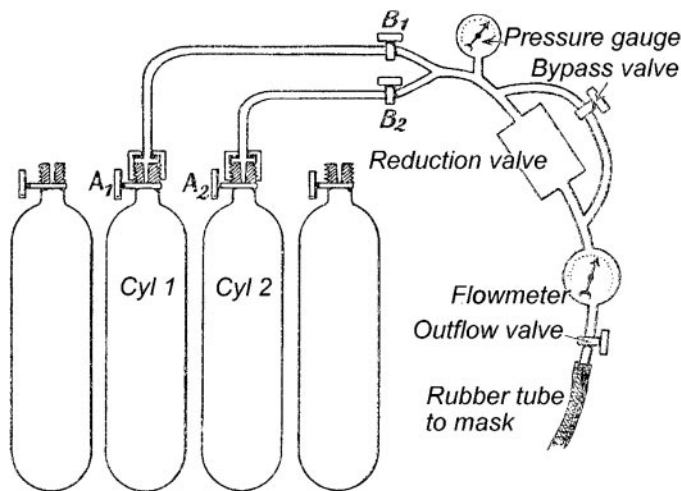


Fig. 3. Oxygen equipment designed for the 1922 expedition. This was the first successful oxygen apparatus for high-altitude climbing. Much modern equipment uses essentially the same principles. (Modified from Ref. 10.)

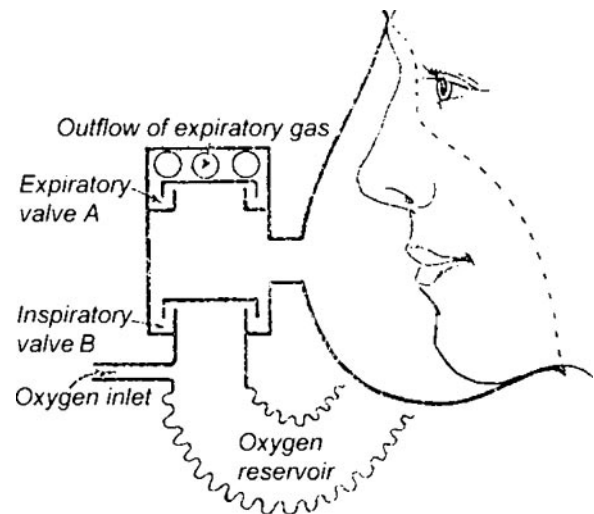


Fig. 4. Finch wearing the oxygen equipment of the 1922 expedition. The face mask is of the “standard” type without the economizer. (From Ref. 10.)

includes valves and a corrugated tube in which oxygen was stored during expiration. The tube was bent in the form of a U so that “the oxygen, being heavier than air, cannot escape through the open end” (29). One wonders how effective this was because the difference in density between air and 100% oxygen is only 11%. Pipe mouthpieces were also made available in case anyone using a mask should find this suffocating. The climber put the rubber tube in his mouth and clamped it with his teeth during expiration. The whole apparatus complete with four full bottles of oxygen weighed ~14.5 kg, and 10 sets were made available to the expedition.

The oxygen flow rates advocated by Dreyer varied from 2 l/min at 7,000-m altitude to 2.4 l/min at the Everest summit. He recommended that oxygen not be used below 7,000 m but always inspired above that altitude. He also suggested that sleeping oxygen be available at a flow rate of 1 l/min. Subsequent experience showed that sleeping oxygen at only 1 l/min was indeed appropriate; however, at altitudes of 8,000 m and above, a flow rate as high as 4 l/min was valuable. At the flow rates recommended by Dreyer, four bottles would provide for a climb lasting for ~7 h. One of the oxygen sets is in the Science Museum (London, UK), although probably not on display.

Because Finch was a trained physical scientist with considerable technical skills, he took charge of the oxygen arrangements on the actual expedition. He instituted periodic oxygen drills, but these were unpopular and indeed there was a good deal of antagonism toward the use of oxygen. Finch stated that, “By the time we reached Base Camp, I found myself almost alone in my faith in oxygen” (14). The anti-oxygen group, which included George Mallory, saw the use of oxygen as unnecessary, and they tended to ridicule the equipment. There were also objections on moral grounds, and Mallory referred to its use as “damnable heresy,” which mystified Finch who pointed out that the mountaineers adopted “other scientific measures



Fig. 5. Drawing showing the mask, inspiratory and expiratory valves, and the economizer that was designed for the 1922 expedition. The economizer stores oxygen during the climber's expiration so that it can be subsequently inspired. The right-hand end of the economizer is open to the air. (Modified from Ref. 9.)



which render mountaineering less exacting to the human frame" (9). Finch's rigorous professional attitude derived from his scientific training was evident in other logistical aspects of the expedition as well (24).

