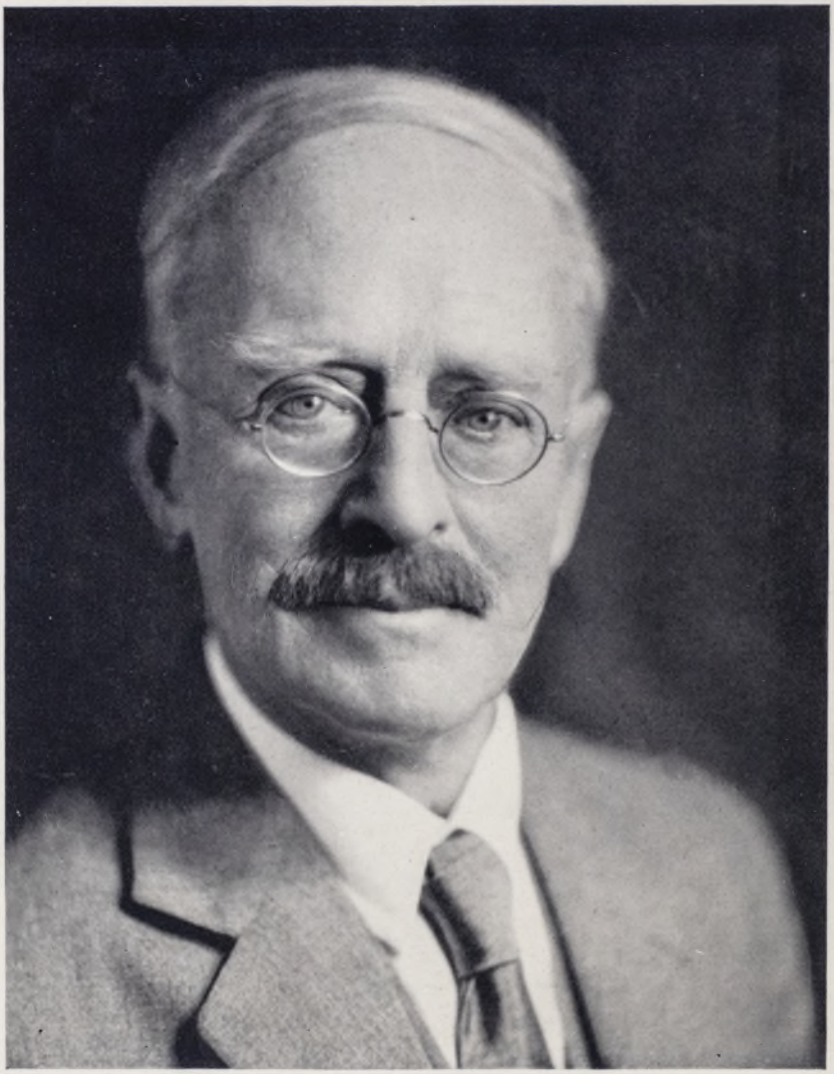

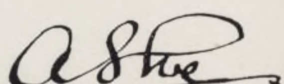

ARTHUR STEWART EVE

1862–1948

ARTHUR STEWART EVE, who will be remembered mainly for his pioneer work on radioactivity and his lovable character, was born at Silsoe, Bedfordshire, on 22 November 1862, son of John Richard and Frederica (Somers) Eve and, after an active and varied life spent for the most part in Canada, passed away in retirement at Puttenham, Surrey, on 24 March 1948, in his eighty-sixth year.

Scholar, teacher, pioneer with Rutherford, soldier and scientific director in the first World War, Eve later was appointed Head of the Department of Physics in McGill University, Montreal, and Dean of the Graduate Faculty. The fine, well-balanced qualities of the man are well presented in the following quotations from an editorial, 'In a Great McGill Tradition', which appeared in the *Montreal Gazette* at the time of his death :

'In the best sense, he was a university character. He was provocative but not contentious, kindly but not sentimental, critical but not cruel, humorous but not foolish, shrewd but not harsh. As he moved about the campus walks in his last years at McGill, he was a man whose life had been deepened by the vigorous use of the mind on illimitable problems, and mellowed by zest and common sense which had kept his outlook keen and reasonable.'

'Dean Eve's discoveries in radioactivity and in geophysics received their due and full recognition from the highest learned societies of the world, including the Royal Society of London, on whose Council Dr Eve served in his later years. They were the recognition of the fruits of his "voyaging through strange seas of thought".

