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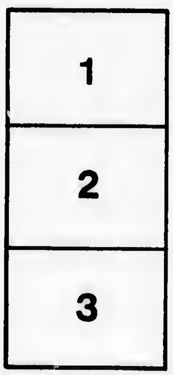

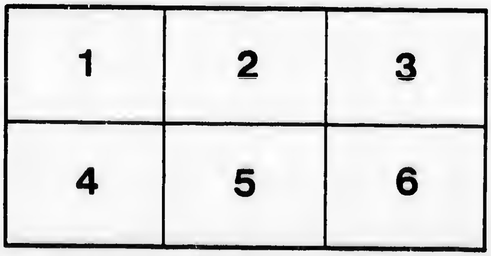

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SKETCH

OF

THE CIVIL ENGINEERING OF NORTH AMERICA.

BY

DAVID STEVENSON, F.R.S.E.,

MEMBER OF THE INSTITUTION OF CIVIL ENGINEERS,

AUTHOR OF A "TREATISE ON THE APPLICATION OF MARINE SURVEYING AND HYDROMETRY TO THE PRACTICE OF CIVIL ENGINEERING;" "REMARKS ON THE IMPROVEMENTS OF TIDAL RIVERS;" "TREATISE ON CANAL AND RIVER ENGINEERING," &c., &c.

SECOND EDITION.

LONDON:

JOHN WEALE, 59 HIGH HOLBORN.

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PRINTED BY NEILL AND COMPANY, EDINBURGH.

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NOTE.

In issuing a Second Edition of Mr David Stevenson's work on American Engineering to the profession and the public, Mr Weale begs to state that he has had chiefly in view its application to new countries, and particularly to India, where, doubtless, engineering works on an extensive scale will soon be in full operation. Mr Weale believes the work (which has been styled a "Sketch of the Civil Engineering of North America") may be regarded in a more general view, and may with equal propriety be styled a "Sketch of Engineering Practice, applicable in New Countries;" and it was this belief that led him to urge Mr Stevenson to allow him to republish it, and Mr Weale takes this opportunity of expressing his thanks to Mr Stevenson for his permission to do so.

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PREFACE TO THE SECOND EDITION.

At the urgent and repeated request of Mr Weale, I have consented to accede to his desire to publish a Second Edition of a "Sketch of the Civil Engineering of North America."

A work on American engineering, founded on observations made by me twenty-two years ago, will be apt, I fear, to be regarded as worthless. Such, indeed, was my own conviction when Mr Weale first made the proposal. But after full inquiry and consideration, I have come to a different conclusion. If my observations were calculated to be useful to the profession at the time they were first published, nothing has taken place that should render them otherwise than useful to the younger members of the profession now, and I do not feel justified in withholding my assent to the request of the publisher and proprietor of the first edition of the work, which is now out of print.

The geological features of America, comprehending its sheltered harbours, mighty rivers and lakes, wooded mountains, and boundless prairies, of course remain unchanged, and works which were found applicable to the physical state of the country twenty years ago are obviously applicable to it now. The fact is, that although public works in America have, since my visit, been enormously extended, the principles of engineering construction, with slight modifications, remain the same. Labour in the United States is still expensive, timber is still plentiful, and lines of communication have yet to be formed at as small a cost as possible through almost unexplored regions. So long, then, as engineering practice has, from the necessities of the case, to be adapted to such circumstances, no very great or radical change in mechanical construction, or in management, is likely to be introduced. It is no doubt true that individual works of great extent, and perhaps originality, may from time to time be erected, such, for example, as the bridge across the Niagara connecting the United States with Canada, which is a recent triumph of American engineering, or the bridge across the St Laurence on the line of the Grand Trunk Railway, which will be another exponent of the engineering skill of the British, but these may be regarded as exceptional works. They are proofs of engineering skill applied to overcome special difficulties, but they do not alter what may be regarded as the characteristics or peculiarities of American engineering, a sketch of which was all that my treatise was ever intended to give. The works alluded to are not indeed specimens of what may be termed *indigenous* American engineering, or, in other words, designs applicable to a country in its infancy, but rather examples of the engineering of an older school for the first time applied in America.

In proof of my statement as to the unaltered condition of American engineering practice, I shall refer to one class of works which has been more extended in America during the last twenty years than in any other country, and in which there has consequently been greater scope for improvement—I mean railways. When I visited the United States in 1837, there were 1600 miles of railway open for traffic, and 2800 in the course of construction. In 1856 there were upwards of 26,000 miles of railway in full operation. Now, it is a singular and significant fact, that, notwithstanding the formation of so many new lines, and the experience that must have been gained during their construction, the American railway system, if we except its enormous extension, appears to have undergone little or no change during the last twenty years. In the interesting and valuable report by Captain Galton, R.E., made to the Board of Trade in 1857, the same features which I found to be peculiar to American railways in 1837 seem to be regarded as their peculiarities still; showing that there is in the people a *conservative* principle, if we may so express it, which leads them to cling to what they fancy best suited to their people and climate. We find, for example, in Captain Galton's enumeration of American engineering peculiarities, detailed descriptions of the locomotives with their long connecting rods suitable for steep gradients, and their four-wheeled trucks moving on a centre pivot, to enable them to pass quick curves, which were the distinguishing characteristics of American locomotives in 1837; while the cage for catching sparks still occupies the top of the funnel, and the guard or "cow-catcher," for warding off stray cattle, runs in front of the engine. The passenger "cars," as they are called, are still the same long-bodied carriages, resting on four-wheeled trucks at either end, with seats at either side, and a passage down the centre. The railways in the neighbourhood of towns are as imperfectly fenced as ever, and a large bell on the engine is still rung at all the level crossings, which are generally without gates or gate-keepers, while the rails are in some cases still carried to the station through the principal streets, "the public being," as Captain Galton expresses it, "left to take care of themselves."