Finch and Geoffrey Bruce carried out the first trials of the oxygen equipment at high altitude toward the end of May 1922 and immediately obtained convincing results. It was clear that climbers who used oxygen could outpace those who were breathing air. For example, when Finch and Bruce climbed from Camp 3 (6,400 m) to the North Col (7,010 m), this took only 3 h with oxygen; this was much less than the usual time without oxygen. Subsequently, they used supplementary oxygen to put in a camp at 7,770 m, which they expected would allow them to reach the summit the next day. However, a fierce storm developed, and they spent much of the night and the following day trying to prevent the tent from being blown away with themselves inside it. This unexpected delay reduced morale to a low level, and then Finch thought of inhaling

oxygen at a low flow rate while they were sitting in the tent, whereupon their spirits improved. They used oxygen during the night and slept well, and Finch stated that he had no doubt that oxygen had saved their lives.

On the following morning, Finch and Bruce set off hoping to reach the summit, but the weather worsened. At an altitude of 8,320 m, they had some difficulties with the equipment and it soon became clear that the long period when they were delayed by the storm had weakened them too much. They reluctantly decided to go down, although they were only a little over 500 m from the summit. However, Finch and Bruce had reached a higher altitude than any human being had previously attained.

#### 1924 AND AFTER

Finch had clearly demonstrated the value of supplementary oxygen for climbing at extreme altitude and indeed had, with Bruce, attained the altitude record.

Subsequent calculations showed that the climbing rate of Finch and Bruce up to 7,770 m exceeded that of Mallory, Norton, and Somervell without oxygen by up to 50% (21) or as much as 300% (5). Furthermore, as a professional scientist with strong engineering skills and someone who had been intimately involved with the design of the equipment for the 1922 expedition, Finch knew more about the technical aspects than any of the other climbers. In fact, on June 16, 1923, when the plans for the 1924 expedition were discussed, Finch was asked to advise the Everest Committee on the use of oxygen. It would be natural to think that, in light of these qualifications, Finch would be an obvious choice for the next Everest expedition, to take place in 1924. However, he was not selected by the Everest Committee and indeed never again had an opportunity to test the value of oxygen at extreme altitude.

The reasons for Finch's rejection have been discussed in detail by Scott Russell (14) and will only be summarized here. First, there was a dispute with Hinks regarding lectures that Finch was invited to give in Switzerland about the 1922 expedition. There was a limitation on the amount of lecturing that expedition members could do, and, according to Finch, Hinks claimed that this agreement would be enforced until Everest was climbed! Because this would not be for another 30 years, it does seem unreasonable. But there were other tensions as well along the lines of those referred to earlier. Finch had the reputation for being an outspoken, unconventional Australian in a setting where these characteristics created antagonism. He was very much a square peg in a round hole in the setting of the Alpine Club in the early 1920s.

It is interesting that subsequent events proved the key importance of developing good oxygen equipment for the first ascent of Mt. Everest. One major reason for the failure of the Swiss on Everest in 1952 was their inadequate oxygen equipment (31). John Hunt, leader of the successful British expedition of 1953, wrote after the expedition (18)

Among the numerous items in our inventory, I would single out oxygen for special mention. Many of our material aids were of great importance; only this, in my opinion, was vital to success. . . . But for oxygen, without the much-improved equipment which we were given, we should certainly not have got to the top.

It is noteworthy that the oxygen equipment of 1922 (Figs. 3–5) was similar in many ways to that used on the successful 1953 expedition. Technical advances meant that the later tanks were lighter and could be filled to a higher pressure, but the reducing valve and economizer used the same principles. Finch saw the equipment in 1952 and referred to it as “splendid” (13). It is natural to wonder whether E. F. Norton, who reached an altitude of 8,570 m during the 1924 Everest expedition without supplementary oxygen, would have been able to accomplish the last 300 m if Finch's expertise had been available. Mallory and Irvine used

oxygen equipment of a new design based on Finch's ideas, but whether they reached the summit will presumably never be known.

Finch went on to become an eminent scientist, particularly on the surface chemistry of metals (4). His early work was on the mechanism of combustion in gases as a result of electrical discharges. He subsequently used electron diffraction to examine surface structures and developed the Finch camera for this purpose, which was a major advance. He also worked on the physical chemistry of lubricants, the electrodeposition of metals on surfaces, and electron diffraction in small crystals. He was elected a Fellow of the Royal Society in 1938.

In 1952, Finch retired from Imperial College to become Director of the National Chemical Laboratory in Poona, India. There, he stimulated research in two new fields related to solid state physics and to surfaces and thin films. He returned to England in 1957. Happily, he was eventually elected President of the Alpine Club and served in that position from 1959 to 1961 immediately following the term of John Hunt. It is not clear to what extent the square peg and round hole had changed their shapes, but probably a little of both occurred.

