SECRET WARRIORS

The Spies, Scientists, and Code Breakers of World War I

TAYLOR DOWNING

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SECRET WARRIORS
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Taylor Downing

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NEW YORK  LONDON
For my grandfather
William Forward John Downing
Who operated a Vickers machine gun in the First World War
and survived
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Soon after midnight in the early hours of Tuesday 5 August 1914, the captain of the CS Alert, a cable-laying ship moored at Dover harbour and owned by the General Post Office, received the special coded telegram he had been expecting. He immediately ordered the Alert to slip out of harbour and head north-east. In the early dawn, the captain drew up the Alert in the grey waters of the North Sea a few miles off the German port of Emden, near that country’s border with Holland. It was only about six hours since Britain had formally declared war on Germany at 11 p.m. London time, midnight in Berlin. Having taken up his position, the captain of the Alert ordered the ship’s grappling equipment to be dropped into the murky waters. The crew of the 1000-ton cable ship were highly skilled in laying and maintaining the undersea cables which, since the mid-nineteenth century, had crossed the bed of the oceans to link continents via telegraphic and, more recently, telephonic communications. They knew exactly how to find the cables to repair them. But this time the vessel’s mission was destructive. Although the Alert was a civilian ship, the captain was about to engage in an act of war.

After a short period of dredging along the bottom of the sea, the grappling hooks were hauled to the surface bringing with them giant strands of thick, insulated cable that flailed like giant, underwater snakes. Dripping with water and covered in mud and seaweed they were dragged on to the deck of the Alert. The crew sawed and hacked the cables, breaking through them, and then tossed them back overboard into the sea. They then repeated the whole process on four further cables, dragging on board and cutting each one before throwing the ends into the sea. The operation, which took about four hours, was fraught with danger for the unarmed British vessel. The captain and lookouts scanned the horizon for any sign of German ships coming out to see what was going on. As the dawn became brighter the sea grew rougher and a heavy rain squall passed over the ship.

The captain of the Alert was carrying out Britain’s first offensive act of the First World War. The five German cables that ran across the North Sea and down the English Channel linked Germany with France and Spain and then went out into the Atlantic to Africa and the Americas. They were now severed. Germany could no
longer send telegrams or cables to its colonies or to the United States. Cut off from the US and much of the rest of the world, the country’s telegraphic links were now limited to its immediate neighbours across land borders. Berlin had lost its top secret communication link with the new world. From now on, any communication would have to be via radio. And there was one major problem with sending signals by radio. Anyone with a receiver could also tune in and listen to them. This would have significant consequences as the war progressed.¹

Just over a week later, at dawn on 13 August, another group left Dover. On this day it was the turn of the aviators of the recently formed Royal Flying Corps. For the first time, Britain was sending aircraft to war to accompany its ground troops. It was a chance for the youngest addition to the military to prove itself. Among the small group of fliers gathered was Captain Philip Bennett Joubert de la Ferté. Just twenty-seven years of age, he was typical of the first wave of military fliers. He had been in the artillery when he heard about the formation of the Royal Flying Corps and was one of the first officers to join. He had to pay to learn to fly himself (with his father’s support) as the army did not then have funds available to train pilots. Joubert quickly took to flying, although the aircraft were so light and fragile that they needed a lot of care. Most flying took place in the early dawn before the wind had got up and Joubert, like most pilots, had experienced the embarrassment of actually being blown backwards when trying to fly into a strong wind. On one flight he had ended up seven miles behind his point of take-off. When war was declared, Joubert was in command of ‘C’ Flight in 3 Squadron, flying a French aircraft built by the Blériot company.

For the journey, Joubert, like most of the other pilots, was accompanied by his mechanic. It was the quickest way of transporting to France the men who were essential to keep the aeroplanes flying. Joubert was briefed at about 5.30 a.m. and given maps of France and Belgium and sealed orders. When he opened them, the orders contained details of his destination. Along with the others, Joubert was given a revolver, a set of field glasses and a spare pair of goggles. The mechanics were issued with a tool kit. Emergency rations of biscuits, a bar of chocolate and a pack of soup concentrate were handed out in a haversack. Advance parties at Dover had acquired a large number of cast-off inner tubes. Each man carried one of these, to be inflated if the aircraft came down into the sea and used as a makeshift lifebelt. But the pilots’ instructions were to ascend to 3000 feet before starting their Channel crossing so if an engine failed they should have enough height to glide across the Channel. There was no planned sea rescue.

