on Piccadilly. As he passed Green Park, he thought about the implications of his discovery. He entered Hyde Park and headed towards the Serpentine. He had promised Katherine he would be home in time to go to the stables in Bathurst Mews. They rode most afternoons, he on a hired horse, she on her bay pony Charlie, which had made the long train journey down from Glenlair. The plan was to circle Kensington Gardens and Hyde Park; it was not a patch on their favourite ride from Glenlair to Old Bridge of Urr, but it was the best they could do in smoky central London.

He owed so much to Katherine. Although he had nursed her through much ill health, she in turn had nursed him through smallpox, which had almost killed him shortly before their move to London. She was his soulmate and scientific helper. Together, they carried out experiments in the attic of their London house, the eight-foot-long, coffin-shaped light box with which they 'painted' with sunlight horrifying their neighbours and giving them the reputation of mad eccentrics. For the thirty-two-year-old Maxwell, the sojourn in London was proving to be the most productive episode of his career.

Maxwell hurried along the footpath beside the enormous expanse of the Serpentine, created in the 1720s by King George II as a memorial to his beloved wife, Queen Caroline. To the south of the kilometre-long lake lay the site of the 1851 Great Exhibition, one of the wonders of the century. Among the visitors to the great glass-and-iron pavilion, so enormous it had enclosed some of the park's tallest trees, had been Charles Darwin, Charlotte Brontë, Charles Dickens and Alfred Tennyson. It had been disassembled bit by bit and reassembled at the Penge Place Estate in Sydenham, South London. To the southwest of its former site was 'Albertopolis', the district nicknamed in honour of the royal consort Prince Albert, who had died the previous December and whose plan it was that the Great Exhibition would leave a lasting cultural legacy in the form of museums and institutions. Maxwell had on numerous occasions visited the newly opened South Kensington Museum.[10]

A ferry was chugging across the Serpentine; swans, ducks and seagulls bobbed around it, but Maxwell paid them no attention. He was captivated instead by a rapidly fading rainbow in the sky. Ever since Piccadilly, a single thought had occupied him: his cog-and-bead model set no restriction on how fast or how slow the electromagnetic field might be jiggled, which could mean only that the colours of the rainbow represented a tiny range of possible frequencies. Beyond this visible 'spectrum', stretching away in both directions, there must exist undulations of the electromagnetic fields that were both more sluggish and more rapid than those of visible light. By convention, the rainbow contained seven colours, but in addition to these, he now realised, there must be other 'colours', invisible to the naked eye. Millions upon millions of them. It was an extraordinary, mind-expanding thought.

For a moment, standing on the path by the Serpentine amid squabbling seagulls, he was overwhelmed by a Faraday-esque vision of reality. All about him, stretching to the very fringes of the known universe, was the electromagnetic field, like a vast invisible ocean of energy in constant upheaval, its multitudinous vibrations filling the air all around him. And he was the first person in the history of the human race to realise this.

As the English biologist Francis Crick would one day observe, 'It is not easy to convey, unless one has experienced it, the dramatic feeling of sudden enlightenment that floods the mind when the right idea finally clicks into place. One immediately sees how many previously puzzling facts are neatly explained by the new hypothesis. One could kick oneself for not having the idea earlier, it now seems so obvious. Yet before, everything was in a fog.'[11]

Maxwell's mind was racing. Might it be possible to artificially vibrate the electromagnetic fields? Was it conceivable that, by means of some yet-to-be-invented technology, invisible electromagnetic waves might be created? He could see no reason why not. But it was now late afternoon and he could not afford to daydream any longer. Quickening his pace, he hurried along the bank of the Serpentine and crossed the road into Kensington Gardens. Ahead of him, in the vestibule of 8 Palace Gardens,[12] Katherine would already be dressed for her ride and waiting for him impatiently.

Karlsruhe, 12 December 1887

Heinrich Hertz knew something was leaping across the space between his transmitter and his receiver. According to Maxwell's theory, if electromagnetic waves were spreading outwards from the stuttering spark of his transmitter like a disturbance from a stone tossed into a pond, they should induce an electric current in the conducting loop of his receiver, which in turn should cause a fresh spark to jump across the gap in the loop. He could not yet be absolutely sure that was happening, but he had an idea.

It was not quick to implement; it took almost a month and the help of his assistant, Julius Amman. But now, fastened securely to the sandstone front wall of the laboratory, between

Victor Hess had revealed became stronger with altitude, indicating that its source was not the Earth but something in space.

