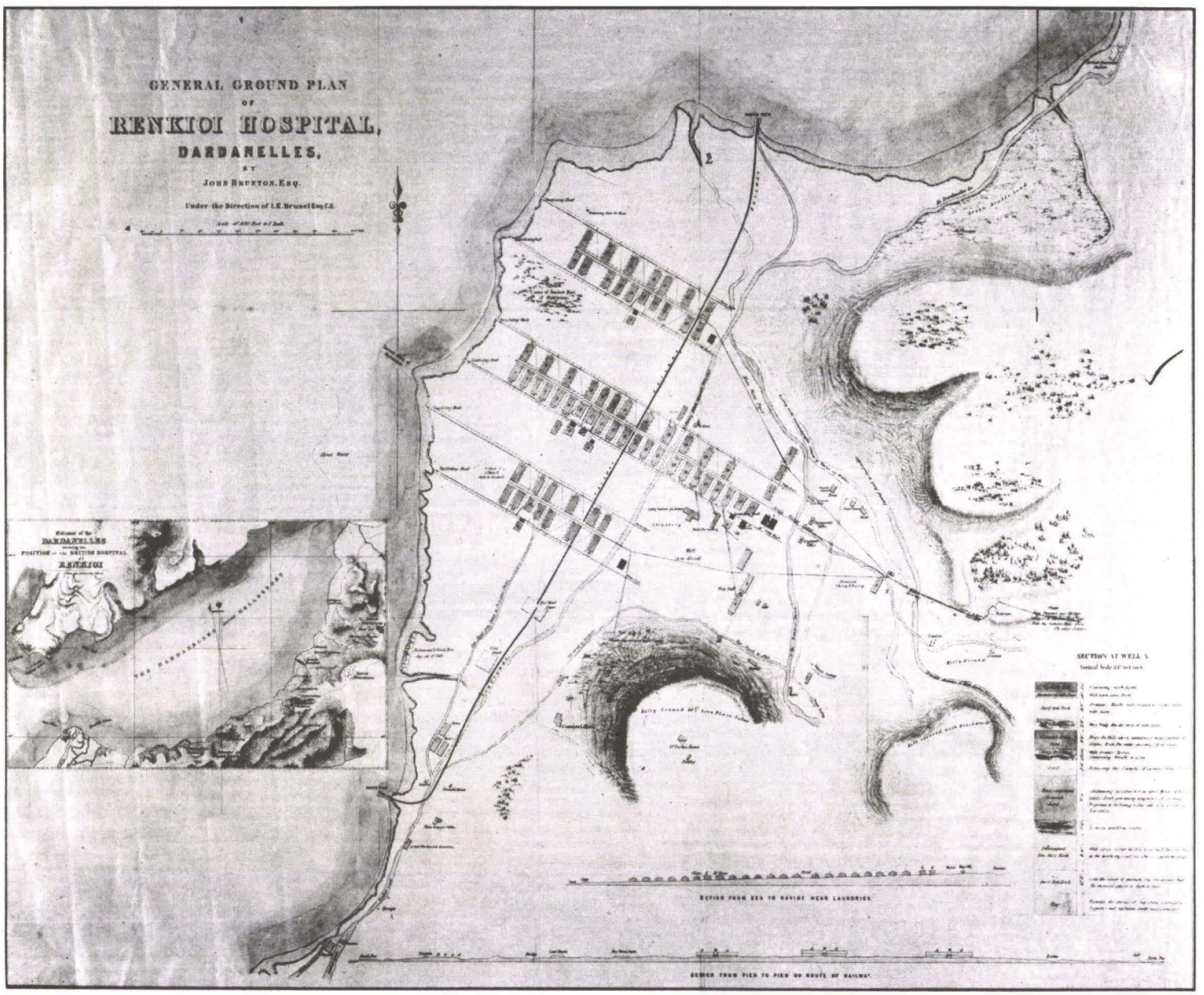
THE ARUP JOURNAL

JULY 1981



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Introduction

Peter Dunican

At Maxwell Fry's 80th birthday party in August 1979 the publisher and editor of *Architectural Design,* Dr. Andreas Papadakis, arranged with me to review for him 'Pioneers of prefabrication : The British contribution in the nineteenth century' by Gilbert Herbert. My review was published in the November issue of *Architectural Design* and in it I said, *inter alia:*

'In detail the examples which are given cover particularly the middle period of the 19th century, but go back to 1787. And, in fact, to a prefabricated hospital arriving in Sydney in 1790. Perhaps 1830-1840 was the real beginning of the export in earnest of prefabricated buildings from Britain, although the Crystal Palace in 1851 marked the ultimate achievement in construction, with one million square feet of exhibition space being completed in less than a year from the start of the design. A most remarkable achievement, still unequalled.'

'Following Paxton's Crystal Palace achievement – which unfortunately was not repeated in its transfer to Sydenham, mainly because of the client's interference – Brunel completed in 1855 a 1000-bed prefabricated hospital in the Crimea in ten months from the date of the initial instruction, which emanated from the direct involvement of Florence Nightingale. This outstanding work was erected by a team of 13 carpenters, one pipelayer, three plumbers and a smith, with some assistance from Greek carpenters. It was a most remarkable achievement which has not been repeated anywhere since.'

Subsequently, and most unexpectedly, I received an approving letter from an *AD* reader which made particular reference to my brief observations about Brunel's Crimea hospital and referred to a private, unpublished and detailed monograph on the subject.

Naturally I was so intrigued by this that I asked to see it. Having seen it I was absolutely convinced that this was a work of historical importance, which should be widely published, preferably in *The Arup Journal;* and here it is.

I consider it to be a most distinguished contribution to the history of our construction industry and a significant challenge to our future performance. I think that we are privileged to publish David Toppin's monograph and I trust that we have done it justice.

I wish I had the ability and tenacity to produce such a work.

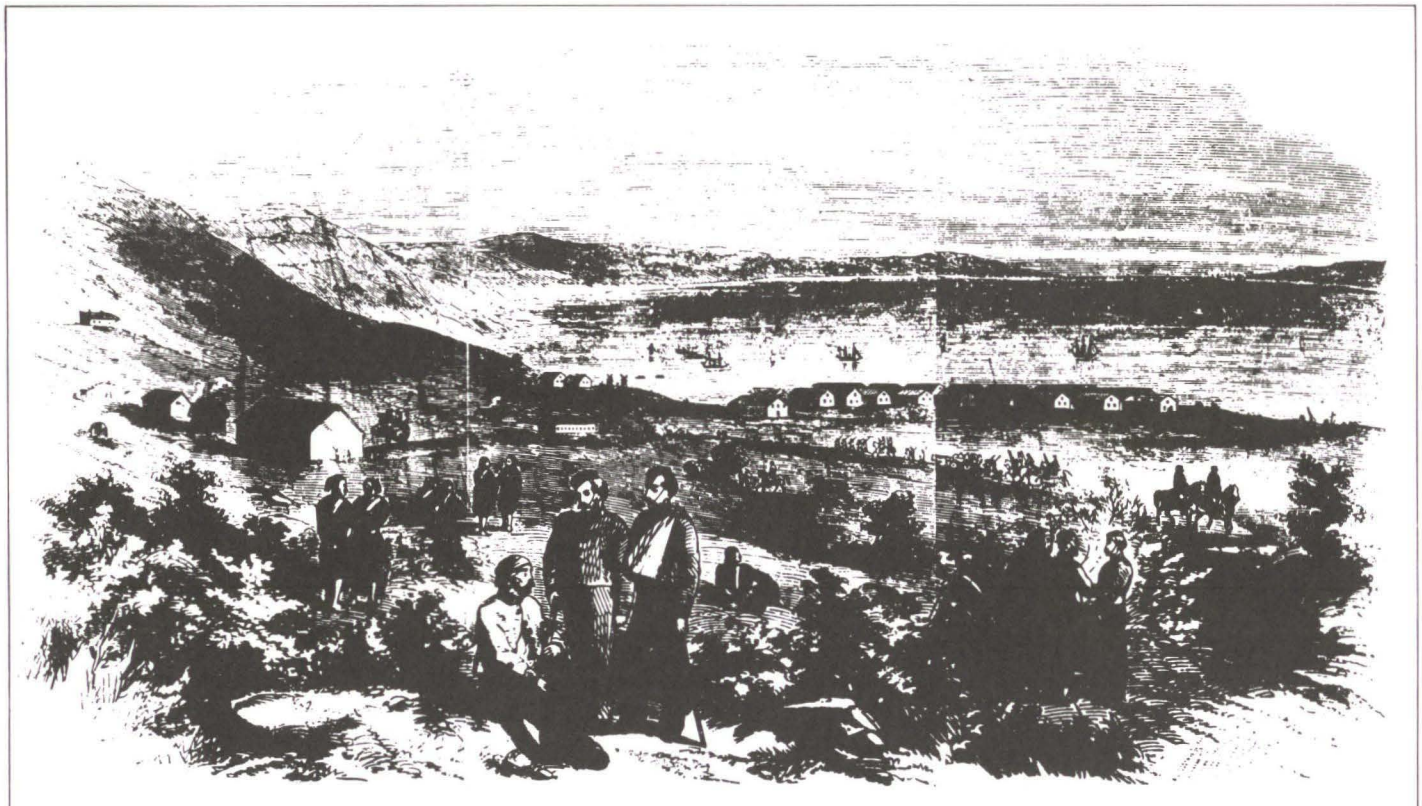

Fig. 1
A contemporary observer's view of the Renkioi Hospital
(*The Illustrated Times,* 1 December 1855. Reproduced by courtesy of City of Westminster Reference Library)

The British Hospital at Renkioi 1855

David Toppin

Introduction

Over 125 years ago two buildings were both designed and constructed in an incredibly short space of time: the Crystal Palace, and a hospital for the Crimean War which was 'designed, constructed, crated, shipped to the Dardanelles and opened for use in six months in 1855'[1]. Whilst the former building was designed by a head gardener and the latter by a civil engineer, Isambard Kingdom Brunel, both are paradigmatic, and, in their contrast, illustrative of the range of early industrialized building. The former is a bravura display and symbol of Victorian daring, ingenuity and technological skill, the latter, perhaps unspectacular and of no momentous single breakthrough, is of courageous common sense, modest in its simple disciplined modularity and honest response to functional, climatic and logistical problems, yet still significant in concept. Both exhibit examples of an architectural planning principle that has come to be known as indeterminacy.

Interest in the hospital lies as much in the concept of indeterminacy as in how this speed was achieved and what the hospital was like. Unlike the Crystal Palace, the British Hospital is a considerably under-exposed topic and commands only relatively brief mention in readily accessible literature[2], and at the same time it has been surrounded in rumour and conflicting claims. Reasons for this must include the bias of writers in ways of interpreting available facts, linked with the shortage and difficulty of access to information on the hospital, coupled with the inevitable overshadowing effect of other works by Brunel of greater magnitude, complexity and contemporary controversy; and the fact that the hospital was conceived as a temporary structure erected outside England and in use for a little over a year.

It has been said that all history becomes subjective; that properly there is no history, only biography. In this account of technical and related social history, revolving therefore around the sheer force of individual personalities, Brunel's multi-faceted achievement, with its genesis in a critical political situation, is remarkable. The hospital is notable for the speed and methods of its design, its linear organizational principle, and its wide sense of energy consciousness in terms of materials usage, environmental management, servicing and assembly process, as well as being an illustration of an early example of prefabrication.

What follows does not, in relation to any history of construction, seek to claim primacy of inventions, and is less about firsts and rather more about mosts[3], and it is in their cumulation that the significance of the building lies. Yet the outstanding point that emerges is that, whilst none of the constituent parts were totally original inventions, it was Brunel's conception of their total functioning together as a co-ordinated plan of action that was in a sense the great invention.

There is no work, to the author's knowledge, which fully describes or does justice to Brunel's achievement, and the wider import of it has still to be satisfactorily interpreted. The significance of his building lies in the fact that the fundamentals that Brunel grappled with, successfully, are still relevant today.

Fig. 2
View of hills surrounding, seen from the site of the Hospital, Summer 1972. (Photo: David Toppin)

The Crimean War

For various motives, England, in the mid 1850s, slid into the Crimean War without real object or occasion, contrary to the policy of her peace-loving Premier, Lord Aberdeen. She sided with the French and war was declared in March 1854[4]. The capture of Sebastopol, the Russian arsenal and naval base, was chosen as the allied objective. Sebastopol could have been taken within a few days of the landing of the French and English in the Crimea, had they chosen to march into it at once from the north. However, deficiencies of leadership resulted in a march

Fig. 3
Map of the Black Sea and its environs, indicating the region of the Crimean War and the site of the Hospital. (Drawn by David Toppin)

round the fortress to the south to begin a slow siege. The enemy were thus given time for defence works and the reinforcement of the field armies. The besiegers were soon put on the defensive and, as a result of the breakdown of organized supply and transport, the little British army nearly disappeared in the Crimean winter[5].

It seems incredible that the British nation, which then led the world in new methods of industrial production and organization, should be unable to provide for 20,000 soldiers half a dozen miles from her fleet in the port of Balaclava, yet the breath of reform, which was transmuting commerce, Parliament, Municipalities, Church and Education, had left the army untouched.

The deficiencies in military preparation led to such a disastrous situation that in the five months from September 1854 to January 1855 only 22,000 of the 56,000 troops sent to the East by the British Government still survived. Of the 22,000, at least 10,000 were in hospitals. The small remainder of men were completely demoralized, their officers no longer having the ability to command. ,The sick and wounded were dying in hundreds in deficient hospital buildings which lacked sanitary provisions, were overcrowded and understaffed. There was no heating in the buildings, and, during the severe winter in January, bedclothes and boots froze on the patients; the moisture of their breath turned to ice. Men suffered frostbite and chilblains, some freezing to death in the exposed wards during the night[6]. Disease spread: dysentery was the largest killer; cholera and typhoid also spread rapidly amongst the weakened troops who had little or no resistance to these diseases. The losses of men from disease far outnumbered those lost from battle.