The people of Dover cheered as Joubert and his fellow pilots climbed into their aircraft on the hills above the cliffs dominating the town. The contraptions they climbed into consisted of wooden frames held together with wire and covered in linen canvas, powered by large combustion engines that sat imposingly near the centre of the structure. Today they look as ancient as the dinosaurs, but to the crowds gathered on that August morning these craft were the very cutting edge of modernity. Only five years before, Louis Blériot had made the first Channel crossing by air. Now Joubert and the other pilots in their flying machines were planning to carry out a similar journey and to take up their position alongside the British Expeditionary Force.
Soon after 6.25 a.m. on what proved to be a beautiful, clear August day, the first aeroplanes taxied across the grass and soon got up to speed. One after another the pioneers in their Blériots, BE2s, BE8s and Henri Farmans took off and rose high into the sky to reach the planned altitude. Then, in a line, each aircraft, powered by an engine that could only muster a few horsepower, headed off across the Channel at roughly two-minute intervals. Their course was to hit the French coast at Boulogne, fly down the coast to the Somme estuary and then head inland to Amiens. Not everything went to plan. A few aircraft were damaged when they came down in a ploughed field. One pilot got lost and had to land and ask an astonished passer-by where he was. On landing in France, another pilot was arrested by officials who could not understand what language he was speaking and thought he must be a spy. It took three days to get the pilot released from prison. Yet another aircraft was delayed as its pilot flew around the Cap Gris-Nez lighthouse and tried to drop his inner tube, like a quoit, on to the spiky top, as though in a fairground.

For Joubert, the flight from Dover to Amiens took just two hours. The aerodrome at Amiens was a simple affair, just a cut grass field with a few large sheds known as hangars at one end. At this point, the RFC had almost nothing in the way of ground transport, were desperately short of spares and had barely any reserves. Having made the journey, Joubert and the pilots of his squadron came to rest along the side of a field as there was not enough hangar space for all the British machines. As the morning passed an enthusiastic crowd gathered, waving flags and shouting ‘Vive l’Angleterre’. The French had been doubtful as to whether the British would join them in their war against the Germans. But here they were, and the Gallic reception included throwing flowers and even fruit in a tremendous welcome. That afternoon, Joubert and his fellow aviators received another visitor, General Sir John French, commander-in-chief of the British Expeditionary Force. A cavalry man who traditionally relied on scouts riding on horses for reconnaissance, he had little idea how effective this new fighting force would be in a similar role, but he wanted to come and see the men and their machines. French was reassured by the sight of forty-nine aircraft from three squadrons lined up along the side of the aerodrome. There was a sense of excitement and jollity about the whole event.

That night Joubert was put up at one of the best hotels in Amiens, the Hotel Belfort. Not expecting billets with comfortable beds and fitted sheets, he had brought no pyjamas with him. Along with several other pilots, he had to borrow a nightdress from the hotel owner. It was the last time for many months that these men would need pyjamas. And as they cavorted along the hotel corridors in borrowed nightdresses down to their ankles they did not look much like a group of men who represented the very latest in the science of war.  

The late autumn sun shone brightly through the tall sash windows in the splendid first-floor meeting room of the Royal Society in the East Wing of Burlington House. Wood-panelled and lined with shelves of books, the meeting room overlooked the courtyard just off London’s busy Piccadilly with its continuous bustle of motor traffic. But the room was surprisingly quiet as the clock struck eleven on the morning of 12 November 1914. Precisely on the last stroke, a clerk opened the large, heavy door and the President of the Royal Society led into the room a procession of ten distinguished
gentlemen, the youngest of whom was in his forties, the eldest in his eighties. First behind the President was John William Strutt, Baron Rayleigh, a Fellow of Trinity College, Chancellor of Cambridge University, a previous President of the Society and one of the most distinguished scientists in Britain. Famous for his work on optics and acoustics, as a young scientist he had come up with an explanation for why the sky is blue, while as a physicist at Cambridge he had helped to determine the absolute values of the ohm, the ampere and the volt. He had been awarded a Nobel Prize for the discovery of argon, an inert gas. He was close to government and served as chair of the explosives committee of the War Office and as president of a key committee on aeronautics. He was in his seventies but still lively and energetic, and he saw the war as an opportunity for scientists to demonstrate how their work could assist in bringing victory.