'But these far voyagings, valuable as they were in their discoveries, never took Dr Eve away from the warmth and colour of ordinary human experience. In the soundness of his humanity he looked for his satisfaction:

' "Not in Utopia—subterranean fields,—
Of some secreted island, Heaven knows where!
But in the very world, which is the world
Of all of us,—the place where, in the end
We find our happiness, or not at all." '

Always fond of engaging in sports, Eve disliked to watch them. As a young man, Eve showed marked enthusiasm and skill in cricket, soccer, tennis and rowing. Games had a pronounced influence on his general attitude toward

life, and in later years he spoke of a successful line of research as 'the real thing' or 'a good game'.

Young Eve was also a first-class scholar. As Exhibitioner, he was trained at Berkhamsted, from which he entered Pembroke College, Cambridge, as a scholar. Here he was fourteenth wrangler and graduated in 1884; passed with first-class honours Part II of the Natural Science Tripos in 1885, and received an M.A. in 1887.

For the following sixteen years Eve was Assistant Master at Marlborough College where his marked success in the training of men now distinguished was not lessened by volunteer military duties and the Bursarship, which he held during the last five years. For reasons of health, Eve resigned in 1902 and went to Canada where he soon became a lecturer in mathematics at McGill University.

Just at this time the whole problem of natural radioactivity was cracking under the genius of young Rutherford. As an active member of the McGill group, Eve took part in the unfolding of the story of radioactivity in those early exciting days. His own contributions included studies in the nature of γ-rays; the discovery of secondary γ- and β-rays from primary γ-rays; total ionization from γ-rays; use of γ-rays for the determination of radioactive material in bulk; measurement of radium in rocks, sea-water, and of emanation in the air; measurement of ions in air over land and sea. This series of well-written, logical papers was finally stopped by the baffling problem of 'penetrating radiation' (cosmic rays).

It was known that γ-rays were not deflected by a magnet, yet the controversy about their nature was prolonged by the fact that the ionization they produced in gases was roughly proportional to the density, whereas for (soft) X-rays very striking departures from this relation had been noted. This barrier to their ready acceptance as a form of Röntgen waves was largely wiped out by Eve through the use of a comparatively hard X-ray tube screened by 1·8 mm. of lead. He states that, 'As matters stand, the most notable difference between X- and γ-rays is that the former arise where the cathode rays are stopped or absorbed, and the latter where the β-rays originate'.

In an early research, Eve discovered that γ-rays from radium produce secondary γ-rays from some depth in any body upon which they fall, and that the intensity of such rays is approximately proportional to the density of the radiator. By means of a magnetic field, he also showed that the primary γ-rays produce secondary β-rays which emerge from the outer surface of the radiator. This point was rather important at the time since it offered a logical explanation of an observation by Paschen which led the latter to the conclusion that γ-rays were negatively charged particles. Paschen had found a positive charge on an insulated lead box intended only to absorb the β-rays from an enclosed sample of radium.

Experiments by Voller appeared to show that radium decayed at an abnormally high rate when deposited in extremely small quantities on metal in open air, and that the activities in such cases were far from proportional to the radium

present. Since this observation seemed to question the Rutherford view that changes in concentration or any other physical variation had no effect on activity or rate of decay, Eve enclosed small samples of this sort in suitably sealed vessels and confirmed the original view of Rutherford.

Since α- and β-rays from radioactive substances are easily absorbed—even by the sample itself in bulk—Eve undertook an investigation of the possibility of using their γ-rays as a standard means to determine the radioactive content. He learned that the γ-rays from radium and thorium have approximately the same character, so that the amount of these substances in an ore sample may be found by comparison with a sealed standard solution containing a known amount of radium bromide. He showed how to measure self-absorption in the standard.

In a further study, Eve learned that the secondary γ-rays from RaC are softer than the primary. These secondary rays were later found by Gray to be softer with increase of the angle through which the primary rays are scattered (Compton effect).