At the time of Hess's discovery in 1912, the only radiation known was that which emerged from unstable, or 'radioactive', elements, such as uranium, thorium and radium. The cores, or 'nuclei', of their atoms spat out subatomic bullets, in the form of alpha particles (helium nuclei), beta particles (electrons) and gamma rays (high-energy photons). As all three types of radiation rocketed through the air, they smashed apart atoms, whose ricocheting electrons could be detected when they charged up an 'electroscope' or triggered the rattlesnake clicking of a 'Geiger counter'. Hess's 'cosmic rays' – a name coined by Millikan in 1925 – mimicked this 'ionising' effect.

At the end of 1929, with Anderson nearing the end of his PhD, Millikan asked whether he would be interested in investigating cosmic rays. It was a no-brainer for the young student; he was in awe of the Caltech president, who had won the 1923 Nobel Prize in Physics for measuring the charge on an electron.[3]

Millikan thought cosmic rays were gamma rays with enormously higher energy than any found on Earth and that electrons they collided with would ricochet like billiard balls hit by a cue ball. By measuring the energy of such 'Compton-scattered electrons', it would be possible to estimate the energy of the gamma rays.* Millikan suggested that Anderson use a cloud chamber for the task, a remarkable device invented by

* Arthur Compton was an American physicist who won the 1927 Nobel Prize in Physics for demonstrating that high-energy light bounces off electrons exactly as if it were made of tiny bullets. It was proof of Einstein's 1905 claim that light travels through space as a stream of particles, or 'photons'.

Charles Wilson in Cambridge in 1911 which could reveal the tracks of subatomic particles. Its principle was simple and had been copied directly from nature. When moist air rises, it cools and condenses into droplets, forming clouds. Wilson mimicked this process by filling a glass chamber with moist air and suddenly cooling it. Air naturally cools when it expands, so he was able to achieve this by pulling out a piston to increase the volume of the air.

A water droplet will form only if there is a 'seed' such as a grain of dust around which it can condense; if the water vapour is so pure that it contains no such impurities, the condensation seeds may be provided by tiny charged 'ions' created when electrons are stripped from atoms by ionising radiation.

Wilson filled a glass chamber with ultra-pure water vapour and cooled it below the temperature at which droplets would normally form. In this 'supercooled' state, the water vapour was desperate to form droplets around any ions, and would do so the instant Wilson expanded and cooled his cloud chamber.

Operating the device proved to be more of an art than a science, but by illuminating the chamber with a bright light it was possible to photograph the tiny trails of bead-like water droplets left in the wake of a passing subatomic particle. Given how mind-bogglingly tiny subatomic particles are – a million million times smaller than the smallest speck visible to the naked eye – revealing their tracks was a stunning achievement. It earned Wilson a share of the 1927 Nobel Prize in Physics.

Millikan knew that if the water droplets were spread out, leaving a thin track, the particle responsible carried a relatively small electric charge; whereas, if the water droplets were crowded together, making a thick track, the particle had a relatively large charge. The charge would help to identify a particle created by a cosmic gamma ray but would not be enough to pin down its identity definitively. Millikan therefore suggested that Anderson place his cloud chamber in a magnetic field; this would bend the path of subatomic particles, with those of low momentum being more curved than those with high momentum. (Momentum, which is the product of a body's mass and velocity, reflects the fact that a slow-moving, massive body is as hard to deflect as a fast-moving, light body.)

However, the cosmic rays and their subatomic debris were extremely penetrating – they were capable of smashing their way through a thick sheet of dense lead – which indicated that they had enormous energy and were travelling extremely fast. Such a fast-moving particle would spend very little time traversing the cloud chamber, which meant the magnetic field would have little opportunity to bend its trajectory. The only way to create a measurable deflection was to use the strongest possible magnetic field.

The experiment was a major challenge and it took a full year to assemble the apparatus in the optical shop of the Robinson Laboratory of Astrophysics, which had been set up to build a world-beating five-metre telescope for Mount Palomar Observatory near San Diego.[4] The Great Depression, which had been triggered by the Wall Street Crash of 29 October 1929, was in full swing: money was tight, and Anderson had to salvage material for his experiment from local scrapyards. Fortunately, he had a long history of improvising with discarded equipment, having powered electrical experiments with used automobile batteries he had cadged from garages while a high-school student in Los Angeles.[5]

Anderson's cloud chamber was the shape of a very shallow biscuit tin, three centimetres deep and seventeen centimetres in