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I. K. Brunel's Crimean War hospital

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SUMMARY
"Those wonderful huts…" (Florence Nightingale). This is the story of the British Civil Hospital, erected in 1855 at Renkioi on the south Dardanelles coast of Turkey. The spectacular hospital was a portable one designed by British engineer I. K. Brunel. It was his only health-related project, and it was known as a Civil Hospital because its staff were all civilians, despite its patients being military.

Key Words: Brunel, British Civil Hospital, Crimea, war

THE CRIMEAN WAR, 1853 TO 1856

The Ottoman Empire contained Palestine's holy places, for the 'guardianship' of which the Christian Orthodox and Catholic churches competed strongly. Russia pragmatically supported the Orthodox stance and France the Catholic. At a more secular level, Tsar Nicholas I angled to increase Russia's influence in the eastern Mediterranean by controlling the Black Sea, the Bosphorus and the Dardanelles whilst simultaneously greatly weakening the Ottoman Empire. To control those waterways would give Russia a chance to threaten Britain's power in India and make Russia stronger in the Balkans, the Middle East and Greece and more influential in Western Europe.

As one can imagine, the Ottomans, Britain, France and the Kingdom of Piedmont and Sardinia rejected Russia's intentions. In October 1853 the Tsar's troops invaded Ottoman lands south of the Ukraine border on both sides of the Black Sea. One month later, at Sinope on the Turkish north coast, the Russian navy destroyed all but one ship of the Ottoman Black Sea fleet. Turkey declared war in November 1853 and in March 1984 so did Britain and France, followed by Sardinia. From here on hostilities increased, at sea in the Sea of Azov, the northern Black Sea, the Baltic Sea and the Russian coast of the Arctic and North Pacific oceans. After gathering for two months at the now-Bulgarian port of Varna, French and British forces invaded the Crimean Peninsula in September 1854 and were joined later by Sardinian and Ottoman troops. There were a total of about 700,000 allied servicemen against about a million Russians, though quoted figures vary. This was a war fought just as much by sea as it was fought on land. The Crimean War became known for the logistical, medical and tactical failures on all sides, but in the same breath it was famous for the work of Florence Nightingale and Mary Seacole, pioneers of modern nursing practices while treating the many victims of infectious disease and comparatively few battle casualties. After the fall of Russia's great Black Sea fortress and main fleet port at Sevastopol in September 1855, there was only sporadic fighting as winter approached. An armistice was agreed in February 1856 and hostilities ended officially when the Treaty of Paris was signed in March of 1856.

Russia had lost the war, half a million men, the naval use of the Black Sea and much prestige and gold, but had lost no territory. Turkey gained no territory, but lost none, and its empire's slow decline was halted for two decades. France regained some of the national self-respect lost years before in Napoleon's catastrophic 1812 retreat from Moscow. The King of Sardinia and Piedmont was aided in his eventual union of the states to form modern Italy. Britain won some glory and a new government but at great cost; her main benefit was to subsequently undertake major military reforms that the war had revealed were necessary.

MEDICINE AND DEATH

The major medical failures by all the combatant countries can be attributed to the almost global inertia of their military bureaucracies. They were comprehensively deficient in policy and capability to support water supply, food for troops, fodder for horses, clothing, shelter, sanitation, transport of

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goods and of casualties, staffing by trained doctors, nurses and orderlies and the delivery of clinical care at the prevailing standard. Anaesthesia was quite new and in the British Army medical service some senior officers refused to allow it.

It is well recorded that medical and administrative staff close to the patients on the Crimean Peninsula and in Constantinople were not lazy, stupid or uncaring, and knew of many of the medical system defects.

			Causes of death	
	Personnel	Deaths	*Injury*	*Sickness*
French	310,000	96,000	20,000	76,000
Ottoman	160,000	45,000	20,000	25,000
British	100,000	22,000	5,000	17,000
Russian	900,000	447,000	73,000	374,000

Medicine among the British and French forces

In two months from mid-1854, the Allied expeditionary force at Varna lost 11,000 men from cholera alone, 90% of them French. It was thought at the time that greater overcrowding was the cause for the French, but worse sanitation as the underlying mechanism was not considered.