Since Strutt had examined about fifty rocks of all types and ages and observed an average radium content (assumed uniform through the earth) twenty-eight times that calculated by Rutherford as sufficient to account for the temperature gradient of the earth, Eve undertook an examination of nine specimens from the North American continent which was not represented in the work of Strutt. It turned out that the average radium content of the American rocks was only 25 per cent below the European average. Eve was forced to conclude that radium was less plentiful in the central core of the earth, since he could not seriously entertain the suggestion that excessive pressure retarded the rate of decay. Since writing this, Professor Terroux has informed me that he has a sample of material containing radium which was used in the initial operation of a powerful press in the Testing Laboratory of the Engineering Building at McGill. It was characteristic of the McGill group to find the answers to questions raised elsewhere.

Eve proposed a very simple method of finding the total ionization of γ-rays absorbed in air only. Let K be the number of ions per cm.[3] per second generated by γ-rays at a distance of one centimetre from a gram of radium bromide considered as a point source. Then the total number of ions per cm.[3] per second from Q grams at a distance r is

$$N=\frac{KQ}{r^2}\,e^{-\mu r}$$

where the coefficient of absorption μ is assumed constant in this pioneer work. The total number of ions per second in all the surrounding air is therefore

$$N\text{ (total)}=\int_0^\infty \frac{KQ}{r^2}\,e^{-\mu r}\cdot 4\pi r^2 dr=\frac{4\pi QK}{\mu}.$$

In an experimental determination of K, Eve noted the importance of using a thin-walled aluminium chamber to approach the ideal all-air conditions for

observation of ions excited by γ-rays from a standard radium bromide solution placed at a known distance. Correcting for necessary absorptions, Eve gives the figure, $K = 3{\cdot}1 \times 10^9$.

From an initial study of 'penetrating radiation'—in which the original ionization was reduced to 30 per cent of the initial value by five tons of pig iron placed around the chamber—Rutherford and Cooke concluded that the persistent effect was not due to radioactivity on the walls of the laboratory, since similar results were obtained in the uncontaminated library.

In search of a possible explanation of the above, Eve undertook the first examination of the atmosphere to estimate the amount of radioactive matter in a known volume—in terms of the radium required to maintain it—and to see if the natural ionization of the air may be attributed wholly to this. A wire at $-10{,}000$ volts collected active deposit from a distance of 50 cm. in a long enclosed tank and the activity of the deposit on the coiled wire was examined by an electroscope. Comparison was made with the activity from a standard solution of radium bromide, similarly determined. As Professor Eve learned later, the lack of hydrochloric acid in this early solution led to a precipitate which retained about half the emanation. Correcting for this, the amount of radium element required to maintain the observed activity in one cubic metre of the atmosphere was found to lie between 4 and 14×10^{11} grams. The average value was not greatly changed by later experiments in which the emanation itself was trapped by charcoal.

The question whether this is enough to explain all the observed ionization in the air was handled in a simple and ingenious manner. The rate of ionization in a *large* tank was observed; active deposit collected, and its rate of ionization measured in a standard electroscope. The ratio of these rates was noted. Emanation from a standard solution was put in a *small* tank; rate of ionization recorded and deposit collected and placed in the same electroscope. The ratio of the rates was over 20 per cent lower in the latter case. This figure was the average of readings taken over many months. Eve might reasonably have claimed a foreign radiation, but he allowed this to pass as an experimental error—or possibly due to radium in the surface layer of the earth.

To test the latter hypothesis, many observations were made over the ocean by Eve and others. These revealed the shocking fact that here the ionization was not appreciably less—even though the radium concentration in the ocean was found to be extremely small compared with that in the land. Summing up at this time, Eve writes: 'The emanation from the radium in sea-water, and the penetrating radiation from the active matter contained in it, are insufficient to account for the ionization observed over the ocean'.

He nevertheless exhausted every available avenue for a possible explanation in terms of known phenomena. Though the sea was calm at the time observations were made, he made an exhaustive study of the high degree of ionization obtained in artificial spray. Though the sea-water contains little radium, he later collected active deposit on a freely exposed wire over the ocean. Strange as it seemed, the active deposit so collected at sea in a single series of readings

was equal, on the average, to that found over land. For the solution of his problem, Eve lacked free access to one essential piece of equipment, viz. a high mountain.

As a natural consequence of the above successful researches, Eve rapidly shifted his main interest to physics, and in 1909 he was appointed Associate Professor of Physics. In the following year, he was elected a Fellow of the Royal Society of Canada.