The organization, strategy and supply services were totally unsuited to waging long-range warfare. At the base hospital at Scutari (now called Uskudar), a huge quadrangular building, formerly a disused barracks, with a grave natural disadvantage as a hospital since it stood over old sewers, there was a complete lack of facilities. There were no arrangements for landing the sick and wounded brought by sea, there was no proper water supply or drainage system, an inadequate number of open privies without any means of flushing or cleaning stood beside the main water storage tank – whose supply was eventually found to be polluted. Very often the supplies of warm clothing, medicine, tents and building materials, shipped from England to the Crimea, got no further than their ports of destination, where they were stolen or left to rot because of the inadequacy of communication and transport systems[6].

Developments

But for two developments, the diminished British Army might have finally perished for want of shelter, clothes, food and medicine. The first of these was the arrival of Florence Nightingale in Scutari, despatched from England in January 1855 by Sydney Herbert. A woman of administrative genius, inexhaustible energy and a withering contempt for red tape, she saved the sick and wounded of the British Army, in spite of its medical chiefs, by creating at Scutari a modern base hospital with trained women nurses and necessary material.

The second development was the emergence of the newspaper correspondent, an unknown person in Sebastopol or Scutari; for this was the first war to be covered by the newspaper correspondent. The daily reporting of the grim facts of the appalling conditions of the troops during that winter gave rise to a growing public awareness in England of the 42% death rate[6].

The emotional indulgence in the celebration of war gradually turned to disillusionment and challenged the statements by the Minister of State, that conditions were improving daily and that the Government was doing everything within its capacity. In January 1855, John Roebuck, the radical member for Sheffield, angered by the Government's inability to recognize the true situation and the need for immediate action, moved a vote of censure on the Government, and proposed a committee of enquiry[6]. The Government of Lord Aberdeen fell and was succeeded by Lord Palmerston's in February; a determined effort was made to better the situation and improve the conditions of the troops. A sanitary commission was sent to Scutari and the reports of Florence Nightingale clearly indicated that the problems of the hospitalization of the troops were the poor quality of medical care and the inefficient supply services available within the military structure, together with the unsuitability of using accommodation not designed or adequate for the purpose.

The request for a hospital

It was against this background that the newly-formed Government asked for a hospital system to be designed, made in England and sent out ready for erection. Quite obviously, the reasons for prefabrication lay in the difficulties of building to a satisfactory standard and rate with local materials, labour and processes. It is perhaps not surprising that the request should have been for an engineer. The massive social changes and technological developments in new materials and techniques were of little concern to the majority of architects at the time. Their preoccupations, impeded by an architectural tradition unable to discard its cultural load, lay more with the derivation of styles, and the conscious art of creating massive enduring structures, than the performance and construction of buildings. Sir George Gilbert Scott held that the great principle of architecture was to decorate construction, and in 1853 Ruskin stated that ornamentation was the principal part of architecture. The problems and potentialities of the first half of the century were left to be recognized and grappled with by others.

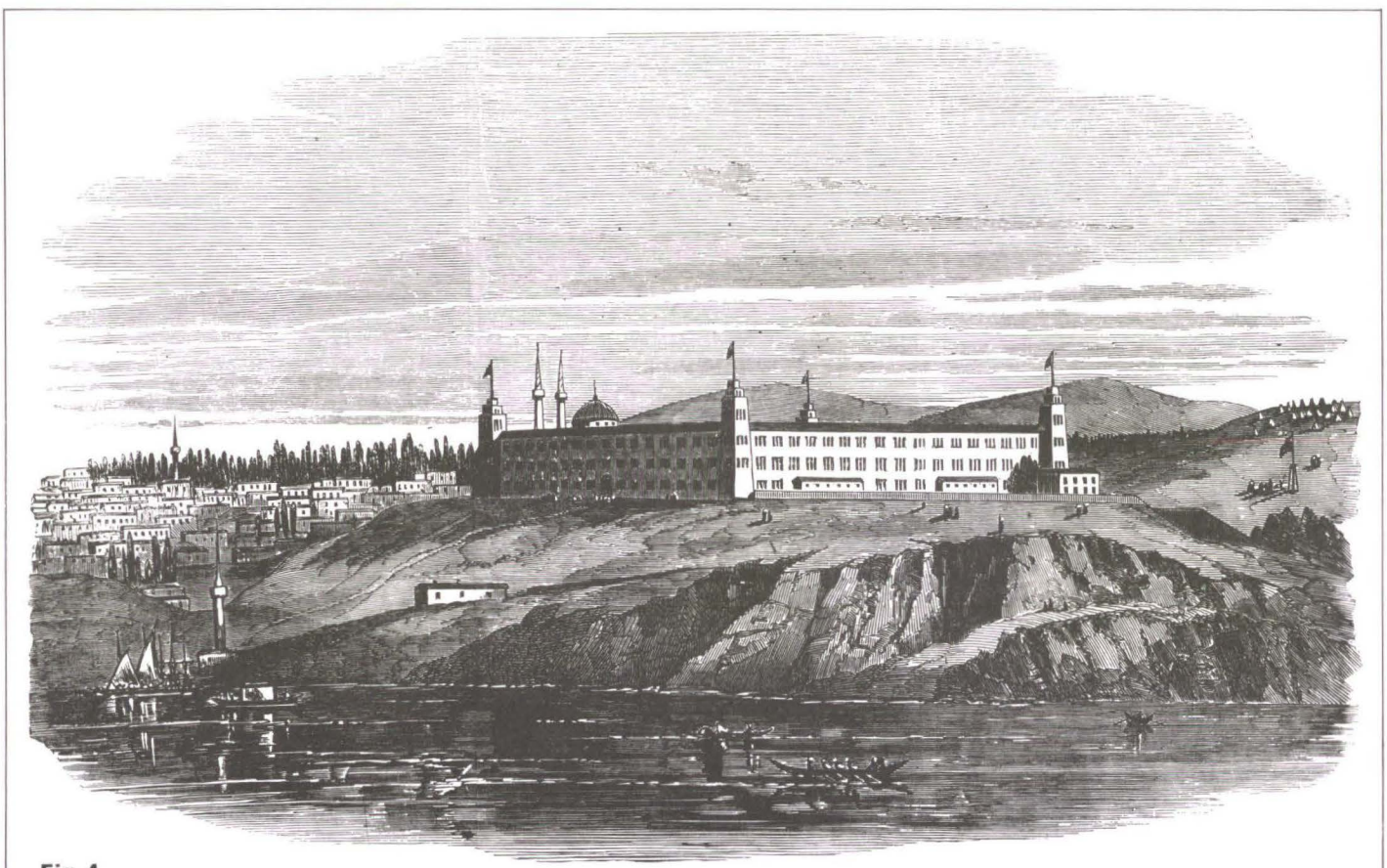

Fig. 4
A contemporary observer's view of Scutari Barracks in use as the British Hospital (*The Illustrated London News,* 6 January 1855)

Isambard Kingdom Brunel

Isambard Kingdom Brunel was born at Portsmouth on 9 April 1806, the third child and only son of Sir Marc Isambard Brunel, civil engineer. Sir Marc was an unself-conscious man of simplicity, unworldliness and natural dignity; from French stock he was self-taught and a born craftsman with a flair for invention[2]. Records indicate that the son showed a brilliant intelligence from the outset. He displayed a talent for drawing from the age of four and had mastered Euclid by the time he was six. Sir Marc was one of the first in England to have mastered the system of mechanical drawing evolved by Gaspard Monge, upon which modern engineering drawing is based, and, under paternal direction, Isambard started the habit of measuring and drawing on the insistence that the habit was as important to an engineer as a knowledge of the alphabet, and which undoubtedly contributed to his extraordinarily acute powers of observation[7].

By the time Isambard had reached adolescence his father had already achieved honour and distinction as an engineer and was able, despite financial vicissitudes, to give his son a good education and training. His childhood was spent at a boarding school in Hove, and holidays at the family home by the river in Lindsey Row, Chelsea. At the age of 14 Brunel went to the College of Caen in Normandy and later to the Lycée Henri Quatre in Paris famous at that time for its mathematical teachers, and, after finishing there, took an apprenticeship under Louis Breguet, maker of chronometers, watches and scientific instruments[2].

The incredible number and variety of projects that Brunel undertook in his life, included tunnels, bridges, railways, trains, ships, harbours and ports; his understanding of timber, for example, stemmed from a line of development of its structural potential in railway bridges.

For whilst the 19th century could look back on a long tradition of centuries of timber bridge truss construction, no serious attempt was made before that century at scientific design. The impetus was provided by the needs of the railways, whose construction commenced in 1821; the railway train is incapable of negotiating steep gradients up or down hill, nor can it operate until the permanent way is complete, thus posing a new problem requiring new solutions prompting original thinking, not least in terms of size and number required in a short space of time.

Experiments with timber

His first major project, which in 1841 established him at the age of 35 as second only to the engineer Robert Stephenson, was the original main line London to Bristol Great Western Railway which used a timber bridge[2]. By the late 1840s he had acquired considerable experience of timber bridge building and carried out experiments to determine the strength of timber beams and methods of preservation. In the later extension of the Great Western Railway into Devon and Cornwall, where Brunel faced the problem of crossing many deep and narrow valleys, he developed a standardized design of timber viaduct of considerable simplicity with spans of 50 and 60 ft. From piers, four diagonal members sprang, supporting the main longitudinal members carrying the platform. The members could be replaced without interruption of traffic and the whole design was based on the repetition of standard units of timber.

As a man, Brunel, short in stature and of no great physical strength, had immense reserves of nervous energy and unlimited capacity for hard work which, coupled with a dogged persistence, could, once unleashed upon a particular project, perform feats of endurance and work output out of all proportion to ordinary physical powers. By temperament, he was complex in character, privately acutely self-conscious; yet cold, proud and self-confident in public[2]. Brunel earned high reputation in the profession for his evidence given before Parliamentary committee on schemes of which he was an engineer[8]. But he was restive under restraint of any law, rule or regulation which interfered – even in an age of individualism – with individual responsibility or initiative, and a persistent and outspoken opponent of the patent laws, reserving special scorn for Government departments and their officials.

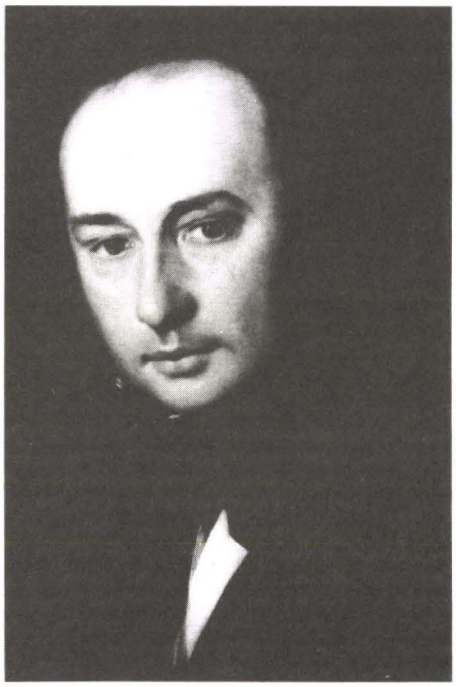

Fig. 5
Isambard Kingdom Brunel, aged 49
(Detail from portrait by J. C. Horsley, 1857. Reproduced by courtesy of the National Portrait Gallery)

The commission for the hospital

Sir Benjamin Hawes, who was Under Secretary of State for War, had married Brunel's eldest sister and was, perhaps, instrumental in Brunel's appointment for the design of the hospital. The state of war must have been a topic of conversation between them and the project might well have been discussed and developed in private. At any rate Brunel must have been forewarned, and with his usual zeal for new tasks, he had explored his first ideas for the design of the hospital by 16 February 1855, for, when he received the official request from the Government through Sydney Herbert, Secretary at War, to undertake the work, he replied on the same day[2] 'This is a matter in which I think I ought to be able to be useful and therefore I need hardly say that my time and best exertions without any limitations are entirely at the service of the Government.'

Definition of problem

This was not the moment to embark on the prolonged development of an elaborate and original design idea. What was required was an exercise in rapidly identifying all the factors essential to the success of the project and proceeding with haste. Brunel was fortunate indeed in having the problem so sharply focused and critically defined by the circumstances of its inception. Obviously the solution had to be conceived in terms of the following essentials:

The environmental needs and provision of facilities for the care of the sick and wounded.

A building complex based on a planning principle capable of adapting itself to unknown site conditions and accommodating an unknown number of patients

A form of construction utilizing an assembly technique appropriate to the possible available labour force

A speedy manufacture of the component parts, with an ease of their means of transportation.

Any answer, however ingenious and carefully conceived, could be rendered useless through a lack of anticipation of contingencies. What emerges is a uniquely appropriate solution judged both from Brunel's own description, and the observation of others on the performance of the hospital in use.

Method

Once committed to the undertaking, Brunel moved with remarkable speed, showing considerable initiative and the beginnings of his design method. Within six days he had placed the contract for the supply of buildings for a hospital with 1000 beds, and had written to Hawes at the War Office outlining desirable conditions, and asking for sketches of contoured maps of suggested sites. To have placed the contract, even by this early stage, he must have been fairly clear about the eventual form of his solution. An outraged squeak from the War Office Contracts Department at this unorthodox and precipitous behaviour produced the following retort[2]. 'Such a course may possibly be unusual in the execution of government work, but it involves only an amount of responsibility which men in my profession are accustomed to take . . . It is only by the prompt and independent actions of a single individual entrusted with such powers that expedition can be secured and vexatious and mischievous delays avoided . . . These buildings, *if wanted at all,* must be wanted before they can possibly arrive.'

Most probably in writing to Hawes, Brunel was trying to establish a more complete brief, yet we can be sure that he did not get contoured maps, for his later explanation of the idea behind the design of the hospital acknowledged that the actual site was unknown. In a further two weeks on 5 March, Brunel reported on his design to the War Office. He recorded[9] 'It is most gratifying to be able to state that from everybody I have received the most zealous and cordial assistance, and found it sufficient to mention the object of my enquiries to obtain immediately every assistance I could possibly require.'

Brunel's explanation of the idea behind his hospital was[10] 'That the aggregate of the building should consist of such parts as might be conveniently united with one whole under great variations of conditions of the form and nature of the site. That the several parts must be capable of being formed into a whole united by covered passages, and that it should be capable of extension by the addition of parts to any size.'