Finch wrote a book on his Everest experiences in German (10) and also a shorter account in English (12). However, his most enduring monument is his book *The Making of a Mountaineer* (9). Farrar's review in the *Alpine Journal* ended with the sentence

All in all, the book is worthy to be set alongside Whymper's immortal “Scrambles [Amongst the Alps]” and Mummery's “My Climbs [in the Alps and Caucasus]” as indicating, as they did in their day, the high-water mark of mountaineering of the period.

The book has inspired generations of mountaineers. Scott Russell edited a reprint in 1988 (14) with a fine 116-page memoir of Finch at the beginning. John Hunt wrote the foreword, which begins “My copy of George Finch's *The Making of a Mountaineer* was a present from my paternal grandmother at Christmas 1924. I was 14 at the time, and it is that book which sowed the seed of my desire to climb.” He went on, “The chapter on the Everest expedition in 1922 added a dimension of realism to the heroic and romantic character of the attempt on the summit which followed two years later. I felt that George Finch, who had done so much to show how the physiological problems might be solved, might well have played an important—perhaps a decisive—part in the ill-fated 1924 expedition.”

Thus Finch, who was acknowledged as one of the strongest mountaineers of his generation, who had demonstrated extraordinary tolerance to hypoxia in a low-pressure chamber, and who had the scientific and technical expertise to develop oxygen equipment for the first three Everest expeditions, was denied the opportunity to participate in two of them because of the complexities of human nature. The story is one more in the never-ending romance of the ascent of Everest.

## APPENDIX 1

*Analysis of the Exercise Tests of Finch in the Low-Pressure Chamber*

Finch performed two exercise tests in Dreyer's low-pressure chamber in Oxford (26, 29). The first was on March 26, 1921, and the second was on about January 14, 1922.

For the first test, the simulated altitude of the low-pressure chamber was 21,000 ft (6,400 m), and Finch stepped up on to a chair, first with one foot and then with the other 20 times in succession in 2.5 min. This description allows us to make a reasonable estimate of his work rate. His body weight was 11 stone 3 lb. (see APPENDIX 2), and he carried a 35-lb. load, giving a total mass of 87.3 kg. If we assume a normal chair height of 46 cm, the work rate is  $(87.3 \times 0.46 \times 20)/2.5$  or 321 kg/m = 52 W. The barometric pressure was 341 mmHg.

For the second test, the simulated altitude of the chamber was 23,000 ft (7,010 m). Finch carried a load of 30 lb. and stepped on and off the chair 20 times at 8 s per step. If we assume the same body weight, the work rate is  $(85 \times 0.46 \times 20)/2.67$  or 293 kg/m = 48 W. The barometric pressure was ~323 mmHg.

Almost no similar experiments have been reported with such a severe degree of acute hypoxia. However, it is clear that Finch's performance was exceptional. The only comparable study in the literature is that of Margaria (22, 23), in which three students aged 22 yr and Margaria himself aged 27 yr exercised on a bicycle ergometer in a low-pressure chamber at several simulated altitudes, including 6,500 m, barometric pressure 330 mmHg. Under these conditions, two of the students were unable to sit on the bicycle and ended up lying on the floor of the chamber where their skin became pale, their lips turned blue, and they lost consciousness! The third student was not studied at this altitude, and only Margaria was able to exercise under these conditions. In fact, Margaria was able to exercise up to an altitude of 7,000 m, barometric pressure 316 mmHg, although he developed spastic contractions of his hand and facial muscles. Margaria concluded that, on the average, work capacity falls to zero at just over 7,000-m altitude. These results are consistent with the statement of Dreyer that, of the 1,000 selected athletic young men exposed to simulated high altitude that he had examined, Finch showed the highest resistance to acute hypoxia. Incidentally, it is extremely unlikely that such an experiment would be allowed under present guidelines for human investigations because of the dangers of the extremely severe hypoxia. Also, it is probable that most of the 1,000 men referred to by Dreyer were exposed to hypoxia by using a rebreathing circuit, not a low-pressure chamber.

## APPENDIX 2

These are the two medical reports that resulted in the withdrawal of the invitation to Finch to join the 1921 expedition (see Fig. 2). These medical reports are transcribed in Table 1.

## APPENDIX 3

The medical reports by Drs. H. Graeme Anderson and F. E. Larkins were pivotal in Finch's exclusion from the 1921 expedition. More information on these two people and A. F. R. Wollaston, the expedition doctor, is reported below.