At the height of his research career, Professor Eve married Elizabeth Brooks, a graduate of McGill University, who shared her husband's enthusiasm for the pioneer work he was doing, and continued to aid and inspire him throughout his distinguished career. Mrs Eve's sister Harriet (Mrs F. Pitcher) was the discoverer of the recoil of atoms which emit α-rays. Many distinguished scientists recall with pleasure visits with the Eves to the Laurentian home of Mr and Mrs Pitcher. The broad interests in the home of Professor and Mrs Eve are shown in the artistic talents developed in their children Richard, Joan (Mrs Dennison Denny) and Cicely (Mrs A. Grinling). A frequent visitor to the home wrote to Mrs Eve, 'I think it was the happiness you had in each other and the Professor's unquenchable spirit that always made your home so lovely to come to. There was a quality that everyone from the age of five upwards loved and admired'.

Activity in sports was essential in Eve's life. Nevertheless he regretfully reduced the number of sports as figure skating and tennis became less appropriate in later years. He was a good tennis player. At the Macdonald Physics Building the first sign of spring was the annual overhaul of fishing tackle and golf clubs by Mr Pye. These sports he loved to the last, and spent many happy holidays fishing on the estate of his brother-in-law, Sir Charles Gordon, in Scotland.

Shortly after Hess had resolved the problem of 'penetrating radiation' by his discovery of radiation from outer space, war burst over the world and caught our subject in its wake. So far as available records show, Eve had started his military career as Honorary Captain commanding the Marlborough Cadet Corps, and as Lieutenant in command of the Cyclists Company of the Second Battalion, Wiltshire Regiment of Volunteers. At the outbreak of war, Eve enlisted as a private in the McGill Provisional Battalion. Following rapid promotions, he raised and trained the 3rd and 4th University Companies which later joined the famous Princess Patricia Canadian Light Infantry. As Major, he was placed second in command of the 148th Battalion affiliated with the McGill Contingent C.O.T.C., and went overseas with them to join the Canadian Expeditionary Forces.

In all these ventures Eve's sound military knowledge and understanding of university men—together with the natural ability to hold the sympathetic attention and respect of all ranks—made him exceptionally valuable. His Commanding Officer, Colonel Alan A. McGee, K.C., reports that Major Eve's realistic view and originality led to innumerable ingenious improvisations which were woven into the regular course of training. While his physical alertness and stamina enabled him to match any tests required of his men, there

was a general opinion that the Major's insight into the possible difficulties of warfare at night over rough terrain was rather deeper than the enemy was likely to develop. Which is to say, the men were perfectly trained in Canadian style. In this, as in all his dealings with men, Eve was firm, fair, and always had very much at heart the best interests of those under his command. A friend in the 148th writes:

'To the world in general he is justly famed for his contributions to the advancement of scientific knowledge, but those who served under him in the old battalion will always think of him as a sincere, unassuming and affectionate friend. He was so keen and untiring and at the same time so inspiring, human and thoughtful. It is not overstating the case to say that he was dearly beloved by all, and especially by us subalterns whose problems he seemed to understand so sympathetically.'

When the 148th was re-formed into the 20th Reserve Battalion to reinforce the Canadian Army in France, Major Eve saw at last the opportunity for active service which had been his aim.

However, he was by this time (1917) fifty-five years old and a distinguished scientist with proven executive ability. When Sir William Bragg became scientific adviser to the Admiralty it was therefore natural that Major Eve was approached and persuaded to forgo active service and succeed Sir William as Director of the Admiralty Experimental Station at Harwich.

It will be readily understood that the Navy of those days was not inclined to place so much confidence in novel devices by 'long hairs' as it is to-day, and in consequence of a well-remembered reluctance to place valuable ships at the disposal of scientists the continued rapid development of devices for the guidance of ships and the detection of submarines at Harwich was maintained by Eve's personal interest as a scientist, and magnificent qualities as an administrator. Of 'asdics' Eve writes:

'Professor Langevin in France and Sir Ernest Rutherford in England formulated a scheme of a most ingenious character but presenting difficulties of a high order. This work was entrusted to Professor R. W. Boyle, formerly of McGill University. He was able to superintend this work in its entirety and to carry it out from its inception to a triumphant conclusion when the apparatus was fitted and tested on a suitable class of ship in the Royal Navy.'

Honours now began to come to Major Eve in rapid succession. For his fundamental researches in radioactivity, he was elected a Fellow of the Royal Society in 1917 and in the following year he was promoted to the rank of Colonel and was made a Commander of the British Empire in recognition of his wartime services.