Rayleigh and his colleagues looked immaculate in their suits, waistcoats, wing collars and ties. One of them was in the full dress uniform of an admiral. The group included several more of the most eminent men of science in Britain. Two were leading physicists and four were prominent chemists. One of them had discovered thallium, another helium. One had pioneered wireless telegraphy at sea. Among them were two engineers, a mathematician, and the Director of the National Physical Laboratory at Teddington. Seven were knights and Rayleigh was a peer of the realm.

The Royal Society was the leading organisation of scientists in Britain. It had been founded in 1660 by Christopher Wren, Robert Boyle, John Evelyn and other prominent ‘natural philosophers’ as a forum to witness and discuss scientific experiments. Two years later the Society was awarded a Royal Charter by Charles II. It had gone into a decline during the late eighteenth and early nineteenth centuries when it became little more than a gentlemen’s debating club, only about one-fifth of whose members were active practitioners of science. But in the second half of the nineteenth century the Royal Society had transformed itself into an influential professional academy of four to five hundred Fellows, all of whom were distinguished scientists.

When war had been declared over the early August bank holiday, the widespread feeling was that it would be a quick war, fought by professional armies on distant fields, possibly with a naval engagement at sea and that without doubt it would all be ‘over by Christmas’. But by the time of the November meeting, it was clear that this was no longer the case. News reports from the front were strictly censored, but Rayleigh and his fellow scientists could see that the European armies were lining up for what would be a much longer war than anyone had expected. Accordingly, these men of science had agreed with Rayleigh that they must make some gesture of support, some indication that the scientific establishment was ready to rally behind the war effort.

Sitting at the central meeting table, Sir William Crookes, the President of the Royal Society, took the chair. As the others fell silent, Crookes began to speak. After the President, Rayleigh spoke and a few others joined the discussion. In less than twenty minutes they had reached unanimous agreement that they should form a committee that would be known as the War Committee of the Royal Society. Its purpose would be to organise assistance to the government and the armed services with any scientific
questions that arose. With their prominent connections across the universities of Britain and within the manufacturing and technical industries of the nation, the senior members of the Royal Society would be supremely well placed to know whom to approach, what to ask and how to help.

After a short further discussion, it was agreed that the Secretary of the new War Committee should write to the War Office, the government department from where the British Army was governed, to the Admiralty, the department of state that ruled the Royal Navy with the largest fleet of warships in the world, and to the Board of Trade, the government department that was closest to industry. The letters should express ‘the readiness of the Committee to organise assistance to the Government in conducting or suggesting scientific investigations in relation to the war’. It was further decided to form two sub-committees so that the men of science could immediately start to investigate possible scientific applications relevant to the war. The first would look into the new technologies of telephony and wireless telegraphy, and into the broad field of ‘General Physics’. The second would investigate the field of chemistry, and would send letters to the directors of the chemical laboratories at every university and college in the country, inviting their assistance in undertaking the manufacture of chemicals, most especially drugs or other medicaments, ‘the supply of which is inadequate in consequence of war conditions’.

There being no further business, the date of the next meeting was set for the same time exactly one week later. The chairman declared the meeting closed and the committee members stood and followed him out of the meeting room. Some of them, like Lord Rayleigh, had urgent business elsewhere. Others settled in the reading room for an hour or so before heading off for lunch. The meeting had been a low-key affair, but it marked an historic step. For the first time, the nation’s leading scientists had come forward to offer the support and assistance of the entire scientific community to the government and the armed forces. It was already clear to Rayleigh and his colleagues that in the twentieth century a war would have to be fought drawing on all the advances that physics, chemistry, medicine and mathematics could offer. This war would be conducted in laboratories and scientific workshops, as well on the battlefields and across the oceans of the world.3

These three scenes illustrate in very different ways how the conflict that would become known as the ‘Great War’ would involve the world of science and the scientists of the day. Thanks to the cutting of undersea cables, the German government had to use wireless telegraphy, radio, for much of its long-distance communications. The Germans’ use of code would challenge the Allies, first to find a way to intercept the signals and second to decipher the intelligence they contained. This demanded the application of new technologies and the development of new code-breaking techniques. After the first aircraft went to war in 1914, the new science of aviation would advance in leaps and bounds over the next few years as each side tried to outdo the technology of its enemy. In four years’ time, aircraft engines would be unrecognisable in their power and output and aircraft designs would have advanced beyond anything imaginable in 1914. Finally, the fact that the most eminent men of science were offering to assist the army, the navy and the flying corps was a recognition of the vital role science would play in a modern, industrial and
technological war.