Throughout 1854, and most of 1855, dysentery and typhus alone killed many hundreds of Allied personnel every week.

British and French army medicine

Civilian British companies contracted by the War Office supplied most food and clothing, but did so fraudulently; poor food meant scurvy for most British soldiers by the time of the invasion. On top of this, army doctors had a vestigial career structure, inadequate equipment and little military-related training. It is important to note that there were no nurses, trained or otherwise. Male orderlies as a group were scarce, poorly trained and generally selected on the basis that they were unfit for other army tasks.

In the armies of those days, nobody washed; neither nobles, newly recruited soldiers nor anyone in between. Bodies, clothing and bedclothes were all infested with lice, making typhus a disease without respect for rank or titles.

The main British hospital, Scutari, was a century-old ex-barracks complex with only one thermometer and a total of 3000 cots, 18 inches apart and 100 to 150 per room. When Florence Nightingale arrived in late October 1854, she noted that to wash a patient once in each cot would have taken eight weeks. Excreta went down a chute in the middle of the floor of each room. Scutari and dozens of other Allied hospitals were death-houses, rife with nosocomial disease; the long-suspect Scutari water supply improved when a rotting dead horse was lifted from the hospital's main well.

Many hundreds of patients and staff died of typhus contracted in Scutari, not even the worst British hospital in the region.

The quality of medicine in the deployed French Army surpassed that of the British early in the war, but appears to have collapsed later, perhaps due to failures in French funding and organisation.

In forward casualty tented facilities, 90% of all French patients had typhus. In the first three months of 1856 there were 20,000 recorded French typhus deaths at sea or after delivery to the 14 French Bosphorus hospitals and another 20,000 deaths from other infectious diseases. Typhus killed 20% of 360 French surgeons and had infected 80% of French hospital orderlies by February 1856. Fortunately, there were no dead horses in their water supply!

Anaesthesia in the Crimean War

Unlike any previous war, all the armies employed general anaesthesia. Chloroform was almost universal, with a documented good safety record. The traditional cannon, bayonet, lance and musket ball injuries were supplemented by new weapons, particularly the Enfield muzzle-loading rifle, firing the *Minié* bullet, creating greater tissue damage from the higher-energy projectiles and more casualties from the higher rate of fire per minute. Those with a chance of survival underwent the operations necessary, many of them happily under anaesthesia which enabled the surgeons to work more slowly and deliberately, in the absence of screams.

The eminent Russian surgeon, Professor Pirogov, the 'Father of Field Surgery', is credited with the first use of anaesthesia close to a battlefield (ether, in 1847). He worked at Sevastopol from December 1854 and supported anaesthesia, trained nurses, casualty triage and new techniques such as plaster casts in addition to inventing some new operations.

Eventually, and only because of the public outcry triggered the by mid-October 1854 exposés of London's *The Times* war correspondents, Florence Nightingale and her enthusiastic band of competent female nurses were allowed to leave England to aid the troops. *The Times* had revealed the lethally inadequate support of the mass of British soldiers