In the meantime, the Physics Department at McGill was guided by Dr Howard Barnes, Macdonald Professor of Physics and Head of the Department (1909–1919). In the war years, Barnes carried an exceptionally heavy load

arising from a great reduction of staff. Even so, this skilful and exceptionally able physicist invented a most ingenious 'vortex gun' of great promise. When his wife died quite unexpectedly, Barnes failed to withstand the shock and suffered a prolonged nervous breakdown. Misjudging his powers of recovery—Barnes was a man with strong discipline and balanced judgment—the University authorities asked Professor Eve to take over the position and duties vacated by his old friend.

With the cooperation of his former Commander-in-Chief, Sir Arthur Currie—now Principal of McGill—Eve immediately began to rebuild the Department. Dr Etienne Bieler, an 1851 Exhibition Scholar who had investigated with Chadwick the minimum range of purely coulomb forces round nuclei, and had himself rendered valuable war service, was appointed to take charge of work in electricity and magnetism and continue with his researches. Dr David Keys was appointed for optics, laboratory practice, and to give lectures to honour students. Eve had met Keys in England during the War and was attracted by his personal charm and unusual training at Toronto, Harvard, Munich and finally with J. J. Thomson in Cambridge. Eve and Keys were to collaborate later in a series of papers in geophysics, and eventually to write two standard textbooks, one on applied geophysics and a second (with Mendenhall) on college physics. The writer takes this opportunity to express his indebtedness to Dr Eve for an excellent opening for research which arose through the loss to McGill of Dr J. A. Gray who became Chown Research Professor of Physics at Queen's, and the recurring ill-health of Dr Louis King, Macdonald Professor and the most able Canadian who has worked in physics. Training and research for the Ph.D. were then undertaken for the first time at McGill. Professor Eve raised funds for travel to scientific meetings.

Just at this time (1929) the Department received a major shock from the sudden death of Dr Bieler in Australia. Bieler was greatly beloved for his first-class ability in physics combined with complete intellectual honesty. Bieler had gone there at the invitation of the Australian Government to apply geophysical methods he had developed in Canada. After very careful consideration of the requirements, Bieler was replaced by Dr W. H. Watson whose work in mathematical physics, philosophy of physics, and analysis of special radar problems amply justified the choice.

Many series of public lectures were initiated by Professor Eve for different purposes, (i) to acquaint an interested Montreal public with new developments in physics, (ii) to give science teachers in nearby schools additional insight and (iii) to stir the imagination of children. Eve himself was a gifted artist who could paint with words a fascinating picture of the great achievements in any field of physical science. He rather urged members of the staff to take part in these series—to their very great profit.

After the Department had been put in good order, Professor Eve again picked up the threads of research—at the age of sixty-seven—but with the continued executive burden so commonly placed on able university men who work on the North American continent. Chiefly he worked on geophysical

problems during the summer months in collaboration with Dr Keys and with assistance from the U.S. Bureau of Mines. Through the solution of a number of fundamental problems, and the insight gained into the leading methods of geophysical prospecting, a first comprehensive text was prepared by Eve and Keys on *Applied Geophysics*. Successful as this publication proved to be, it failed to reach the standard of novelty and importance embodied in the work done in his prime.

Though he gave lectures to graduate and honours students, Professor Eve seemed to enjoy most his lectures to large undergraduate classes. These were always stimulating and generously illustrated with novel experiments and incessant attention to numerical problems. His experience and ripened judgment so developed are represented in the popular text on *College Physics* written with Dr Keys who by this time had also enjoyed great success with large classes. This text is of such excellence that one hundred colleges have adopted it.

Upon his return to Canada (1919) Eve was elected President of Section III of the Royal Society of Canada (Mathematics, Physics, Chemistry and Astronomy), and in 1929–1930 he was President of the Society as a whole. The annual meeting was held that year in Montreal, and Fellows will recall not only his Presidential Address but also his trans-Atlantic conversation under arrangements which permitted the full membership to hear the enthusiastic and friendly voice of Rutherford.

Eve served for three years on the Council of the American Physical Society and arranged for the first meeting of the Society in Montreal in February 1926. Not the least attractive feature of the meeting was a dinner arranged by the University at which Sir Arthur Currie presided. At that time, Eve defined a physicist as 'one who has to untie the last knot'. Many physicists are still measuring time from that dinner.