Much writing about the Great War concentrates on the troglodyte world of the trenches that made up the 450 miles of battle lines known as the Western Front. This extended from the English Channel, through the western tip of Belgium, across the industrial north-east of France and down through the chalklands of Picardy, then ran east through the Champagne district and circuited the great fortress defences of Verdun, finally turning south into the Vosges mountains and the Alps on the Swiss border. The First World War is often seen exclusively as a war fought by armies of millions living in the subterranean world of the trenches, slogging it out in human wave assaults and being slaughtered in dreadful numbers. The Western Front in which the French, British and Commonwealth armies faced the German army dominates the popular image of the war, although much fighting took place on other fronts and against other enemies.4

The role usually given to science in the First World War is that all it did was to introduce ghastly new inventions to the arsenal of war, including powerful new high explosives and hideous clouds of poison gas. It has been written that it was a ‘chemists’ war of poison gases and explosives’.5 This brutal industrial-scientific war, conducted by means of the long-range artillery shell, the machine gun and newly-formulated chemical weapons, it is argued, led to killing on a vast, appalling, unprecedented scale. In many histories of the war, the contribution of science goes no further than this. It was seen as murderous, destructive and entirely negative.

Beyond this common view of the war, however, it is possible to see how engineers, chemists, physicists, doctors, psychologists, mathematicians, intelligence gatherers and propagandists were taking part in an unknown struggle that made a more positive contribution to what happened at home, at the front, at sea and in the air. They helped to fight a war that was won by scientific advantage, achievement and breakthrough in many fields that helped to transform life after the conflict ended. Many of the foundations of scientific progress in the 1920s and 1930s in fields such as radio technology and medicine, aviation and psychology were laid in the four years of war. In Britain, the new skills developed in aeronautics and intelligence gathering would live on for much of the rest of the century. The expertise that went on to produce the jet engine, a powerful aviation industry and the supersonic airliner was developed during the First World War. In addition, Britain is still today, for good or ill, a nation renowned for its intelligence-gathering capabilities and is often referred to as ‘the surveillance state’.6

However, at the opening of the twentieth century the world of science was itself deeply divided. Several men of science (the word ‘scientist’ was still relatively little used) thought that their discipline was best pursued in academic isolation through pure research. Fighting for professional status and independence in the universities, they believed the only valuable science was pure science. They looked down on the world of applied science, just as gentlemen as a class looked down on those who dirtied their hands with business or worked in industry. But a growing group of scientists began to feel that this was a false distinction, that the principal role of science was to improve the lot of men and women. For instance, Professor John Haldane of New College, Oxford, a leading physiologist, used his understanding of poisons and of respiration to
work tirelessly for the improvement of industrial health in coal mines. Professor John Ambrose Fleming, a top electrical engineer at University College, London, in addition to his academic duties also worked as consultant and scientific adviser to commercial companies and invented the first electric valve. In the world of medicine, of course, there never was a distinction between pure and applied science. All medical research was for practical purposes and an immense amount of it took place in the early twentieth century. But although medicine had been the exception rather than the rule, there was unquestionably a shift towards finding the practical application of science and of using scientific principles to understand and improve the electrical and mechanical world that was developing fast in the early years of the century.

As part of this transition, new organisations came into being in Britain in the years before the war to advise on the science behind many of the great technological changes that were transforming the age. The Advisory Committee on Aeronautics was established in 1909 and the Medical Research Committee in 1913. They and other such bodies bred a new type of scientist who helped to link the universities with the practical world, the academy with government and industry. These scientists helped develop new forms of intelligence gathering, helped to save lives by developing new medicines, advanced the understanding of how the human mind worked, and brought dramatic breakthroughs in code breaking, naval warfare and the war in the air. In 1915 Professor John Ambrose Fleming summed up the impact of these changes in a public lecture when he said: ‘It is beyond any doubt that this war is a war of engineers and chemists quite as much as of soldiers.’