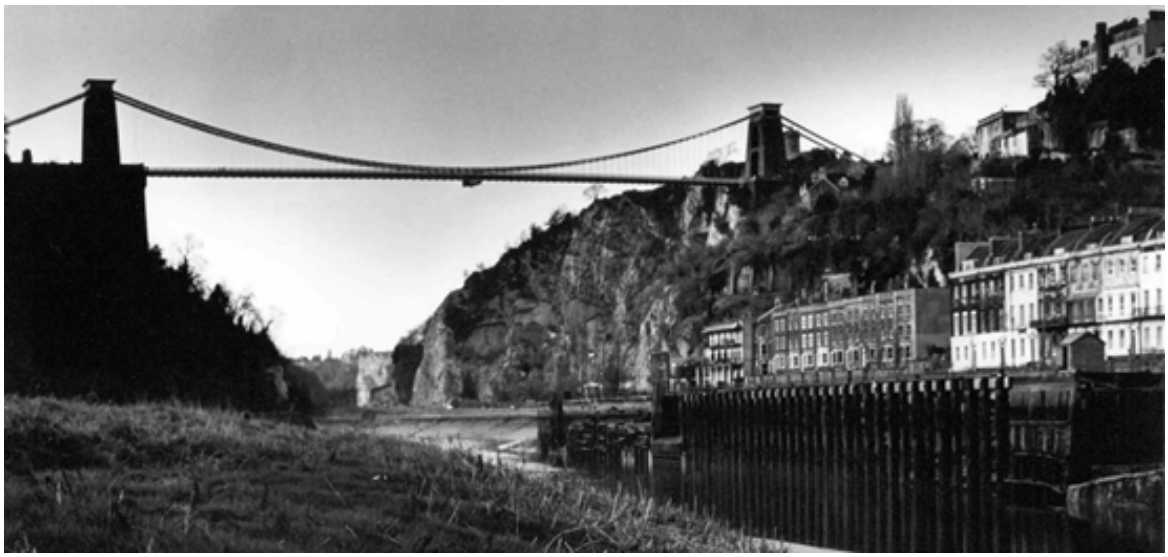

FIGURE 1: The Clifton Suspension Bridge, 70 metres above the Avon River (photo: Dr David Murrell FANZCA).

in the Crimea by the government and army. The nurses arrived at the end of October 1854 to start work at Scutari, greatly improving conditions within a few months.

ISAMBARD KINGDOM BRUNEL (1806 TO 1859)

Isambard Kingdom Brunel was the foremost British engineer of the mid-19th century, leading the world in the design and construction of bridges, railways and ships. His parents were *émigré* French engineer Marc (later Sir Marc) Brunel (and later *Légion d'honneur*) and an Englishwoman, Sophia Kingdom.

Thames tunnel, Bristol's docks and Clifton Bridge

I. K. Brunel followed his father's footsteps and trained in engineering in British and continental schools. At 21 he was appointed site engineer for one of his father's big projects, the first tunnel beneath the Thames. The young Brunel succeeded, and so did his father's project. Brunel then solved the silting problem in Bristol's system of docks and locks on the Avon River, simultanously aiding his career and the longevity of the docks, still in use today.

The Avon Gorge at Clifton divided Bristol, which needed a road bridge. Against seasoned competitors, Brunel won the city's contract with his first bridge, a suspension design using flat chains of wrought iron. Although the design was finalised in 1831, the project lapsed with the bridge unfinished. After Brunel's death in 1859, the works resumed in his honour and were completed in 1864.

Brunel's 40 bridges included *Clifton*, the *Maidenhead Railway Bridge* (a long brick-arch railway bridge near London) and the magnificent *Royal Albert* railway bridge joining Plymouth and Saltash over the Tamar River. He was too ill to attend the Royal Albert Bridge opening in 1859 and died the same year. These three and most of his other bridges remain in use today.

PS Great Western, SS Great Britain & PSS Great Eastern

Brunel also became famous for his ships. His *Paddle Steamship Great Western* was launched in Bristol in 1837. At 2300 tons displacement and made of wood, she was powered by sails and side paddle wheels and was the biggest European vessel ever built, the only larger wooden one being Chinese, c1450. The *PS Great Western* was a commercial success as the pioneer regular trans-Atlantic steamer, averaging a speedy 8½ knots on the fastest powered crossing of the Atlantic until then. She made 45 round trips between Britain and New York and was a Crimean War troopship.

The *Screw Steamship Great Britain* was launched in Bristol in 1843 by Albert, the Prince Consort, who had arrived on Brunel's *Great Western Railway* from London. Displacing 3600 tons, the *SS Great Britain* was by far the biggest vessel ever, the wonder of the age. She was the first ocean-going large iron vessel, the first large ship to use a screw (i.e. propeller), the first to have a strong cellular double hull of wrought iron plate and the first to be further strengthened by multiple water-tight compartments. She carried tens of thousands of British voluntary settlers to Australia in 55 out-bound trips and she was also a Crimean War troopship. Her hull floated for 90 years.

Brunel's third and greatest ship was the *Paddle Screw Steamship Great Eastern*, at 32,000 tons, ten times the displacement of the *SS Great Britain*, and powered by sails, a propeller and gigantic side paddle wheels. She was designed to carry 4000 passengers and circumnavigate the world without refuelling. She was launched at Milwall on the Thames in 1858, had a top speed of 13 knots, five funnels (one for each engine) and, as the world's biggest ship until 1900, uniquely could lay the trans-oceanic telegraph cables of the 1860s and 1870s.