From 1930 until his retirement in 1935 Professor Eve was asked to assume additional duties as Dean of the Faculty of Graduate Studies and Research. He directed much effort toward the establishment of a uniform standard for the Ph.D. in all departments.

In recognition of his position in Canadian science, Dean Eve was granted an honorary degree of Doctor of Laws by Queen's University in 1933, and at his last convocation in Montreal, McGill University granted the same degree and appointed him Emeritus Professor of Physics in recognition of his long and effective services. Friends arranged a farewell dinner at the Mount Royal Club at which the Dean was toasted and replied with a brief review of highlights in his life. Most shocking was the murder of the Czar and his family. A host of friends joined in gifts to Dean and Mrs Eve including a painting of the Dean by Holgate which hangs in the Physics Library.

Immediately upon his retirement to London (1935) he was appointed Honorary Physicist for the Radium Beam Cancer Research Board, succeeding his friend Sir John McLennan. Here he was on his most familiar ground. He was fascinated by the methods of handling exceptionally strong sources. As a pioneer who first learned how to study the ionization of γ-rays, his advice

was valuable. A little later he was elected to the Council of the Royal Society and the Council of the National Physical Laboratory.

These duties might have absorbed his energy (apart from golf and fishing) but for the wholly unexpected death of his friend Lord Rutherford. As a former colleague and lifelong friend, Eve was persuaded to undertake the *Rutherford* —'being the Life and Letters of the Rt Hon. Lord Rutherford, O.M.'. A gifted writer, Eve is particularly successful in capturing the spirit of the early days in Montreal. He writes (p. 91) of his first meeting with Rutherford:

'My own first meeting with Rutherford was at McGill in January, 1903. Rutherford was already famous, radium was the rage and the radioactive theory of the break-up of atoms was a topic of supreme interest. Journalists besieged the Laboratory and wrote fabulous and fantastic stories until they were forbidden the sacred precincts.

'At this first interview I realised that Rutherford's eyes had a curious fascination. As you looked at them you began to understand the saying, "If thine eye be single, thy whole body shall be full of light".'

Speaking of the main 'break' in the problem of radioactivity, he quotes Soddy (p. 86):

'Rutherford and his radioactive emanations and active deposits got me before many weeks had elapsed and I abandoned all to follow him. For more than two years scientific life became hectic to a degree rare in the lifetime of an individual, rare perhaps in the lifetime of an institution. The discovery that the emanations were "argon" gases, followed by that of thorium X as an intermediary product between thorium and the emanation it produces, led rapidly to the complete interpretation of radioactivity as a natural process of spontaneous atomic disintegration and transmutation.'

Of one of his earliest researches (1904) Eve writes:

'I was asked by Rutherford to make a sensitive, small-capacity electroscope, the gold leaf of which would remain charged for two or three days. This I failed to do. So Rutherford said: "Lester Cooke used to make them; why can't you? Get Jost to make you one". So I went to Jost, the mechanic, and repeated this. He said, "If I could not make a better electroscope than Cooke, I'd shoot myself!". So he made a beauty to look at, but a bad one to go. Its leaf collapsed in twelve hours. This puzzled me. One night I could not sleep and got up in my diggings and made an electroscope of a tobacco tin, an amber mouth-piece of a tobacco pipe, and some Dutch metal foil; charged it with sealing wax and went to sleep. The leaf of this home-made freak electroscope remained open and charged for three days, and solved the problem. An electroscope made of material outside the Laboratory would remain charged for 48 hours inside the Laboratory, but all the material inside the building was contaminated and coated with active deposit including the slow period

transformations of radium. Rutherford said, "Good boy!" although I was eight or nine years his senior in age.'

Shortly after completing the work on *Rutherford*, Eve was stricken (1940) with partial paralysis. With magnificent courage and constant help from his wife, he partially recovered and was able to walk in his garden. Except for occasional and brief lapses, he was mentally keen and remained the grand old man of Canadian science. Visitors from home and abroad sought his advice on Canadians and Canadian affairs, and were cheered by his great courage and wit.

Looking over his life in review, one sees a purposeful pattern kept flexible to meet prevailing conditions. Eve kept his broad aims to himself, and carried out each day's work—however difficult—with admirable serenity.

J. S. Foster

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