I have written extensively about the boffins, backroom scientists and mavericks of the Second World War. In a sense this book is the prequel to these histories, looking at the boffins of the Great War (not that the word ‘boffin’ was ever used during that war). But it is not just those obviously defined as scientists who provide the subject matter for this book. This is the story of many individuals with specific skills, often from the universities or from industry or the arts, who contributed to the war effort. In the top secret world of the code breakers, the Admiralty recruited men and women with specific and vital linguistic skills and brought in classical scholars who were experienced in piecing together the full meaning of a manuscript from fragments of text. In the censorship of the press and in the new medium of the cinema, the War Office recruited a broad range of writers including one of the greatest novelists of the day, while the army engaged film-makers, cinema distributors, photographers and artists to help depict the war for the public at home and abroad. A general awareness of the existence of a ‘Home Front’ came into being and slowly it was realised that in a modern war a vital relationship would exist between what people thought at home and the general level of support needed to sustain the fighting abroad. So a wide net was cast to recruit the skills needed to manage this relationship and to win the war.

*Secret Warriors* takes in aviation, intelligence and code breaking, engineering and gunnery, chemistry and medicine, as well as censorship and propaganda. It follows the work of some extraordinary individuals who became part of the first ‘total war’ in which all the resources of the state were involved. This was not just a war fought by sailors, soldiers and airmen, but one in which public opinion would play a central role in supporting the fighting front. As the war progressed it drew in an ever-widening
group of experts, scholars, scientists and literary figures. They were the secret warriors of the Great War. A huge group of brilliant men (and they were mostly men, although there were a few women) were drawn into the titanic struggle. For the first time in this nation’s history some of the finest brains from the university laboratories, colleges, factories and hospitals of Britain willingly came forward not to do their bit on the battlefield but to contribute their expertise at a time of national crisis.

As the Great War was transformed from a conflict fought by professional armies on continental fields into a national struggle that affected most aspects of the life of the nation, so the scientific and intellectual establishments were drawn in. As the army and the air force, and to a degree the navy, became more professional and more prepared for a long, bitter, attritional war, so the best and the brightest were called upon to contribute. A few of those who helped to solve the problems of aeronautics, to carry out extraordinary new forms of surgery or to write the first narratives of the war, became household names. Most, however, remained unknown and returned to relative obscurity in their laboratories, libraries or university departments. Many remarkable individuals appear in these pages. This is their story. It is an unusual one.
The year 1914 is often seen as the end of an era. It has been described as the last year of the ‘long’ nineteenth century, and as marking the final break between the old world order and the modern era. As a consequence, Edwardian Britain is often depicted as a sort of Indian summer, the last decade of the old world before everything was engulfed in the Great War. It is sometimes portrayed as an elegant, golden age shimmering in the distant light of country house parties, with public schoolboys playing cricket on long hot summer afternoons, the navy in great battleships proudly ruling the waves, the pomp and glory of imperial durbars … and so on. It is presented as a period of stability and continuity before the tsunami of war washed everything away.1

However, this is to see life in the first decade of the twentieth century through the looking glass of hindsight. Most evidence shows that the Edwardians believed they were living through years of immense promise and potential, years of dramatic change in the present that offered exciting new possibilities for the future. They saw the Victorian era ending symbolically with the death of the old queen and the coming of the new century. New ideas, new technologies, dramatic changes in workers’ rights, the provision of state pensions and the big debate about ‘Votes for Women’ were the characteristics of their age. The word ‘new’ itself became one of the most fashionable words of the age: people spoke of the ‘new art’, the ‘new morality’ and the ‘new woman’. All of this generated great debate. Edwardians argued intensely as to whether so much ‘newness’ was a good or a bad thing. But they were not wrong about the scale of change they were living through. One of the young technological pioneers of the age, John Moore-Brabazon, summed up the spirit he and his friends felt when he wrote, ‘I think we were all a little mad, we were all suffering from dreams of such a wonderful future.’2

Britain was still a deeply divided land. In London there was a glittering West End and an impoverished East End. In the countryside there were superbly wealthy country homes and bleak village hovels. Workers had formed trade unions to battle for their rights and for a better livelihood; and rich owners were determined to give them neither. Industrial unrest was widespread; in 1912, for example, forty million working
days were lost in strikes. Suffragettes demanded rights for women; the establishment wanted to preserve the status quo. Change was not happening evenly or necessarily fairly. But it was happening.