Railways

Complementing his ocean fleet, Brunel designed the *Great Western Railway*, a 7-foot ¼ inch gauge, high-speed twin track from London Paddington to Bristol Temple Meads station initially, and eventually to Penzance, far to the South West. The first trains ran from 1838 and the whole London–Bristol route was opened in 1841. In addition to bridges and deep cuttings, the railway included a tunnel of three kilometres through the Box Hill, near Bath. The Box Tunnel employed tens of thousands of labourers and was said to be the biggest engineering project since the Giza pyramids. Many side-branches followed in the South West, Wales and England's Midlands. Brunel was a rail advisor overseas in Tuscany, India and Victoria, Australia. The Great Western Railway eventually had 4000 miles of track in Britain, years after Brunel's death.

BRUNEL'S HOSPITAL

Commissioning the project

In mid-February 1855, the War Office directed Sir Benjamin Hawes KCB, Deputy Secretary at War, to invite Brunel to submit a design of a large portable hospital to be sent to Turkey in support of British Crimean troops.

Just three weeks later, in early March, Brunel's detailed design was in the hands of Sir Benjamin, who endorsed it immediately! Within two months the first ship was unloading the first components of Brunel's 1000-bed hospital in Turkey and Renkioi.

Renkioi was also known as Erenkoy and now Itape. Among the dozen alternative sites carefully examined, one of Renkioi's winning advantages was that it had good sea access, including two suitable pier sites; the landform sloped gently towards the

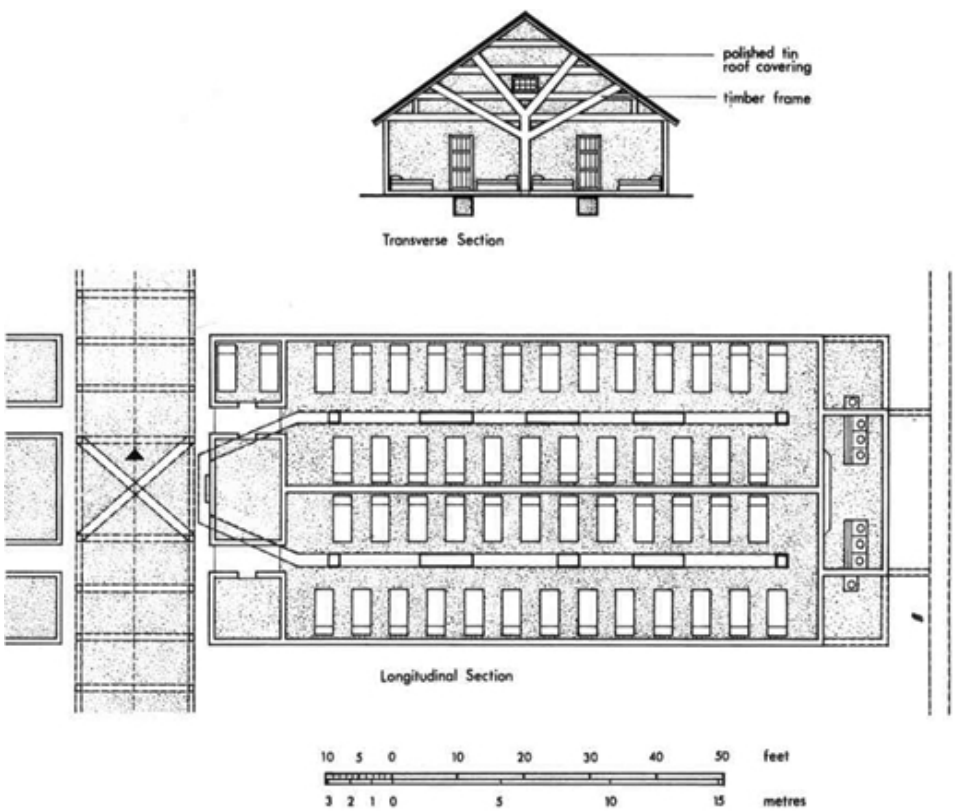

FIGURE 2: Ward hut plan view and end elevation.