It would be interesting to know who Brunel saw and what advice he sought during this time. Yet there seem to be no records of his contact with advisers – whether medical, constructional or manufacturers of equipment. However, his choice of principal material, wood, has genuine virtues: in terms of performance in use – visually undemanding, acoustically quiet, thermally comfortable because it has a thermal conductivity which places it among the range of more than moderately good heat insulating materials, and also a low thermal capacity enabling its vegetable fibre surfaces to warm quickly; in terms of construction – freely available and easily workable. Certainly we can assume that the evolution of the organizational principle and the decision on the enclosure system was made early on for him to have placed the contract for the buildings.

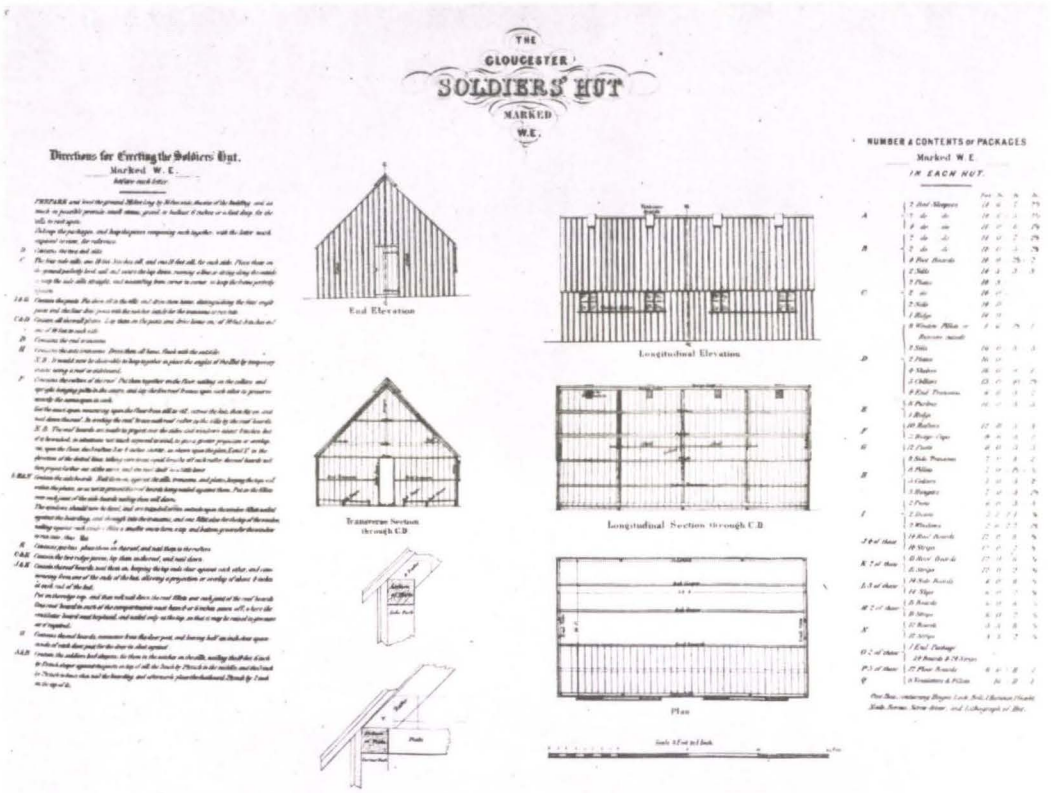

Fig. 6
Working drawing for the 'Gloucester' soldiers' hut, illustrating the extent of rationalization of timber hut construction, in terms of prefabrication, coding of components and assembly process.
(Reproduced by courtesy of the Public Record Office, London)

Fig. 7
Prefabricated portable wooden barracks manufactured in Gloucester for the French Army in the Crimea (*The Illustrated London News*, 6 January 1855)

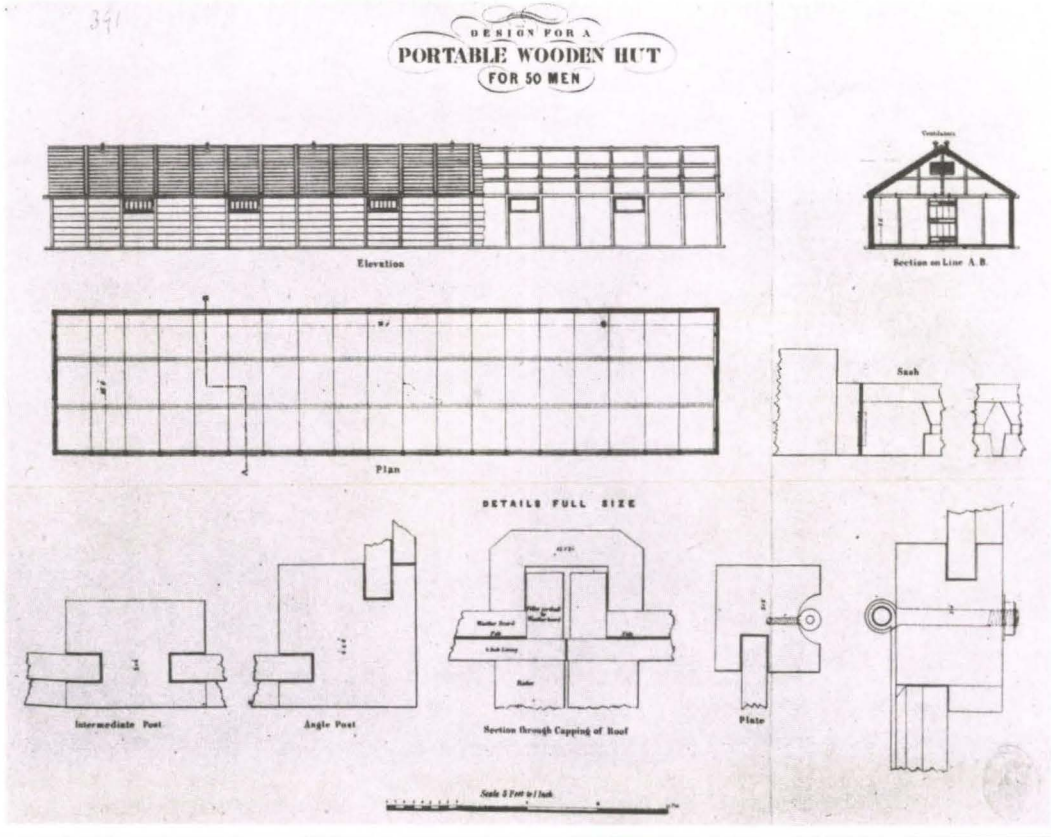

Fig. 8
Drawing of a simple portable wooden hut illustrating details of unsophisticated character.
(Reproduced by courtesy of the Public Record Office, London)

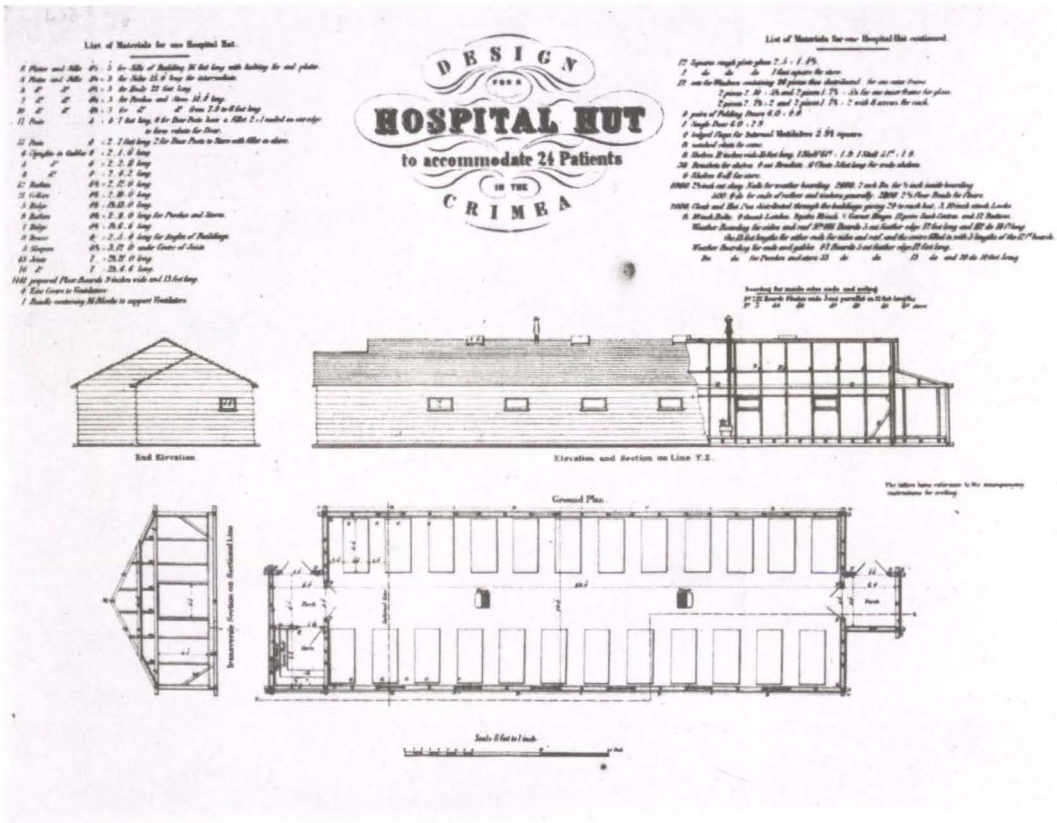

Fig. 9
Drawing of a hospital hut showing coding of components. (Reproduced by courtesy of the Public Record Office, London)

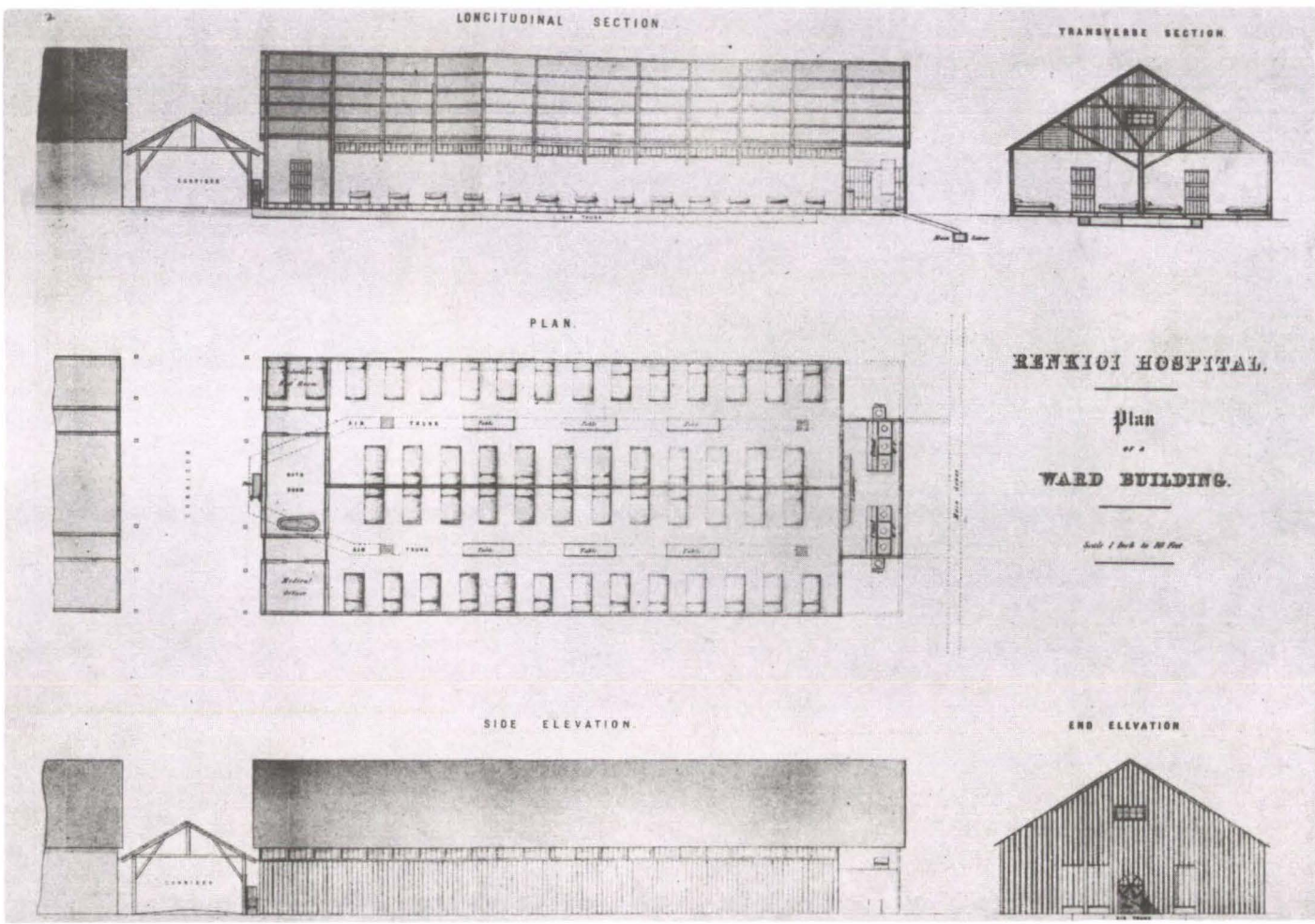

Fig. 10
Drawing of Brunel's ward building. (Reproduced from Dr. E. A. Parkes' report on the formation and general management of Renkioi Hospital, on the Dardanelles, (Turkey).

As will be seen later, the basic concept of Brunel's design was based on timber pavilions, and it is known that from pioneer beginnings in the 1830s, British industry had, by the time of the Crimean War, developed a significant technical competence and production capability for the manufacture of prefabricated buildings, ranging from modest wooden or corrugated iron huts to the most elaborate iron villas, churches and commercial buildings. Considerable experience had been gained in manufacturing large quantities of prefabricated huts quickly for export to Australia and elsewhere, and a system of coding of the parts had been developed[6]. Thus for the enclosure system Brunel drew on existing resources.