In the rarefied world of pure science nothing short of a revolution was taking place in the twenty years before the Great War. At Berlin University in 1900, Max Planck discovered quantum theory and a new basis for theoretical physics. At Zurich in 1905, Albert Einstein proposed his ‘special theory of relativity’. These ideas were to transform the intellectual landscape of the twentieth century, utterly changing views on space, time and matter. At Manchester University in 1911 Ernest Rutherford discovered the nucleus of the atom and nuclear physics was born. At Cambridge from 1910 to 1913, Bertrand Russell and A.N. Whitehead revolutionised the foundations of modern mathematics with their Principia Mathematica. Meanwhile in Vienna, Sigmund Freud laid down the basis for psychoanalysis as a formula for the treatment of psychological problems through dialogue between patient and psychoanalyst. A new science of genetics was established. Incredible advances were made in understanding the activities of microbes in the new science of bacteriology. These fundamental changes in a brief period of time, as Eric Hobsbawm has observed, utterly transformed ‘man’s entire way of structuring the universe’. But of course, only a tiny number of people picked up these revolutionary ideas. In 1910, there were barely 700 members of the British and the German Physical Societies combined. The total number of pure scientists in the world in 1914 could be counted in only the thousands. And mostly they researched and worked in Western Europe with only very small numbers in either Russia, the United States or elsewhere. In 1901 the Swedish Academy of Sciences first awarded the Nobel Prize to scientists who had made major advances in their field. By 1914, of the first seventy-five highly prestigious awards, all but ten were made to scientists in northern Europe, mostly Britain, Germany, France and the Netherlands.

Most Edwardians knew nothing of these seismic changes and few would have understood them had they known of them. But if merely a few hundred advanced thinkers felt the earthquakes in the world of pure science, pretty well every Edwardian would have been aware of the massive technological changes that were impacting on almost every aspect of their lives. Developments in electricity, the spread of the internal combustion engine, the advance of the chemical industries, huge improvements in medical science, dramatic developments in communications technologies were all bringing about what many saw as a new age. Some people even went as far as to hope that these new scientific technologies could soon eradicate altogether the traditional problems of poverty, disease and war. Others were more pessimistic and feared that traditional values and long-standing social relationships would disintegrate as a result of all this turmoil.

Many of the scientific changes that were taking place had their foundations in the Victorian era, although the consequences were only being felt in the early part of the new century. The first, electricity, had already begun revolutionising life at the end of the nineteenth century. Just as coal and steam power had been at the heart of the Industrial Revolution, so electricity was at the foundation of the new era. It had been known since ancient times that electricity existed, but it was not until the seventeenth
and eighteenth centuries that men of science analysed and began to understand concepts like electrical currents and electric fields. In 1879, the American Thomas Edison invented the electric light bulb - or at least designed the first incandescent bulb that could be mass produced, in which a metal filament glowed white within a glass bulb. Two years later he built the first modern electric power station in New York to supply the electricity for his light bulbs. Within two decades, by 1900, a recognisably modern form of the electrical power industry was beginning to emerge. Electricity was produced in large generating stations sited near the main centres of demand. In Britain, the Ferranti company built one of the first of these giant generating stations in 1889 at Deptford, only a few miles east of London. Electricity travelled at a high voltage along cables from power stations to the local user where it was stepped down to a low voltage through a transformer.

The principal use for electricity at the end of the nineteenth century was to replace gas lighting in public streets in order to provide a cleaner and safer form of illumination. This central fact of demand determined the shape of the early electricity supply industry. In Britain by 1900 there were about 250 separate companies supplying electricity in a range of different voltages from 100 to 480 volts. There was no uniformly accepted standard of supply. At least half of the companies were owned by local municipalities and their task was merely to light the streets of their town or city. Even by 1914 relatively few households in Britain – only about one in ten – had access to electricity. And the 10 per cent of houses connected to the electricity supply were clearly the wealthiest homes in the bigger towns and cities. During the first decades of the century the numbers grew dramatically, partly fed by the huge growth in the electrical industries as new manufacturers like the General Electric Company (GEC), whose slogan was ‘Everything Electrical’, developed into industrial giants. Manufacturers produced a vast array of electrically powered domestic gadgets, from the telephone to the electric fire, from gramophones to vacuum cleaners. By the time of the First World War, these household items were only just beginning to revolutionise the home, but they pointed towards the future.