Major Henry Graeme Anderson (1882–1925), M.B.E., M.D., Ch.B., F.R.C.S. (England), was born in Scotland and was educated at Glasgow University, Kings College London,

Table 1. *Transcribed version of the two medical reports shown in Fig. 2*

**Report by Dr. H. Graeme Anderson**

Telephone 75, Harley Street,  
PADD. 5042. W.1.  
17 .. 3 1921

## Surgical Report on Capt. G. I. Finch

Altitude Test = 58 Seconds. = good [this was a breath-holding test]. Sallow. Nutrition poor. Spare. Flabby. Pupils react. Knee jerks present. Cerebration active. Mentality good - a determined type. But his physical condition at present is poor. No varicose veins. No hernias. No haemorrhoids. Movements of all joints full and free.

[Signed] H. Graeme Anderson, M.D., Ch.B., F.R.C.S.

**Report by Dr. F. E. Larkins**

Telephone, Paddington 5042 75, Harley Street,  
W.1.  
March 18, 1921

## Medical Report on Capt. G. I. Finch

General appearance -	Tired. Sallow complexion
Nutrition.	Poor.
Physique.	Fair.
Height.	6' 02 in
Weight	11 <sup>st</sup> 3 [157 lbs]
Previous illness.	Malaria
Heart - apex beat	1¼" + 4¾" = 6¼" in 5 <sup>th</sup> interspace ½" inside? mcl no cardiac murmurs or irregularities.
Pulse -	72. Vessels slightly thickened
Blood Pressure.	118.
Chest	measures 34"-38" no impairment of resonance breaths sounds normal V.R. & V.F. normal
Blood examination	R.B.C. 4500,000 W.B.C. 10,500 Hb. 85%
Nervous system.	Reflexes normal. Coordination normal.
Hearing.	Normal.
Sight.	R & L 6/6.
Ears, nose & throat.	Healthy
Urine.-	1022. acid No albumin <u>Reduces Fehling</u>
Alimentary system.	17 teeth missing No enlargement of liver, spleen, stomach. No tenderness of appendix

This man is not at the moment fit. He has been losing weight. His urine reduces Fehling. He is slightly anaemic, and his mouth is very deficient in teeth.

He may improve considerably with training. His urine ought to be retested once a week. His teeth deficiencies can be overcome with plates.

[Signed] F. E. Larkins, M.D.

and the London Hospital. He was house surgeon at St. Mark's Hospital (London, UK) from 1907 to 1908 and surgical registrar at several hospitals, including the Royal National Orthopaedic Hospital (1909–1912). He joined the Royal Navy in 1914 and was attached as surgeon to the original Royal Navy Air Service Expeditionary Force. He gained his aviator's certificate at the Royal Aero Club in 1916 and was later transferred from the Royal Navy to the Royal Air Force as Major. In 1919, he authored a 255-page book (*The Medical and Surgical Aspects of Aviation*), which was

apparently the earliest textbook on this subject. This book includes a section on the influence of acute exposure to high altitude on the body and so he was well-informed on this topic.

Francis Edmond Larkins (1880–1962), M.B., Ch.B., M.D. (Edinburgh), D.P.H., R.C.P.S. (Edinburgh and Glasgow), was born in Kingston-on-Thames (Surrey, UK) and took his medical degree at the University of Edinburgh. He was a house physician at the Edinburgh Royal Infirmary and had other appointments at the Infectious Disease Hospital (Leith, UK) and the Children's Hospital at Newcastle-on-Tyne. He published several articles on children's diseases and was particularly interested in caries in elementary school children and children's nutrition. Incidentally, his interest in caries may explain his detailed comments on Finch's lack of teeth.

Alexander Frederick Richmond Wollaston (1875–1930), M.A., B.Ch., M.R.C.S., L.R.C.P., F.R.G.S., was born in Clifton near Bristol and was educated at Clifton College, Kings College (Cambridge, UK) and the London Hospital Medical School. He was a gifted naturalist who early made up his mind to become an explorer and only studied medicine to facilitate his chances of travel. In fact, he once wrote to his father, "medical practice as a means of a livelihood does not attract me—in fact I dislike it extremely." In a letter to a young man who was considering going into medicine, Wollaston wrote "I made such a horrible mistake when I went in for a profession which I loathe, and I am so constantly regretting it." He took part in several expeditions, including the British expedition to Ruwenzori, Central Africa, 1905–1907, and two expeditions to Dutch New Guinea, 1910–1913. He was a surgeon in the Royal Navy during World War I and medical officer and naturalist on the 1921 Everest expedition. In later life he was elected a fellow of Kings College, where tragically he was shot dead by a demented undergraduate. It is interesting that his entry in *Who Was Who* lists F.R.G.S. (Fellow of the Royal Geographical Society) as his primary degree.

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