A person of Brunel's varied experience would often have been involved in the design activity of forming assemblages through the combining of repetitive elements. But even so, the idea behind the hospital is remarkable; not least for its portending of the idea of indeterminate buildings – i.e. those buildings in which not all aspects are fully determined at the time of their design, and are characterized by a linear organizational planning principle which accommodates an incomplete brief and at the same time contains built-in potential to meet unknown growth [1]. Shortly after Brunel reported to the War Office, a prototype ward was erected on the premises of the Great Western Railway at Paddington.

The size of the ward was considerably larger than existing huts, and one of the objects of the prototype must surely have been a number of tests which included the lightness and strength of the structure, and the performance of heating and ventilating systems to see if further economies and improvements could be made.

A report on the hospital dated March 1855, written by Brunel to satisfy his friends' curiosity, appears to be the only instance in which he printed an account of his works. It shows an elastic and efficient plan of action, capable of adapting to unknown conditions and anticipating possible contingencies. It gives considerable insight into his design method, and reads almost like a primer. He outlines his strategy and sets down his definition of requirements[10]. 'The conditions that it was considered necessary to lay down in designing these buildings were :

First, that they should be capable of adapting themselves to any plot of ground that might be selected, whatever its form, level, or inclination, within reasonable limits.

Secondly, that each set of buildings should be capable of being easily extended from one holding 500 patients to one of 1,000 or 1,500 patients or whatever might be the limit which sanitary or other conditions might prescribe.

Thirdly, that when erected they might be sure to contain every comfort which it would be possible under the circumstances to afford.

Fourthly, that they should be very portable and of the cheapest construction.'

Proceeding, Brunel then explains : 'The mode in which it has been sought to comply with these conditions is as follows :

The whole hospital will consist of a number of separate buildings each sufficiently large to admit of the most economical construction, but otherwise small and compact enough to be easily placed on ground with a considerable slope, without the necessity of placing the floor of any part below the level of the ground. These separate buildings have been made all of the same size and shape ; so that with an indefinite length of open corridor to connect the various parts, they may be arranged in any form, to suit the levels and shape of the ground . . . so that by lengthening of the corridors and the addition of any number of these buildings, the hospital may be extended to any degree.'

What this amounts to is a very subtle definition of the size of a basic unit based on a trade-off between its increasing economy of construction and decreasing ability to adjust itself to unknown site conditions ; as well as the elucidation of a coherent repetitive principle of organization of the units, and a system of extension to accommodate an unknown patient load. He continues[10] :

'Each building, except those designed for stores and general purposes is made to contain in itself all that is absolutely essential for an independent hospital ward room ; . . .

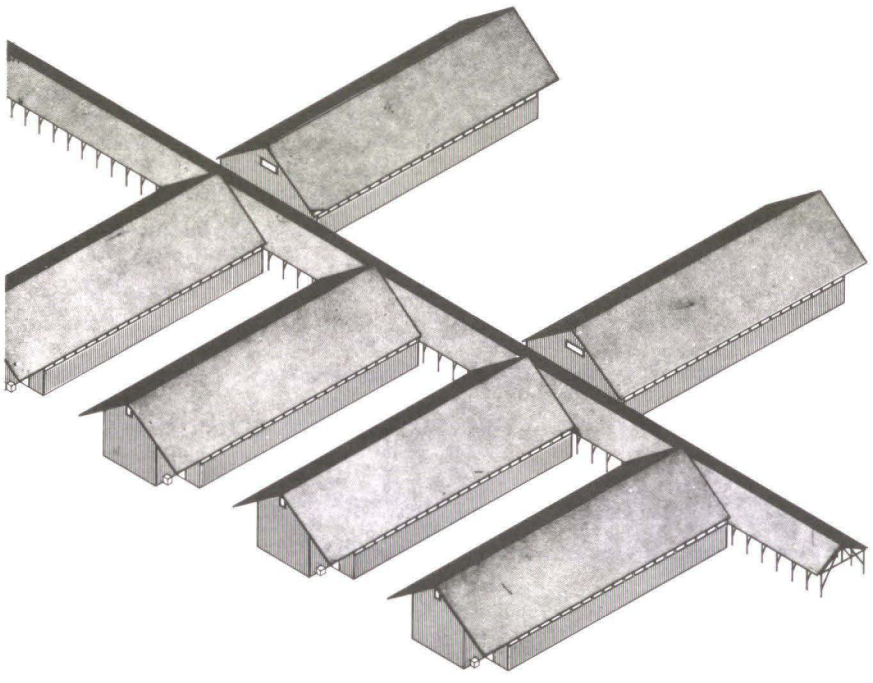

Fig. 11
Isometric drawing illustrating the linear organization of Brunel's standard ward units : pavilions either side of a connecting corridor, characteristic of indeterminate buildings. (Drawn by David Toppin)

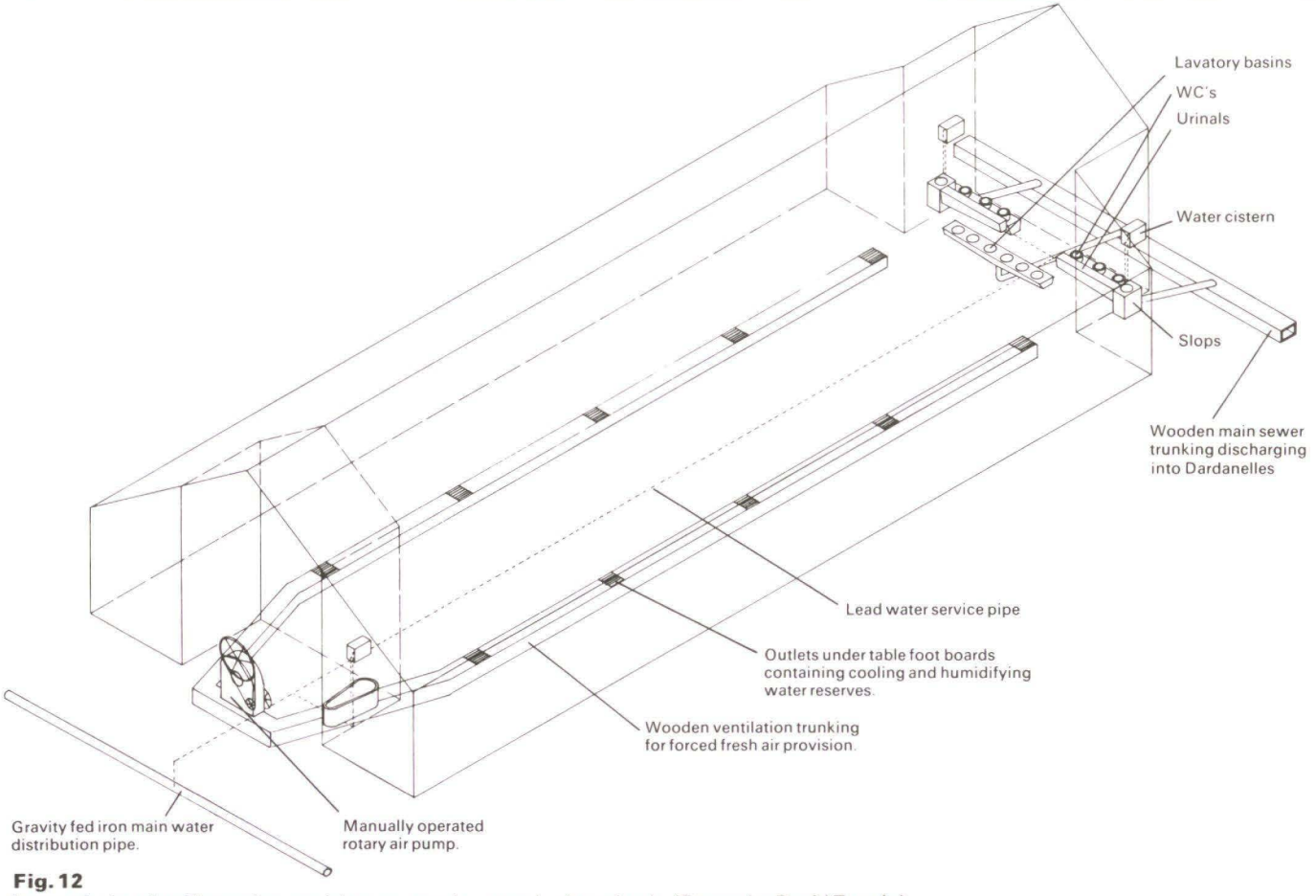

Fig. 12
Isometric drawing illustrating servicing systems in a standard ward unit. (Drawn by David Toppin)

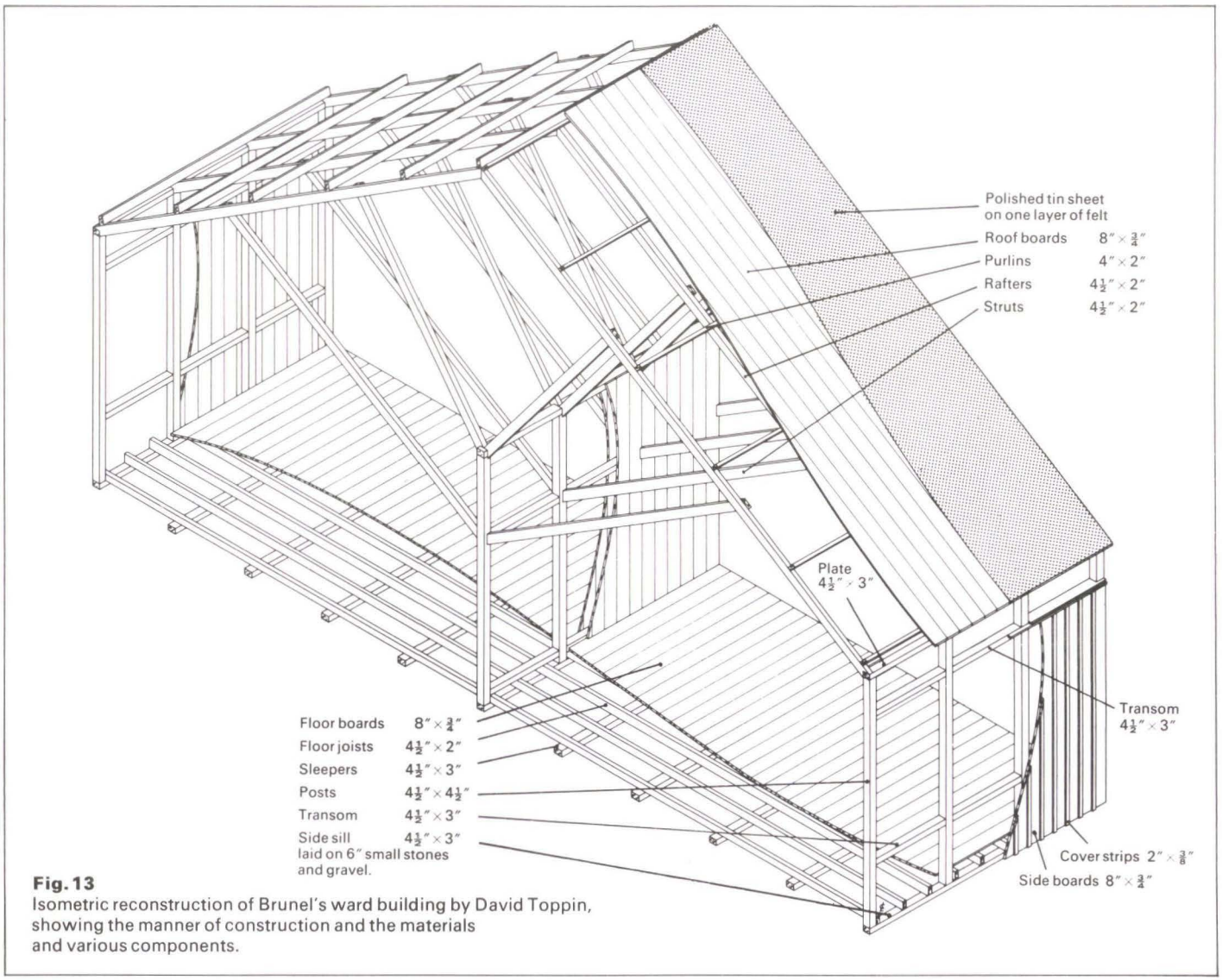

Fig. 13
Isometric reconstruction of Brunel's ward building by David Toppin, showing the manner of construction and the materials and various components.

'To ensure the necessary comforts, and particularly to provide against the contingency of any cargo of materials not arriving on the spot in time, each building contains within itself two ward rooms, one nurses room, small store room, bath room. surgery, water-closets, lavatories, and ventilating apparatus.'

'The ward room, . . . intended for 26 beds each, which is found in practice to be a size of room admitting of proper control and supervision, . . . is made wide enough and high enough to ensure a good space of air to each bed, even if these should be unduly crowded.'

Here, Brunel is juggling with the size and composition of the unit for self-containment, and trading off variously the size of the unit for effective control and supervision, economy of provision of self-contained facilities, and contingency of supplies.

Turning to the provision of sanitary facilities he continues[10]: 'With respect to closets and lavatories, after examining and considering everything that has been done, both in hospitals of the best description and poor houses of the cheapest construction, it was found that the requisite security for cleanliness and the greatest amount of economy of labour and on consumption of water, could be obtained by a cheap description of water-closet designed for the purpose; and with the same object of diminishing the amount of labour and waste of water, and securing cleanliness without depending upon the constant attention of assistants, fixed basins for lavatories and mechanical appliances for supplying and drawing off water were adopted.'

From the report it is clear that Brunel gave considerable thought to the anticipation of the climatic conditions under which the hospital might have to operate, and the means of attaining environmental control in the wards. The systems for the protection against heat and cold, supply of air by natural and mechanical means, control of humidity and artificial and natural lighting were all carefully worked out[10]. 'As a protection against heat, experience in hot climates and experiments made expressly for the purpose satisfactorily proved that a covering of extremely thin and highly polished tin, which reflects all direct rays of heat, was the cheapest, lightest, and most effective protection, and every piece of woodwork not covered with tin is to be whitewashed externally.'

In the provision of heating and in the event of the buildings still being in use in the winter– 'The framework is adapted to receive an internal lining of boarding and the interstices can be fitted with a non-conductor.'