In the wake of electricity came a huge growth in new electronic industries like those of the telephone and radio, both founded on the development of the electric telegraph. This was another nineteenth-century industry. In 1844, in America, Samuel Morse had demonstrated a code that became a universal system for translating letters into dots and dashes, which could then be sent as electrical pulses along telegraph wires. Tens of thousands of miles of telegraph cables were soon in place, crossing countries and continents. The first underwater cable linking Britain and France was laid in 1851 and the first transatlantic cable began operating in 1866. British scientists soon established themselves as leaders in the technology of insulating copper wires in a rare tree sap and wrapping them in protective steel wire. The Eastern Telegraph Company dominated the process of linking all parts of the British Empire and by the 1870s telegraphic cables extended to Hong Kong and Australia. Initially used by diplomats and news agencies, the telegraphic cables made the world a genuinely smaller place. News, information or dispatches that would have taken weeks to transport around the globe by ship, now arrived in minutes. Officials headquartered in their capitals could send orders to generals and admirals in the field. The first ever world wide web of telegraphic cables was created in a single generation in the second
half of the nineteenth century.\footnote{Half of the nineteenth century.}

In 1876 this went a step further when an American, Alexander Graham Bell, patented his invention of the telephone, basically a telegraph but able to carry the electromagnetic signal of a human voice. It took a while for telephones or ‘speaking telegraphs’ to catch on as they depended upon a complex and costly infrastructure of local exchanges and telephone operators. Moreover, surprising as it may seem today, few people could see the point of the telephone; official and business users already had the telegraph and could send telegrams worldwide. The telephone seemed nothing but a frivolous extension to this service. It remained largely an urban device and by 1914 there were still only about 1500 exchanges in Britain, of which the vast majority had fewer than 300 subscribers.

By the 1880s, the German physicist Heinrich Hertz had established the existence of electric waves travelling at the speed of light. Hertz’s work, though/ was purely theoretical and academic. It took others to make some practical application of the discovery. The principal figure in the development of the use of radio waves to send Morse signals was Guglielmo Marconi, an Italian who settled in London and during the 1890s made a series of inventions that created the new technology of wireless telegraphy. Marconi’s principal interest was in improving and developing long-distance wireless communication with ships at sea. In March 1899 he sent a radio signal from Britain to France and in 1901 succeeded in sending a signal from Britain to America. In 1909, aged only thirty-five, he was awarded a Nobel Prize for physics for his work on electric telegraphy. At about the same time came the invention of the thermionic valve. Two electrodes were placed inside a glass vacuum tube, enabling electric current to pass in one direction but not in the other. Advances on this principle followed rapidly, creating one of the first truly electronic components. The use of valves made it easier both to transmit a more powerful radio signal and to amplify a signal once it had been received, improving the transmission of the human voice as well as of Morse code.

In 1900 the Marconi Wireless Telegraph Company was formed in order to establish land-based radio stations that could communicate with radio operators on ships at sea. Marconi tried to enforce a monopoly by not allowing any of his radio operators to communicate with operators from rival companies, a prohibition that soon became impossible to sustain as other companies like Telefunken in Germany developed their own systems. For a while there was a sort of anarchy of the air waves, and before long an international agreement was needed to standardise the bandwidths that could be used. In 1906 a conference in Berlin created some sort of international order in the spread of long-range radio communications. Land-based stations transmitting out to sea had to accept certain uniform agreements about the use of wavelengths and in addition agreement was reached on the sending of distress signals. The Morse signal for SOS (three dots, three dashes and three dots) was approved as an international sign of distress, the spoken equivalent being the word ‘Mayday’ – based on the French m’aidez, help me.

Over the next few years, several incidents headlined the value of the wireless telegraph at sea. In 1910 the murderer Dr Crippen escaped from Britain by sea but was arrested on arriving in Canada when the captain of the ship he was sailing on became
suspicious and telegraphed Scotland Yard with his suspicions. And in April 1912, when the Titanic hit an iceberg and went down with the loss of 1500 lives, the need for every ship to carry a radio was dramatically highlighted. Only one ship in its vicinity, the RMS Carpathia, heard the Titanic’s distress SOS, yet that vessel was able to rescue more than 700 passengers who otherwise would have perished. Other ships within range were not equipped with radio and so did nothing to help, and hundreds of passengers drowned as a result.

By the early twentieth century, key developments in the nineteenth had led to the development of another huge industry – the chemical industry. Formerly the province of small-scale local manufacturers, the production of sulphuric acid and bleaching powder had become an industrial process early in the nineteenth century. Then, in 1856, the English chemist William Perkin produced the first synthetic dye, mauve. Two years later, a German chemist synthesised the dye magenta. These and other new colours proved hugely popular in the production of textiles for the fashion industry. In the 1860s another English chemist, Alexander Parkes, invented cellulose, one of the first synthetic plastics. In order to produce these synthetic colours and materials a new chemical industry grew up using organic chemicals, that is compounds that contain the highly versatile element carbon. Although many of the original discoveries had been made in Britain, by the early years of the twentieth century Germany dominated the industry. And coal tar, produced in Britain in vast quantities as a by-product of the conversion of coal into coke or coal gas, was nearly all exported to Germany. Here, giant chemical companies like BASF (Badische Anilin- und Soda-Fabrik), Bayer and Hoechst acquired almost a world monopoly in the manufacture of chemical products derived from coal tar. The chemical industry was making an ever broader range of products, including those needed for the refining of sugar and petroleum; for the manufacture of glass, paint and cement; for photographic materials, cleaning compounds and agricultural fertilisers; and for medicinal and pharmaceutical products. For instance, on the cusp of the new century, in 1897, Bayer invented aspirin. It would soon be described as the new wonder drug.