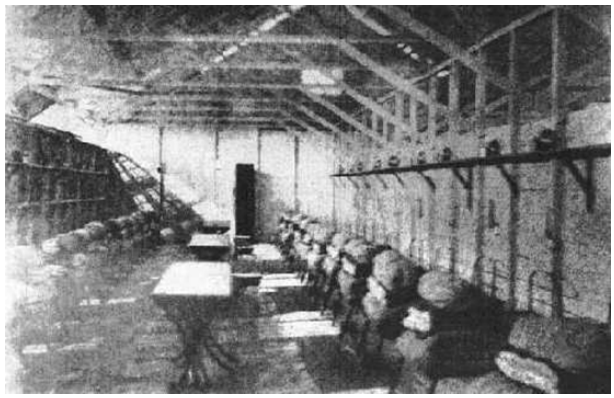

FIGURE 3: Inside a ward hut of Brunel's Civil Hospital at Renkioi.

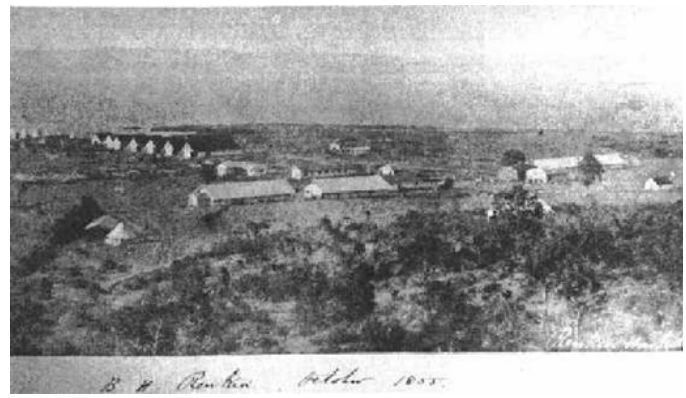

FIGURE 4: Receiving patients, Brunel's Civil Hospital, 1855.

coast, which aided transport. In addition, there was enough space (270 acres of sheltered land, with area for expansion to 3000 beds if needed) and an abundance of clean, fresh water (used mainly to flush the sewerage drains). It had fertile soil for growing vegetables and fruit. Its only disadvantage was that it was two days' sail on the wrong side of Constantinople, but that was balanced by being two days closer to Britain.

Design, shipping and assembly of the Civil Hospital

Brunel's Civil Hospital was unique due to the background he brought to the design process. Prefabrication was rare at the time and unheard of in the context of hospital design. The various components were in two-man portable packs, loaded in multiple ships in case of shipwreck. When approaching the hospital site, the ships used one of two piers, north or south, according to the wind direction. With this plan in place, eventually 11,500 tons of material and stores were landed from 23 ships. Setting up the hospital was as precise as Brunel's design. The assembly team that accompanied the components comprised an engineer and 17 other skilled men (foremen, tradesmen and two water closet makers). The elaborate reticulated water supply and sewerage drains were placed first (Brunel favoured effective sanitation and made this a feature of his hospital). The ward huts were identical and largely self-contained, each with 50 patient beds and a separate two-bed room for nurses. The wards were set on either side of a long enclosed corridor to enable easy movement between huts without needing to enter the elements (humid and hot in summer and cold and bitter in winter). An ablutions room with basins and water closets was at the ward's outer end. Few people anywhere were familiar with water closets and so instructions were included. Brunel didn't invent the water closet but used it to provide controlled sewage disposal. The sewerage outfalls were well offshore, averting the development of foul areas in the hospital grounds. Brunel placed a railway between the two piers (with horse-drawn wagons) running to the corridors at right-angles, to enable the easy movement of patients, other personnel and of goods from ship to hospital. Ducted, humidified forced-air ventilation (i.e. air conditioning) was directed from the enclosed corridor (the nurses' room end of the ward), through the ward to the ablutions room and then outside. Hut ventilation could be by man-pumped fan, at 1000 or more cubic feet of air per minute, but mainly came from the near-constant sea breezes via controllable ventilation openings in the upper part of the hut walls.