As all the buildings except the kitchens and wash houses were constructed entirely of wood, Brunel considered it essential that stoves or fire places should not be used: '. . . each ward building is provided with a small boiler, heated by candles, which by experiment have been found amply sufficient for all that can be required.'

Ventilation

'To secure ventilation in a hot climate with low buildings extending over a large area, and therefore incapable of being connected with any general system of ventilation, it was considered that *forcing in* fresh air by a small mechanical apparatus attached to each building would be the only effective means. Each ward-room is therefore furnished with a small fan or rotary air pump, which, easily worked by one man, is found capable of supplying 1,000 to 1,500 cubic feet of air per minute, or 20 to 30 feet for each patient. This air is conveyed along the centre of the floors of each ward-room, and rising up under foot boards placed under the tables, is found to flow over the floor to every part of the room . . . By forcing the air into the room, instead of drawing it out, the entrance of bad air from the closets, drains or any other nuisances, is prevented. The fan is placed at the opposite end to the closets and drains; and all the fans being in the open corridor, the workmen can be seen by a single sentry and kept to their work.'

'Besides this mechanical supply of air, opening windows are provided along the whole length of the eaves, and spaces left immediately beneath the roof at the two gables, amply sufficient together to ventilate the rooms thoroughly if any breezes are stirring, without the help of the fan.'

Humidity

'There is a very simple provision made for passing the air over a considerable extent of water surface; which would not only cool it, but diminish the effect of excessive dryness, which is said to be occasionally in this climate more oppressive than even the temperature.'

Lighting

'The light is admitted by a long range of narrow windows, immediately under the eaves, which protect them from the direct rays of the sun. These windows open, and are provided with shutters inside, which exclude the light, but admit the air . . . Internally the lime wash has a slight tint of colour to take off the glare . . . Candles are to be used exclusively for lighting, and lamps and lanterns have been constructed for the purpose.'

Fire protection

'A proper supply of fire engines is provided and other precautionary measures are adopted against fire.'

Drainage and water supply services

'With each set of buildings is sent a pumping apparatus, a small general reservoir, and a sufficient length of main, with all its branches, to supply water to every detached building; and all the pipes and branches are of such construction to admit of being put together without any soldering or cement. A system of drains is provided, formed of wooden trunks properly prepared, and of sufficient extent to form a complete and perfect system of drainage from evey building to a safe distance from the general hospital'.

Construction portability and cost

'The construction of each building has been studied with very great care, so as to secure the minimum amount of material, the least possible amount of work in construction or erection, and the means of arranging all the parts in separate packages capable each of being carried by two men; and the result is that each building is the cheapest and lightest that has yet been constructed in proportion to the area covered.'

Transport

'For the transport of the materials to the spot selected, two sailing vessels and three steamboats, capable of carrying one hospital for 1,000 men which is the first about to be sent out, have been secured. In each vessel is sent a certain number of complete buildings, with every detail, including their proportion of water pipes and drains, closets, lavatories, baths, etc, and a small amount of surplus material and tools; and in each of two separate vessels are sent a set of pumps and mains and a kitchen and washhouse. So that by no accident, mistake or confusion short of the loss of several of the ships, can there fail to be a certain amount of hospital accommodation provided with every comfort and essential.'

'The cargo space required for their conveyance is about a ton and a half to a ton and three quarters measurement per bed.'

Equipment

'As the space in the wards is very liable to be encroached upon, and the beds crowded, portable baths have been designed, into which the more helpless patients can be lifted, and lowered, on a frame or sack, without requiring space for assistants to stand around, or with the bath placed only at the foot of the bed.'

'The kitchen and laundry have each required many special contrivances.'

Other spaces

'A number of small buildings, intended to be despatched from the main body, are provided for residences for the officers and servants of the establishment, and for a small detachment of soldiers. A slaughter house and a store yard and some other appurtenances are also provided, the extent of which depends on the circumstances of each case.'

Flexibility of accommodation demand

'The ward room is made wide enough and high enough to ensure a yard space of air to each bed, even if this should be unduly crowded . . . if pressing emergency should lead to the beds being placed closer, and fifty per cent. more patients introduced, it is believed that the perfect system of ventilation which is secured would render these hospitals very superior to any now in use for the army.'

Prospecting for a site

The newly formed Government had decided to officer the hospital with civil medical practitioners instead of calling in the already overburdened and inadequately organized Army Medical Officers. The physician appointed during March 1855 as Medical Superintendent was Dr. Parkes.

Dr. Parkes was not overtly involved in the design of the hospital, as he himself commented after consulting with Brunel and inspecting his proposals. The design had already been considered and fixed and was 'distinguished by the perfection of detail and excellence of method which stamped all the works of that excellent engineer. I was convinced nothing could exceed the excellence of the mechanical arrangement, and that the most pressing duty seemed to be the choice of a fit locality for the hospital.'[11]

Dr. Parkes left London on 5 April having made arrangements for the medical organization of the hospital, and requisitioned medical and purveyors' stores for 1,000 men. He arrived in Constantinople on 18 April.

Brunton's appointment

The choice of the engineer to prospect for a site and superintend the erection of the buildings was obviously of critical importance in Brunel's plan of action. He was an exacting man to work with, as some of the letters of heavy sarcasm to his backers and withering scorn to his erring assistants show. However, amongst his many capabilities was the ability to both recognize the necessary human qualities and abilities needed for the task and to develop in his assistants and supporters the trust and loyalty necessary for the functioning of his projects.

The man chosen was John Brunton. His father William was a railway engineer who had been one of Brunel's early rivals in the original selection of the engineer for the Great Western Railway works. John Brunton may have been one of Brunel's assistants, but at the time he was at Dorchester engaged in railway duties for a firm called Hutchinson and Ritson on the Wilts, Somerset and Weymouth Railway. His selection for the task was obviously a surprise for he says: 'One day I received a telegram from Mr. Brunel requesting me to come to town by that night's mail and be at his office by 6 o'clock next morning.' He travelled overnight from Dorchester to reach Duke Street in the early morning.

'A footman in livery opened the door, and told me in reply to my enquiry that Mr. Brunel was in his office room expecting me. I was ushered into the room blazing with light, and saw Mr. Brunel sitting writing at his desk. He never raised his eyes from the paper at my entrance, I knew his peculiarities, so walked up to his desk and said shortly "Mr. Brunel I received your telegram and here I am". "Ah" was his reply "Here's a letter to Mr. Hawes at the War Office in Pall Mall, be there with it at 10 o'clock." '[12]

At the meeting with Hawes, Brunton was offered the job of prospecting for the site and superintending the works, on the recommendation of Brunel. He immediately accepted. But he could not agree to certain conditions of his duties – for the supply of materials and labour he would have had to apply to the Royal Engineer in charge of the district who in turn would apply to the War Office.

'I saw that if my hands and feet were thus to be bound with red tape the important work would never be completed either to my credit or to the attainment of the end in view. This I stated plainly, and firmly I said I must be perfectly free to act promptly on all occasions that might arise and to be in a position to employ what men I required and purchase such materials as I deemed necessary. We argued this point for at least an hour, I stuck to my colours, convinced that I was right. He got rather angry "What were your expenses coming up here", he asked – I named the sum. He immediately wrote out a cheque, "There" said he, "is a cheque for your expenses and ten guineas for your time and trouble – you will get the cash for the cheque downstairs good morning".'[12]

Brunton was obviously a man after Brunel's own kind, and as stubborn. He too was acutely aware of the conditions necessary for effective leadership. However, within a day of his return to Dorchester he was recalled to the War Office. 'I told him that not only did I stand by all my previous demands as to the power to be placed in my hands, but I had others . . . in addition the Commissariat should have orders to pay all accounts certified by me, that I should receive Her Majesty's Commission as a Field Officer in the Service, and be entitled to draw all the allowances, rations, etc. to which that rank in the service entitled me. To which Hawes replied, "you are a hard man to deal with, but I suppose you must have it." . . . On leaving and when he handed me my signed terms of engagement Mr. Hawes said, "There Mr. Brunton, you have now in your hands greater powers than any other officer in Her Majesty's service. I feel sure you will not abuse them".'[12]

Brunton left England at the end of March with a party of 30 men: carpenters, joiners, fitters, etc., from the Army Works Corps, and after briefly attending to some hospital work at Smyrna he joined Dr. Parkes in Constantinople. After consultation they decided that Brunton should start to search for a site on the borders of the Black Sea eastwards to Trebizond, and he set out on mules with a small party consisting of a Dragoman and a guide.

What were the desiderata that he was looking for in a site? The original hospital plan by Brunel for 1,000 men consisted of 22 wards connected by an open corridor, which required at least four acres of fairly level ground for the wards alone:

The locality had to be free from all causes of endemic disease and have a temperate climate; a slight but not excessive wind was desirable. The site, while being a reasonable distance from the scene of the war, had to be situated close to the sea, and not at a distance or on a height which would have made the conveyance of materials, stores and patients difficult, if not impossible; equally essential, it must possess a good landing place, accessible at all times in all weather.

At the site itself, the ground had to be level enough to avoid terracing or major earthworks, yet with sufficient fall to carry off any rainwater. A large supply of good water was essential both for consumption and for the flushing of the sewers as no cesspools were to be allowed, with a reservoir at sufficient height to supply the wards and to flush the sewers, in order to avoid the necessity of horse power to pump up the water. A good outlet with running water was necessary for disposal of the sewage.

Towards the Dardanelles

After some days examining various localities along the borders of the Black Sea, which were found to be unsuitable due to the absence of good water and the malarious influence of the coast, noticeable in the inhabitants, Brunton was forced to re-trace his steps; he started to search along the Bosphorus, but still to no avail. On submitting his report to Dr. Parkes, Brunton was instructed to continue his searches westward, and with a small steamer at his disposal, sailed to the Sea of Marmora with more success.

He found an excellent site, as far as healthiness and position were concerned, on the island of Prinkipo (now known as Buyukada), but there was a grave deficiency of water.

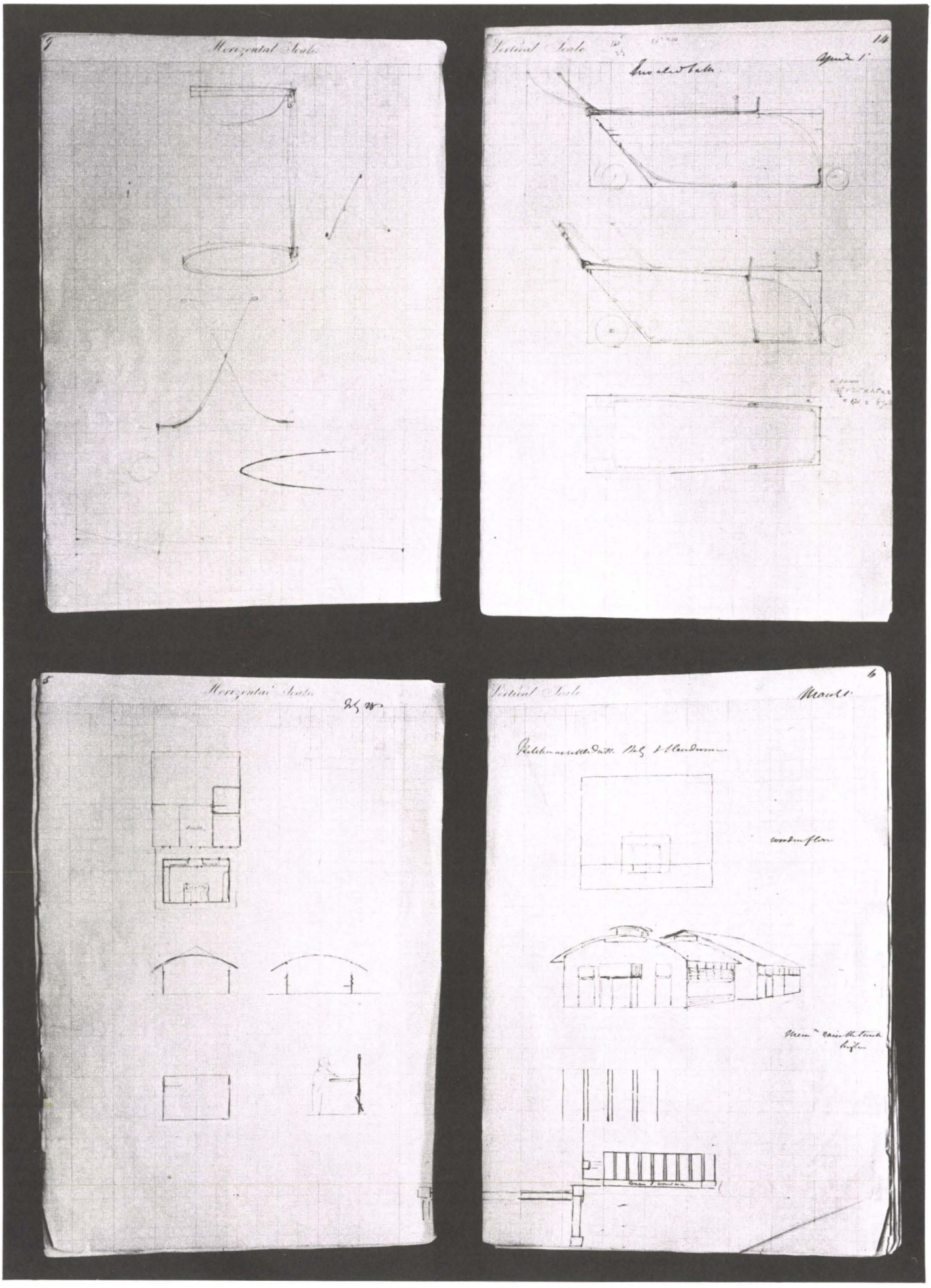

Fig. 14
Leaves from Brunel's sketch books. Sketches for various parts of the Renkioi Hospital.
Top left : Portable washbasin. Top right : Invalid bath. Bottom two leaves : Metal kitchens and sculleries.
(Reproduced by courtesy of Wills Memorial Library, Bristol University)