Furthermore, in the years before the war, the German chemist Fritz Haber invented a process for producing ammonia, a compound containing nitrogen and hydrogen, by synthesising the two elements from the atmosphere using iron as a catalyst. Another chemist in Germany, Carl Bosch, went a step further by developing a brand new high temperature, high pressure process for the bulk industrial production of ammonia. This became known as the Haber-Bosch process. Meanwhile a third German chemist, Friedrich Ostwald, developed a process for turning ammonia into nitric acid. All three chemists were to win Nobel Prizes for their work. The production of these chemicals was intended for the use of agricultural fertilisers, but both ammonia and nitric acid had a further application. They could be used to make explosives.

Dramatic changes also took place at the beginning of the twentieth century in the field of medicine. The use of anaesthetics had begun in the early nineteenth century and ushered in a revolution in surgery, enabling the surgeon to carry out more radical operations than had been possible before. This had coincided with a growing understanding of the role of bacteria as the cause of infection. The thorough
sterilisation of equipment to be used in surgery and the ability to maintain strict standards of cleanliness turned the operating theatre into the modern, clinical space familiar today. Antiseptics were developed in the decades before the war to treat bacterial infections, although there was still a general feeling that many bacteria were too powerful to be treated by drugs. In 1909, Paul Ehrlich, a specialist in the new science of bacteriology, developed a drug called salvarsan that provided a treatment for syphilis. German chemists were pioneers in many developments in antiseptics and by 1914 most of these drugs were produced by the booming pharmaceutical industry in Germany.

Another item familiar to modern medicine that came into wide use just before the First World War was the X-ray, invented accidentally by another German, Wilhelm Röntgen, in Wurzburg in the 1890s. On the brink of the new century the Curies discovered radium but failed to appreciate that exposure to it could be fatal, and Marie Curie herself died of leukaemia caught from over-exposure. Together, radiology and X-rays began a new era for diagnosing fractures and malformations. The development of film and plates for X-rays came out of the photographic industry and the manufacture of X-ray equipment became another branch of the electrical industries. Out of these industries also emerged the development of the electrocardiograph at the University of Leyden in 1903. Invented as a device to record the electrical activity of the heart muscle, it greatly helped the diagnosis of heart disease.

In addition to the more accurate diagnosis and treatment of disease came substantial improvements in preventative medicine; advances in the supply of clean water and the disposal of waste and sewerage were coupled with the introduction of mass immunisation projects. The incidence of diseases like cholera and typhoid that had been the scourge of large, crowded nineteenth-century cities went into a marked decline in the early twentieth century. The whole concept of public health and of the need for the state, or local authorities, to make provision for improved sanitation and the chemical purification of water supplies became recognised in Europe and North America in the decades before the war. With this went a decline in death rates, a marked drop in infant mortality and a further growth in population.

Another sign of the broadening interest in and support for public health measures in Britain was the establishment in 1913 of the Medical Research Committee (the forerunner of today’s Medical Research Council). The government set up this committee with funds raised by National Insurance contributions, payable since Lloyd George’s radical budget two years earlier. Every worker in the country paid a penny towards a fund to build sanatoria to treat tuberculosis, one of the great killers of the day, especially among the poor in overcrowded cities. The contributions were known as the ‘TB Penny’. Part of this money – a sum of £57,000 per year – was allocated for research. The role of the Medical Research Committee was largely to coordinate such work, although it was itself allowed to carry out research into all aspects of medicine. A group of nine leading scientists, chaired by Lord Moulton and supported by an Advisory Council made up of representatives from the universities, were to formulate plans for medical research that would be funded by the ‘TB Penny’. The creation of the Medical Research Committee marks another important step in the state’s growing interest in the health of the nation, although its work had barely begun when the war