The hut design addressed function. Brunel took into account all aspects, designing spaces for wards, kitchens, slaughterhouses and laundries. There was a kitchen and laundry allocated to each ten wards. All the wards and most other huts were made of wood, being light and thus easily transported; they proved to be durable as well. Corrugated iron was specified for the kitchen huts, in view of the cooking fires. Roofs were insulated with felt beneath polished tin. Each ward hut had natural light (windows) and beds three feet apart, set in orderly rows and easily accessible to all staff. The huts had horizontal floors set on posts to avoid potential trouble from rain water trickling down the gradual slope of the site. Food preparation and quantity were good, in fact they were far better than what the barracks back home were able to provide. The laundries had 200°C drying rooms for all garments, blankets and sheets. Safety measures for the hospital included two fire engines.

Consciously or not, Brunel had addressed the existing theories of epidemic spread. Medical men (and Florence Nightingale) blamed foul air, overcrowding, poor diet and poor ventilation; the hospital's design dealt with each. Flush toilets were in the ambit of Dr John Snow's "bad" water theory—there was no cholera at Renkioi. Body lice, contracting typhus and not washing had not been identified as linked, but ablution facilities and lice-killing laundry were there for all, anyway. Unsurprisingly, typhus was almost absent at the Civil Hospital, in marked contrast with the many other Allied hospitals..

Brunel's hospital spoke for itself. A comparison between the death rates at Scutari and Renkioi makes it clear that this forward thinking was exactly what the development of wartime medicine needed; medicine anywhere, in fact.

Death rates: Scutari versus Renkioi

- Barracks Hospital, Scutari: 10,000 patients; 42% died (Koolalee, five miles north, was worse).
- Civil Hospital, Renkioi: 1400 patients; 3% died, with a similar casemix.

Florence Nightingale was enthusiastic about the British Civil Hospital at Renkioi, though she never actually saw it. The design greatly appealed to her and she referred to "those wonderful huts" and "magnificent huts". She was keen on ventilation, light and miasmas, but "good" drinking water was not on her list for years to come. Brunel's post-war comment about his hospital project was more understated: "…. just a sober exercise of common sense….".

For him it was a minor project, but still one to be approached from first principles, just like any other.

END OF THE WAR

As a result of its many calamities in the Crimean War, the British Army's logistics, equipment and battle tactics were improved, along with the medical service, including hospitals. Military training and a career pathway were set up for doctors and trained nurses became a standard part of the health support of troops. Other medical advances to come out of the war included civilian nurse training and practice that could copy and further develop the styles of Florence Nightingale, Mary Seacole and others in the Crimean theatre. Surgical anaesthesia and operative practice likewise could expand. Professor Pirogov became as great a figure in Romanov Russia as any British doctor at home post-war. Hospital organisation was a great victory. The lessons of the hospitals in Constantinople and at Renkioi were available for subsequent designers and clinicians in Britain and elsewhere. Public health became the highly productive career pathway of Dr Parkes, the Medical Superintendent at Renkioi. An able clinician, scientist, teacher, administrator and judge of men, Dr Parkes was equally at home in civilian and military environments and became known as the 'Father of Public Health' in Victorian Britain.

BRUNEL'S HOSPITAL AFTER THE WAR

Brunel's hospital was considered a success, although it was not quite one year old when closed. Had the war lasted longer, it is easy to imagine that Brunel's design would be more emphasised in medical history than is the case.

The final patients were discharged by June 1856, and shortly afterwards, the fittings were auctioned on-site. Brunel's appointee, Mr Brunton, the engineer who had erected the hospital, bid for and purchased the water closets and air conditioners and soon sold them to the British Army and Royal Navy respectively. The buildings were donated to the Ottoman Empire. Within a year, many huts were reassembled near Salonika, in relief of an earthquake.

Brunel, a medical amateur, had not copied any hospital that had ever existed. His design addressed the many medical and non-medical aspects of function needed to establish and operate a large medical facility that would work well.

It optimised overall care, minimised transmission of contagious disease and expedited movement of patients, goods and staff within the facility, and to and from the site. No hospital anywhere since mid-Victorian times has ignored the features that Brunel put together so quickly in 1855. His principles are universally recognised as basic to any organised hospital, whether near a battlefield or disaster site or at the centre of a peacetime Western metropolis.

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