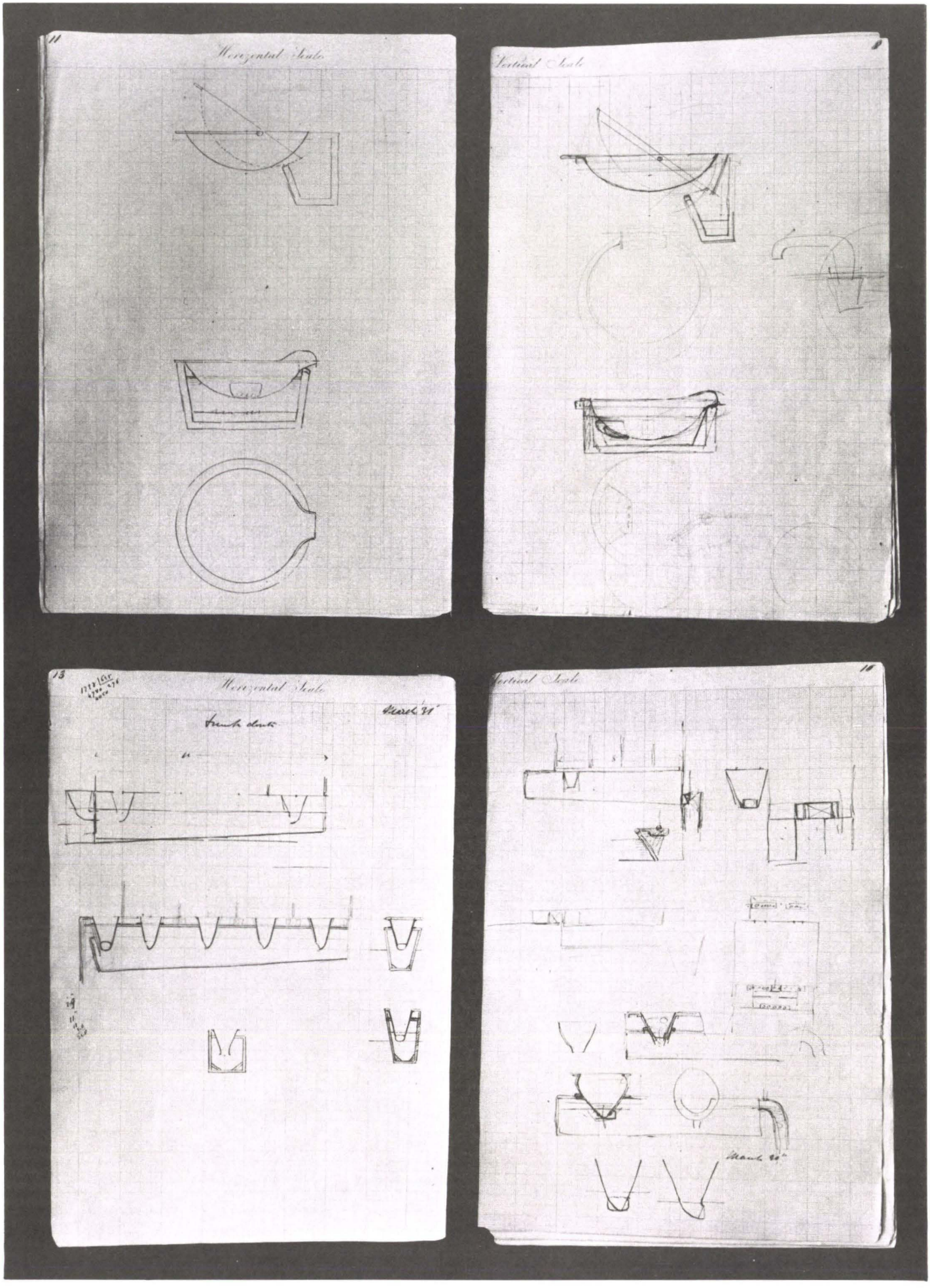

Fig. 15
Leaves from Brunel's sketch books. Sketches for various parts of the Hospital.
Top two leaves : Lavatory basin. Bottom two leaves : Closets.
(Reproduced by courtesy of Wills Memorial Library, Bristol University)

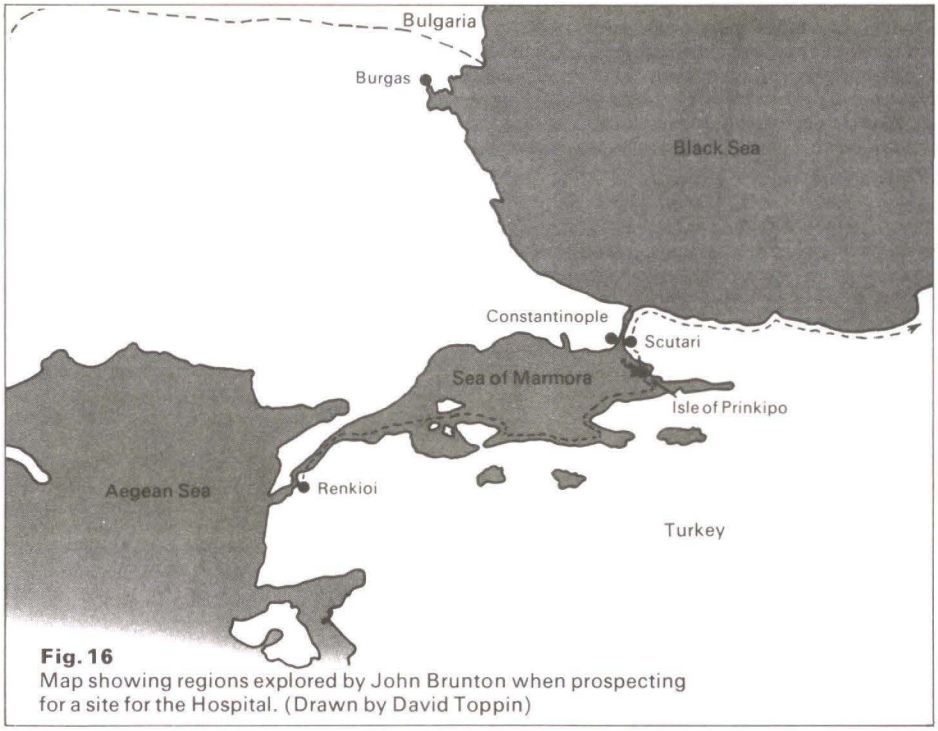

Fig. 16
Map showing regions explored by John Brunton when prospecting for a site for the Hospital. (Drawn by David Toppin)

Fig. 17
Part of the site of the Hospital used as a camping site, Summer 1972. (Photo : David Toppin)

Continuing further along the coast, he reached the Dardanelles, and a few miles west of the principal town of Chanak Keleshi (now called Canakkale) his searches ended.

'I found a splendid site combining all my requirements as to natural formation, supply of water and freedom from malaria. I ascended the rather precipitous hills lying immediately to the south and found fine springs of water.

The village of Renkioi lay on top of the hills about two miles to the south west. I immediately drew up my report and sent it to Constantinople.'[12]

On 3 May Dr. Parkes inspected the site and confirmed its suitability. His only objection was its distance from the seat of war. From Constantinople it was an additional 100 miles beyond the Bosphorus, about an extra 14 hours by steamer on half power, yet it had the considerable advantage of being in the direct line to England with transport steamers, sail and store ships constantly passing.

The Times correspondent on his first visit to the hospital, was struck by the natural beauty of the surroundings and the excellence of the site. 'The village of Renkioi lies embedded in the hills at the south of the Dardanelles on the Asiatic side. The plain on which the hospital stands is about two miles off, and runs down on the slope to the coast . . . The surrounding country is purely agricultural and the natives seem quiet, industrious and inoffensive. The plain of Renkioi consists of a sandy loam; it is bounded by an amphitheatre of mountains, 1,000 feet high, whence an abundant supply of water is collected . . . The amphitheatre of hills protects the hospital against the land wind, which, however rarely blows; the rush of water between the Mediterranean and the Sea of Marmora seems to keep up a perpetual sea-breeze.'[13]

Management of resources

During this time Brunel was attending to the arrangements for the shipping of the crated hospital parts. His letters to Parkes and Brunton at this time provide a classic example of that scrupulous attention to detail which was the secret of his success as an organizer. To Brunton on 2 April he wrote: 'All plans will be sent in duplicate . . . By steamer *Hawk* or *Gertrude* I shall send a derrick and most of the tools, and as each vessel sails you shall hear what is in her. You are most fortunate in having exactly the man in Dr. Parkes that I should have selected – an enthusiastic, clever, agreeable man, devoted to the object, understanding the plans and works and quite disposed to attach as much importance to the perfection of the building and all those parts I deem most important as to mere doctoring '

'The son of the contractor goes with the head foreman, ten carpenters, the foreman of the W.C. makers and two men who worked on the iron houses and can lay pipes. I am sending a small forge and two carpenter's benches, but you will need assistant carpenters and labourers, fifty to sixty in all . . . I shall have sent you excellent assistants – try and succeed. Do not let anything induce you to alter the general system and arrangement that I have laid down.'[2]

On 13 April he wrote to Brunton again concerning the shipping arrangements and revealed a passionate concern for cleanliness, again showing how clearly he understood the reasons for the catastrophe at Scutari: 'Materials and men for the whole will leave next week. I will send you bills of lading for the five vessels: the schooner *Susan* and barque *Portwallis,* the sailers *Vassiter* and *Tedjorat* and the *Gertrude* and *Hawk* steamers. By the first named steamer, a fast one, the men will go with Mr. Eassie's son.'

'I would only add to my instructions attention to closet floors by paving or other means so that water cannot lodge in it but it can be kept perfectly clean. If I have a monomania it is a belief in the efficiency of sweet air for invalids and the only point of my hospital I feel anxious about is this . . .'[2]

Five days later he sent the bills of lading for the complete hospital and added :

'I trust these men will pull all together, but good management will always ensure this – and you must try while you make each man more immediately responsible for his own work to help each other – and to do this it is a good thing occasionally to put your hand to a tool yourself and blow the bellows or any other inferior work, not as a display but on some occasion when it is wanted and thus set an example. I have always found it answer.'[2]

Meanwhile, he had written to Parkes and revealed another of his concerns, that all his precautions could be defeated by the patients themselves, who may well have never seen a water closet in their lives. 'All the vessels with the entire hospital will I believe have left England before the end of next week, that is before 21st. Finding that none of the Ordnance Stores were likely to be ready, and indeed that no positive time could be ascertained for their being ready, I obtained authority yesterday to purchase one third of the required quantity of bedding and some other similar stores and they are now going aboard with the buildings. I have added 20 shower baths, one for each ward and six vapour baths.'

'You will be amazed to find also certain boxes of paper for the water closets – I find that at the cost of a few shillings per day an ample supply could be furnished and the mechanical success of the W.C.'s will be much influenced by this. I hope you will succeed in getting this used and not abused. In order to assist in this important object I send out some printed notices or handbills to be stuck up, if you see no objection, in the closet exhorting the men to use the apparatus properly and telling them how to do so. If you do not approve of such appeals the paper can be used for other purposes and perhaps impart some information in its exit from this upper world.'

'The buildings will be very quick after you; I almost fear you cannot have satisfied yourself about the site by the time they arrive.'[2]

Fig. 18
Shipment at Trieste of wooden barracks for the Allied Armies in the Crimea.
(*The Illustrated London News,* 13 January 1855)

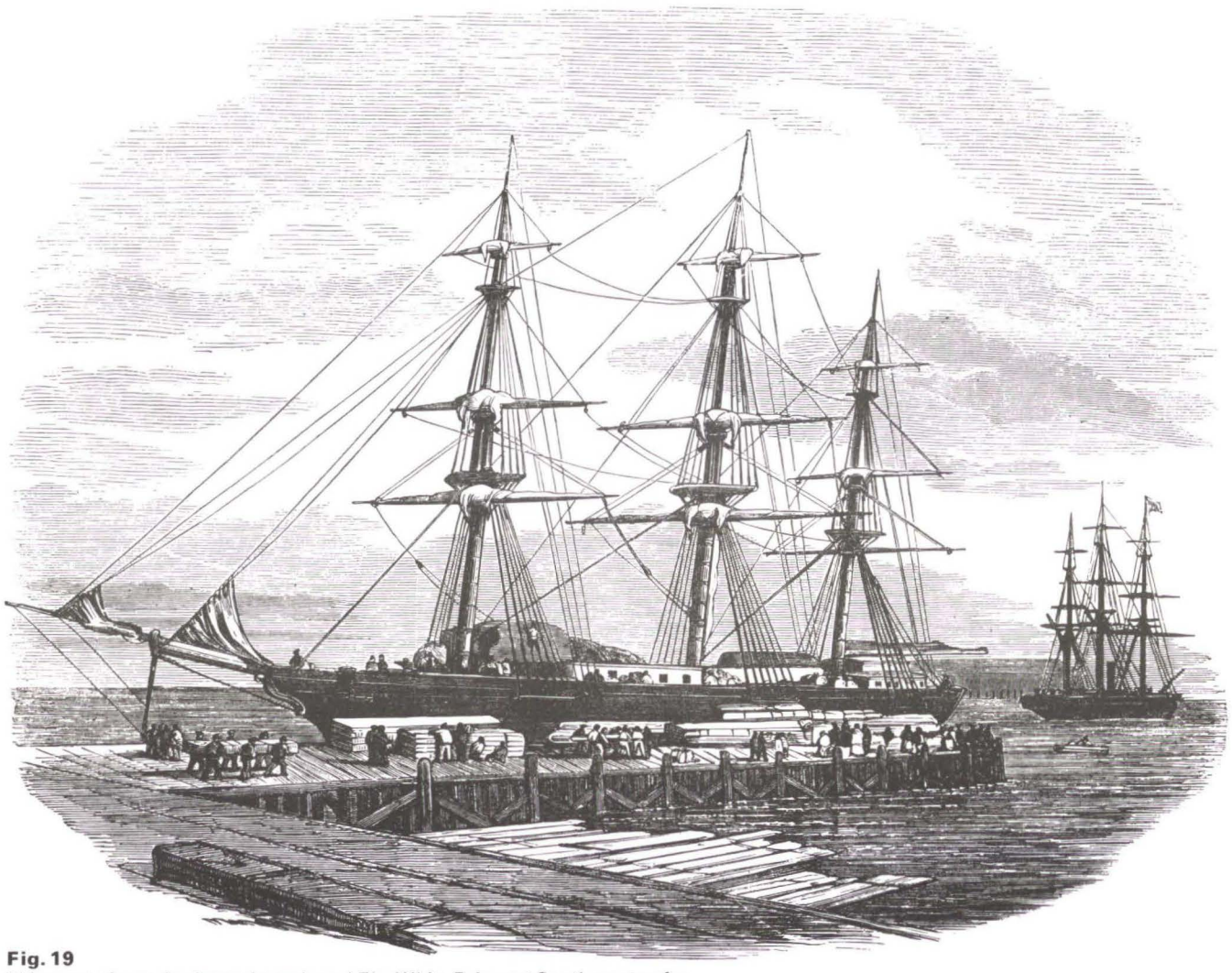

Fig. 19
Shipment of wooden barracks on board *The White Falcon* at Southampton for the French Army in the Crimea. (*The Illustrated London News,* 3 February 1855)

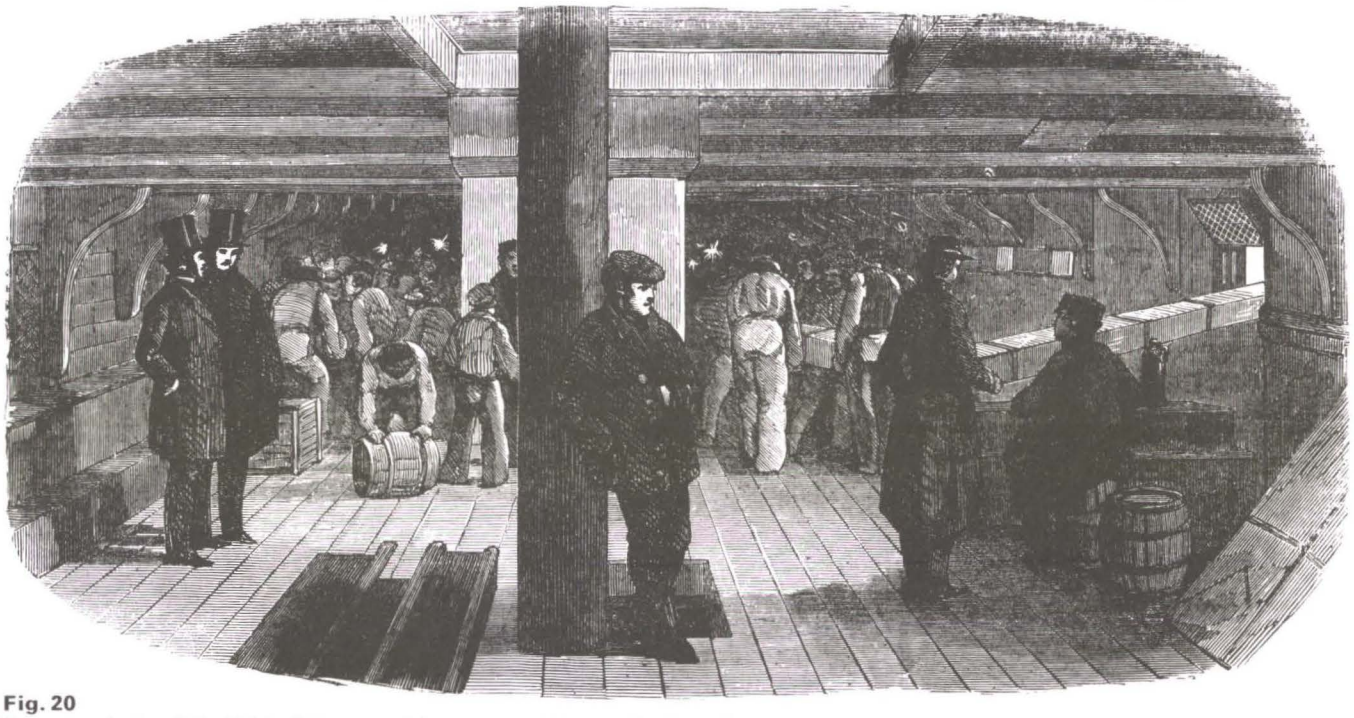

Fig. 20
Between-decks of *The White Falcon* receiving on board the wooden barracks.
(*The Illustrated London News*, 3 February 1855)

The first steamer *Gertrude* arrived on 7 May and was unloaded by Greeks employed from the local villages, and erection of the hospital began on 21 May.

Brunel had given Brunton strict instructions as to the sequence of operations when on site. Brunton was to have constructed the complete system of drainage and to have laid on the water supply before any building was to have been capable of admitting patients. Following his setting out of the ward units to suit the peculiarities of the site he had to obtain as a first condition, 'a perfect system of drainage, a good supply of water, free ventilation and the most perfect cleanliness . . . these conditions being assumed as essentials, preceding the mere covering in of space and providing shelter for patients.'

The plain of land projecting into the sea between the two bays rose regularly and gradually from 10ft to 100ft above the sea over a distance of $\frac{1}{2}$ mile to the foot of the hills. Brunton was able to accommodate 34 units, capable of holding 1,500 sick, in three lines, each consisting of wards on either side of a central corridor, without any terracing or excavation and with considerable ease of water supply and drainage. For further expansion of the hospital to the envisaged 3,000 patients, there was sufficient space to extend the first two lines and simply repeat the system to contain a further 750 men on each line.

Brunton discovered springs two miles from the hospital complex, the first about 700ft. above sea level and the other on the summit of the mountain at nearly 1,000ft. He employed a large quantity of local Turkish labour to dig the trenches and lay earthenware pipes to a large reservoir that he formed 70ft. above the highest ward. From here he carried the water in iron pipes down the centre of the corridor; branching off at every ward there was a lead service pipe supplying the ward cisterns which in turn supplied the baths, lavatories and closets. This simple gravity system obviated any need for pumping the water and enabled easy flushing of the sewers. From the lavatories and closets at the ends of the wards the sewage was conveyed in wooden trunking, and discharged some distance into the Dardanelles.

Brunton was unable to find suitable local carpenters to assist his own English labour force in the assembly of the hutting framework, which had to be put together very carefully on account of the economy of the construction, and complicated by the size of the units being much larger than the largest Crimean Huts. This operation took longer than Brunel had anticipated, yet within seven weeks Brunton had the hospital ready to receive 300 patients as well as having erected a row of officer's quarters for the arrival of the physicians, surgeons, nurses and other orderlies.

Use

On 12 July Dr. Parkes reported that the hospital was sufficiently complete to accept 300 patients, and by 11 August he was ready for a further 200, yet it was not until October that it was called upon to accept its initial intake. This seems surprising, particularly in view of the circumstances that led to the hospital's inception. A pithy paragraph from the report of the correspondent of *The Times* dated 27 September alluded to the fact that this was due to the military authorities at the front. 'Permit me to express my wonder that the hospitals of Renkioi and Smyrna should be permitted to remain empty. It is well known that threats have been uttered that they should both be "starved out," and that the medical men should have no other employment than that of "picking their teeth". But the appointment of an inspector, chosen from among those who have had better taste than to countenance such expressions, and whose duty should be to apportion the cases of both sick and wounded, would remove all difficulties and be very beneficial to the soldier. Never has the head of the army Medical Department had such materials to work with. He might have established a new era in his department of the profession. How the advantages so liberally offered by Government and the British public have been turned to account I must leave others to explain.'

There was considerable hostility on the part of the army towards the civil hospitals. The implication was that the army could not cope with the situation. The medical officers felt their chances of promotion were infringed and they resented the high pay the civilians commanded. Consequently the flow of the sick and wounded to the civil hospitals was considerably obstructed.

Through the detailed reports of *The Times* correspondent at Renkioi we are fortunate in being able to evaluate the provisions intended in the design of the hospital against its actual performance in use[13].

On 1 October the correspondent observed: 'The *Imperador* steamed into sight about midday with 215 sick and wounded from Balaclava . . . The ship was anchored about a quarter of a mile from shore, the sea quite calm, and the weather moderately warm. Nothing could have been more favourable. As the permanent piers are not yet completed, that able officer Mr. Brunton, the chief engineer, ran out into the sea, with the help of his navvies, in the space of quarter of an hour, a perfectly firm platform, between 60 and 70 feet long, and capable of supporting any number of persons who could stand upon it. Orderly medical officers were appointed to receive the sick on landing, to supply any immediate wants, and to order their conveyance to the wards, if necessary, upon stretchers. The two inspectors, Drs. Goodeve and Robertson, stationed themselves at the extremity of the corridor to sort out the cases as they arrived, so that, in accordance with the admirable plan of the establishment, surgical cases, fevers of contagious nature, cases of dysentery, scurvy, etc, may be at once classified and placed under conditions most favourable for cure. Every ward had its proper surgeon or physician, with his staff of ward master, orderlies and nurses. A strong body of Greeks was marshalled as porters, stretcher carriers, etc. It will be scarcely credited that not more than one hour and 25 minutes elapsed between departure of the first boat from the *Caradoc* and the stowing away of the last patient in his comfortable and well appointed bed. The ease and rapidity with which the whole proceeding was conducted must have been most gratifying to all concerned, as it doubtless will be to those at home.'

The weather's vagaries

By the middle of November the correspondent reported a change in the weather from baking in the Asiatic summer of nearly 100°F by day and night to 50°F by day and 40°F by night, coupled with a strong sharp northerly wind and occasional rain storms. Thereafter the hospital buildings were subjected to the vissicitudes of the weather. There were

frequent and sudden changes from the generally cool and mild winter weather to hot southerly gusty winds with torrential cloudbursts, thunder and lightning. By the beginning of December the buildings were receiving major testing in the new climatic conditions. 'The buildings seem to be proof against the wind. There have been several shocks of earthquakes, one of which made the houses in the village of Renkioi rattle; but they were scarcely felt in the hospital . . . Many of the buildings are watertight – my own for example, but the rain had made its way into others, although the roof was covered with a layer of felt and sheet tin. It will, no doubt, surprise your readers as much as it surprised all here that water could overcome the obstacles presented by a smooth metallic surface, and even now there is some difference of opinion as to the cause, although a remedy has been discovered. Dr. Robertson, one of the inspecting physicians, thinks that it is capillary attraction acting along the joinings of the sheets of metal. The engineers rather incline to the belief that the water finds its way alongside the tacks used for fixing the sheet, and by that means get through . . . A coat of thick paint of white lead spread over the lines where the metal plates are in apposition and are nailed down has proved perfectly efficacious in checking this annoyance.'

The winter sets in

On 19 December the correspondent noted:
'Winter weather has set in, and all are glad of fires. On the 16th snow flakes penetrated the out-houses and the less finished buildings like dust, and water froze in the pipes, which in many places burst, and caused a corresponding amount of discomfort on the 17th when the thaw came. It has been found necessary to complete with all speed the side boarding on the north aspect of the long corridor, which is now perfectly sheltered and dry. A good deal of work has been required on the roofs of the hospital to render them watertight, and to close the apertures left as ventilators during the heat of the summer.'

'I am sorry to say that the sheet tin roofing does not answer its ends satisfactorily. Rain finds its way between the joinings of any accidental aperture, and the thinness of the plates renders them liable to tear upon the least strain . . . Indeed for the future the engineers intend to cover the hospitals with two layers of felt, instead of one layer protected by the tin sheeting. The native tiles make a better roof, as is proved by the mess house, but the general buildings are not constructed to support such material. All the buildings have stood firm, however high has been the gale; no accident from this source has happened, although it has blown "great guns", and the shipping along the coast has sustained considerable damage.'

In early January the weather had become almost like an English summer. Wasps were seen about the fields, and the hillsides swarmed with the flights of goldfinches, but on the 14th of the month this mild weather broke and the countryside was covered with snow:
'During the severest time of the snow-storm of the 14th I visited the wards. The lavatories, etc, facing the blast were penetrated to a considerable extent, but all the appartments occupied by the patients were warm and comfortable. I may assert, without contradiction, that nowhere was any man exposed to circumstances connected with the sudden change from summer to winter which could in the smallest degree have given him discomfort, or increased the severity of his disease.'

'The ample stoves blazed cheerfully in front of the convalescents grouped around them, and the covered corridor afforded a sheltered walk to those disposed to take active exercise. The buildings have been severely tested, when we consider the effects produced upon the wood, the metal, the iron pipes, according to the laws of expansion and contraction, by a sudden change of temperature amounting to 40 deg of Fahrenheit, attended with a violent wind and a snowstorm positively blinding.'

During these months of changeable testing weather, building continued and the correspondent related:

'The utmost activity prevails in the erection of the hospital huts and in the completion of the main corridor . . . roads are being constructed about the place . . . The English artisans are willingly busy, the Greek workmen as usual are driven to their employment, the sound of the hammer is heard in all directions, except during the pelting of the very heavy rain when it becomes necessary to seek for shelter . . . The buildings are rising in rapid succession, and are not very far from their limit longitudinally. As their numbers increase they will be erected on vacant ground already selected on the sides of the main street, if I may call it so. At nightfall the long corridor is regularly lit with lamps.'

Railway

By 4 December the hospital was ready with 1,000 places and by the beginning of January was up to 1,500 places. During November, changes in the hospitals at Scutari and Smyrna into barracks or winter quarters for the troops established Renkioi as the central medical depot south of the Bosphorus, leading to its major intake in December and January. At the same time as the snowstorm previously mentioned, the Renkioi Railway was opened for carrying the sick the 3/4 mile journey from the south pier to the corridor, considerably facilitating the working of the hospital.

'It is but a single line and the trucks are drawn by horses . . . As the caique runs alongside of the pier, the patients are raised, as they lie in their beds on the stretchers, and are deposited on the flat railway carriage, which, when full, starts at a rapid pace towards the hospital. As the line is not quite finished, a medical officer and a fatigue party were on duty at the temporary terminus to see that every facility was given to the patients for their conveyance over the short distance which remained.'

At the end of December the correspondent reported a new development:
'The railway connecting the north and south piers is being constructed as quickly as labourers can be obtained, but the Greeks still retain a strong partiality for holydays.'

And by the end of January:
'The railway now runs from the pier into the corridor, where a turntable receives it, to direct the carriages upon branch lines which will bring them to the very doors of the wards. Instead of patients being carried singly upon stretchers, between two men staggering over the rough and wild countryside, with their worn out and groaning burden, 50 or 60 men are put upon trucks, covered up with blankets and galloped into the hospital along the smooth tramway in a few minutes. Never was a more successful work undertaken, and it will remain a matter of history that the first railway ever laid down in Asia Minor was on the plain of the Renkioi Hospital and used as a transport for sick and wounded soldiers during the campaign in the Crimea . . . It is a fact that a single trial of a railway spoils one for all other means of transport; the speed and the order with which the men are arranged on the trucks, the ease and celerity with which they are run into the corridor, the certainty with which the military officer takes the name and regimental number of every man, and the medical officer learns the nature of the disease, that the case may be despatched to the proper ward, are advantages such as can be gained by no other system whatever.'

The anticipations that Brunton and Parkes had formed of the suitability of the site were confirmed by the experience of more than a year. In spite of the sudden and great changes of temperature the climate remained generally moderate; there were few days in which the most delicate patients could not get out into the sheltered corridor for a short time during the day. The adequacy of the natural drainage of the land ensured that there was no consequent disease arising from the action of heat on the moistened soil, and there was always a plentiful supply of good water from the springs in the mountains.

There can be no question as to whether or not Brunel achieved the objective for which the hospital was designed, for example as revealed by the small number of deaths in spite of the presence of the severest forms of disease; a death rate of 0.3% as compared with the 40% at Scutari Barracks Hospital. The fact that fevers and contagious diseases did not spread from bed to bed must have been due in large measure to his adequate space standards, means of ensuring proper ventilation and the hygienic conditions made possible by the provision of the drainage system as well as the specially designed equipment and facilities. The type of construction employed with its low thermal capacity could have led to intolerable environmental conditions in the wards, in a climatic situation that changed from 100°F to freezing. Yet it is precisely these kinds of construction with their high surface insulation which respond most effectively to handling of the outer surface fabric, coupled with environmental manipulation; albeit in this instance relying upon the availability of labour-intensive assistance. The fact is—even under the range of conditions experienced in the situations described—that the environmental performance was satisfactory; and it further goes to show that the correctness of Brunel's anticipation of the problem was matched by his understanding of the means for dealing with it.

By the end of March the hospital could have accommodated, with a little pressure, 2,200 patients. In a further three months Dr. Parkes estimated that the whole hospital for 3,000 would have been finished and in full activity. For this huge figure, all based on Brunel's ward and corridor principle, Dr. Parkes had evolved a system of medical organization based on the principle of subdivision into self-contained hospital units, known as a Division[5], each consisting of 500 patients. Each Division was to have its own kitchen dispensary, purveyors' provision, issue store, utensil store, pack store and matron's linen store. Each ward was to have its own medical officer, either an assistant surgeon or an assistant physician, who was responsible not only for treatment but cleanliness, hygienic condition and discipline of the ward. Each division had its Divisional Officer, to supervise the Ward Medical Officers, a ward master in charge of four orderlies and 10 nurses as well as a lady sister to superintend the nurses and tend to the worst cases[11].

Parkes was to have had in operation a daily reports system from the Ward Officers, on the efficiency of service of the ward and its hygienic condition, to the Divisional Officer who was to satisfy himself of its accuracy and attend to its points, and then forward it on to the Superintendent. The total number of patients admitted and treated by the hospital was 1,408, the number of deaths 50. However the largest number of patients at any time was 642, and the Division system was never really tested, though Dr. Parkes was sure from his experience that the system would have worked[11].

Fig. 21
View from hills of southwest portion of plain used as site for the Hospital, Summer 1972.
(Photo : David Toppin)

Fig. 22
View from hills of northeast portion of plain used as site for the Hospital, Summer 1972.
(Photo : David Toppin)

After the signing of the General Peace Treaty on 30 March 1856, instructions were given to close the hospital down. Brunel in his characteristic methodical way, sent Brunton his disposal instructions[2]: 'I don't want the thing to be flung into a ditch when done with, but should prefer a useful end; that each part should be made the most of and methodically and profitably disposed of. Everybody here expressed themselves highly satisfied with Everybody there and what we have done. I should wish to show that it was no *spirit* but just a sober excercise of common sense . . .'

Auction

By May the greater number of patients had been either discharged or invalided home and in July the remaining medical staff were sent home. In August, Brunton set about advertising the hospital for sale by public auction and tried to persuade the Turkish Government to purchase the whole hospital, as it stood, and use it as a military school; but to no avail.

The eventual sale of the building by public auction took place on 20 September. Prior to this a great fire in Salonica had left a large number of homeless. John Brunton recalled[12] '. . . a deputation came over to purchase some of the wards of the hospital . . . for housing these homeless ones. When the Tallal or auctioneer commenced his labours the bidding for these wards was brisk, and they realised good prices. Day after day the sale went on – much to my satisfaction – till at last we came to what I called the machinery department, a list of which was published. I valued this lot in my mind at £10,000. The bidding for this lot was very slow – it reached £450 – and the Tallal kept calling out this sum for a long while, and still no advance – he had orders to knock down no lot without a signal from me.'

'I went to him and asked him to point out the bidder of this amount, which he did, and I at once recognised the Greek who was a sort of agent for Calvert the British Consul. I sought out Calvert in the crowd and remonstrated with him. I know that all the people of the Dardanelles held Calvert in such dread that they dared not bid against him. Calvert said "Come Brunton, knock this lot down; you know your orders are very strict: you must sell everything by public auction." I remonstrated with him and said I certainly would not knock it down for any such price, if he wanted the lot he must boldly bid for something near its value. The shouting Tallal still went on.'

'At last Calvert, calling me aside, said "Look here Brunton, knock it down and I will give you an undertaking you shall have the profits." I was staggered that such proposition as this should come from a British Consul. "No Calvert," said I " you have the wrong pig by the ear this time". I called out at once to the Tallal "£1,000 for this lot, I buy it in." Calvert was furious. I immediately determined what I would do and sat down and wrote Calvert an order to send down a steamer that night to take this lot of things to England where I knew I could sell them for a vast deal more than had been offered at the auction.'

Back in England, Brunton had to face the wrath of the War Office for departing from instructions, and was responsible for a grave breach of duty and orders. Reluctantly he was given storage space and allowed to dispose of the items on behalf of the War Office.

A few days afterwards the Medical Department of the Government advertised for tenders for 500 water closets and a number of lavatories for Netley Military Hospital, which was then in course of erection. John Brunton related[12] 'In my own name I sent a tender and a sample. As I had purchased these articles I knew what the wholesale price was or ought to be. My satisfaction was great when in due course, my tender was accepted. I sent in the lot and acknowledgement came for the receipt of the same. Sales went briskly on, and at last I had only remaining 60 ventilating fans which had been sent for the purpose of ventilating the hospital wards. I could not find a customer for these and was despairing when one morning I saw an article in the newspapers stating that the stoke holes in Her Majesty's gun boats had proved so deficient in ventilation that the stokers had struck work.'

Brunton proposed a scheme to the Admiralty which on testing proved successful and resulted in the sale of the fans. Thus were all the parts disposed of and Brunton closed his accounts to the profit of the War Office.

It was not to be long after this that Brunel's health started to fail and his prolific career was coming to an end. By the time of the building of the *Great Eastern* ship, the labour and anxiety involved proved too much for his physical powers, and he broke down on the day of the start of her trial trip with an attack of paralysis. 10 days later on the evening of 15 September 1859 he died.

His life-long friend, Daniel Gooch, wrote of him 'By his death the Greatest of England's engineers was lost, the man of the greatest originality of thought and power of execution, bold in his ideas, but right. The commercial world thought him extravagant, but although he was so, great things are not done by those who sit down and count the cost of every thought and act.'

Conclusion

Brunel was not an architect, nor had he any experience in hospital design. His work previous to the hospital was primarily concerned with the design and construction of mechanical systems, machine-based enclosures, or those in which people tended to wear outdoor clothes; yet in this work he showed in his commonsense approach a highly perceptive grasp of human needs – and failings – and an understanding of the measures necessary to deal with both.

In a sense the hospital can be regarded as a unique Brunel work, since it was the only instance where the end product was an enclosure necessitating a specific environmental performance, to accommodate a direct human need. Whilst the hospital shows a form which was uninhibited by contemporary architectural morals, it may only be speculation to ask did Brunel employ this method because of the incomplete brief, or, did the method arise out of the problem? Certainly there was nothing new to Brunel, as a railway engineer, about the extendability of linear arrays. In using the linear form with pavilions on either side of a connecting corridor he not only exploited its indeterminate characteristics as a direct reaction to the problem of an incomplete brief, but he also anticipated what was later to become the conventional hospital form.

Design and organization

Born out of a successful response to the challenge of a crisis, it cannot be said that the hospital was an original invention, though some of the parts were specially designed. Brunel's real wit lay in seeing the potential for solution in the application of the relevant existing technology; a technology no more advanced than his understanding of its successful application and manipulation. The originality lay rather more in the conception, in perceiving right at the outset that fundamental to the undertaking was the problem of organization. The success of the project illustrates the efficacy of his powers of organization, for this was not just a collection of huts and other components modified from a manufacturer's catalogue, but a highly organized plan of action, right down to the last detail of assembly and transportation, yet with a built-in latitude, so that at no point could the plan become too highly stressed and shatter.

Whilst commonsense solutions and good management are timeless, Brunel's fantastic turn of speed was, in the end, only made possible by his own initiative and capabilities. This speed, based in some measure, perhaps, on an extremism of method and extravagance of personality, was achieved through the use of a powerful design technique, as well as by the use of a repeated element that was capable of being manufactured by industrial fabrication methods.

Lessons

The lessons of such an exercise are various, and interrelated. Certainly, Brunel, in designing for mechanical services, did not merely look for neat ways to install them, but of setting them to work in partnership with the fabric of the building. Artificial heat, natural and artificial light, forced and natural ventilation all worked together to give an equable indoor climate. The second linked lesson is that this environmental performance was achieved without recourse to any technological novelty. Here was a building with an environmental technology, not called in as a desperate remedy – albeit called in as a remedy in a desperate situation – that was naturally in the working method brought to bear on the problem.

The successful performance of the building should guarantee it a place in the history of environmental control. Yet it is not just that it worked, rather that it worked through the application of the ultimate form of environmental, and all other, power – knowledge. For it was the overall proposition that Brunel made, which presupposed a knowledge so complete of the parts of the system and an understanding of their contributions and interactive relationships in the functioning of the whole that is the prime and outstanding lesson.

Brunel's prodigious powers

In the final analysis, the 'sober exercise of commonsense' may not seem enough to explain this achievement, and it is to the man we have finally to look; for whilst Brunel lived at a time when the young profession of civil engineering shone with a glow of adventure and romance, no single person imparted more momentum to the greatest social revolution in history. Quite apart from the hallmarks of genius, some mentioned earlier – streaks of precocity, scepticism towards conventional answers, freshness of vision and acuity of perception, the faculty of combining high flights of theory with a keen sense of the practical, as well as a head for generalizations and an eye for minute particulars – here was a man with truly Herculean powers. 'What most distinguished him was the force which drove him to the limit of his bent and which charged his personality with that mysterious magnetic force which so often discomfited his opponents and which drew others to follow him.'[2]

It would be interesting to speculate on, but outside the scope of this article, from what vital spring of the spirit he derived his prodigious creative powers, and on the way that the history of construction might have been written had, by some chance, the multiple potential of Brunel been lured further from works of civil engineering, as his was surely 'a mind of large general powers accidentally determined to some particular direction, ready for all things but chosen by circumstances for one. It is often by a trivial, even accidental, decision that we direct our activities into a certain channel and thus determine which of the potential expressions of our individuality become manifest . . .' 'Every decision is like a murder, and our march forward is over the still born bodies of all our possible selves that will never be.'[14]

References and notes

(1) WEEKS, John. Indeterminate architecture. *Transactions of the Bartlett Society*, vol.2, p.6. University College, London, 1964.

Weeks is incorrect in his assertion that the hospital 'was designed to open with 300 patients and be extendable to accommodate 1500'. Brunel's original contract was for 1000 beds, and it was always envisaged, according to Dr. Parkes, that the eventual size of the hospital would be 2500 to 3000.

(2) ROLT, Lionel T. C. Isambard Kingdom Brunel; a biography. Longmans Green, 1957.

In the few cases where I found the sources relating to Brunel or the hospital to conflict in fact or original quotation, the version by Rolt has been accepted. He had access to earlier works on Brunel[7,10], as well as to original, hitherto unpublished, documents belonging to the Brunel family.

Although Rolt refers to Dr. Parkes, it would appear that he has not read his report[11], which is further confirmed by his not mentioning it in his bibliography, as is also the case with Professor Clapham's book[12].

(3) BANHAM, Reyner. The architecture of the well-tempered environment. Architectural Press, 1969.

(4) WEBB, Robert Kiefer. Modern England from the eighteenth century to the present. Allen and Unwin, 1937.

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(9) Personal letter from Brunel to Sir Benjamin Hawes, Under Secretary of State for War, dated 5 April 1855.

(10) BRUNEL, Isambard III. The life of Isambard Kingdom Brunel, civil engineer. Longman, 1870.

(11) PARKES, Dr. E. A. Report on the formation and general management of Renkioi Hospital, on the Dardanelles, Turkey, addressed to the Secretary of State for War. The War Department, 1857.

(12) CLAPHAM, Prof. J. H., *Editor*. John Brunton's Book. Cambridge University Press, 1938.

John Brunton was the son of Brunel's old rival, William Brunton, who died in 1851.

(13) THE TIMES. Various reports by their correspondent at the British Hospital, Renkioi, 1855 and 1856.

(14) DUBOS, Rene. Louis Pasteur. Little, Brown & Co., 1950.

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The author

David Toppin trained as a civil engineer at Manchester University prior to studying at the Architectural Association. His experience encompasses public and private sectors and he now practises both as architect and consulting engineer. Additionally he is a tutor at the Architectural Association and runs a course there under the title of 'Anatomy of Construction'.

The central body of material, on which this monograph is based, first appeared in a shorter form as a History Thesis at the Architectural Association. Since that time it became increasingly clear that the subject warranted further investigation and development. As a consequence, much relevant additional material has been incorporated, both of a factual and interpretative nature, resulting in the evolution of the present version.