Nor have I been able to discover that any material progress has been made in the harbour, river, or canal engineering. The fact, indeed, of the rapid extension of railways to which I have referred renders it, I should say, impossible that canal and river engineering should receive the same attention which it did in that country previous to the introduction of the new system of communication. I have therefore thought it best to republish the original sketch very much in its original form, the only alteration introduced being the corrections of anachronisms, and a notice of whatever I have been able to ascertain to be new in design or construction.

I must advert to one exception—the lighthouse system—which was most imperfect when I visited the country, but has since been remodelled, and instead of repeating the former article on that subject, I have given a sketch of the new arrangements, taken chiefly from the Report of the American Lighthouse Board.

To these explanations I only add, that, as my observations, made upwards of twenty years ago, are still applicable, we may reasonably infer that the practice they describe has been found well-suited to the country, climate, and people, and, therefore, we may confidently express the hope that the information they contain may prove useful and instructive, particularly to young engineers practising their profession in newly settled countries, for whom, chiefly, they have been published in their present form.

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DIRECTIONS FOR PLACING THE PLATES.

12 *Plates and* 40 *Woodcuts.*

* The references in the text, pp. 188, 190, to Plates XIII. and XIV., have been made, instead of XI. and XII., in error.

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SKETCH

OF

AMERICAN ENGINEERING.

CHAPTER I.

HARBOURS.

Natural facilities for the formation of Harbours on the American Coast—Tides—Construction of Quays and Jetties—Cranes—Graving Docks—Screw Docks—Hydraulic Docks—Landing Slips, &c.—New York—Boston—Philadelphia—Baltimore—Charleston—New Orleans—Quebec—Montreal—Halifax.

THE eastern and southern coasts of North America are indented by numerous bays and sheltered sounds, which afford natural facilities for the formation of harbours more commodious than any which works of art alone, however costly, could possibly supply, and to an extent of which, perhaps, no other quarter of the globe can boast. The noble rivers with which that country abounds, and its inland lakes, which, for expanse, deserve the name of seas, are subjects of great interest to the general traveller; but to the civil-engineer, who is more alive to the importance of deep water and good shelter in the formation of harbours, and who, at every step in the exercise of his profession, feels the difficulty, and is made aware of the expense, of attaining these qualities by artificial means, the natural harbours of the continent of North America are particularly interesting.

The original founders of the American seaports appear to have been very judicious in their selection of situations. The towns, if not placed at the mouths of fine navigable rivers, possess, in most cases, the advantages of sheltered anchorages, with deep water, and other accommodation for all classes of vessels. The great object, indeed, in founding most of the towns in the United States seems to have been, either the *formation of a port for shipping*, or the *cultivation of a valuable adjacent tract of country watered by a navigable river.* In some cases where agriculture was the primary consideration, the harbours do not possess the natural advantages to which we have adverted as peculiar to American harbours, but stand in need of works for their improvement, which would involve a greater expenditure of capital, and occupy more time in their execution, than a country, as yet new in the arts, has been disposed to bestow upon them. Viewing the harbours of America generally, however, no one can fail to be struck with their importance, and convinced of their mighty effect in advancing the prosperity of that enterprising country, especially when viewed in connection with its inland navigation.

The largest ports of North America are Quebec, Halifax, and Montreal, in the British dominions, and Boston, New York, Philadelphia, Baltimore, Charleston, and New Orleans, in the United States. Besides these, there are many towns on the coast, of later origin, having less trade and importance, but nevertheless possessing fine natural facilities for the formation of harbours.

I was fortunate enough to visit many of the American ports, and in most of them, I found that accommodation for vessels of great burden had been obtained in so satisfactory a manner, and at so small an expense, as could not fail to strike with astonishment all who have seen the enormously costly docks of London and Liverpool, and the stupendous asylum harbours of Plymouth, Kingstown, and Cherbourg. I have little hesitation in saying, that the smallest of the post-office packet stations in the Irish Sea has required a much larger expenditure of capital, than the Americans have invested in the formation of harbour accommodation for trading vessels along a line of coast of no less than 4000 miles, extending from the Gulf of St Lawrence to the Missisipi.

The American Packet-ships trading between New York and the ports of London, Liverpool, and Havre, are generally allowed to be the finest class of merchant-vessels at present afloat; and, for their accommodation, we find in England the splendid docks of London and Liverpool, and in France the docks of Havre. An European naturally concludes that a berthage no less commodious and costly awaits their arrival in the ports where they were built and launched, and to which they sail; but great will be his astonishment when, on reaching New York, the same fine vessel which lately graced the solid stone-docks of Europe, is moored by bow and stern to a wooden quay; and, on leaving the vessel, he will not fail to miss the shade of a covered verandah enclosed within high walls, the characteristic of a British dockyard, and will have any thing but pleasant sensations when he is ushered forth upon a hastily constructed wooden jetty, which, in certain states of the weather, is deeply covered with mud, and at any time affords a footpath which is not very agreeable.

This state of things strikes a foreigner, on first landing in America, in a very forcible manner. The high, and in some cases superfluous, finish, which the Americans bestow on many of their vessels employed in trading with this country, lead those who do not know the contrary to expect a corresponding degree of comfort, and an equal display of workmanship, in the works of art connected with their ports; and it appears at first sight a strange inconsistency, that all the works connected with the formation of the harbours in America should be of so rude and temporary a description, that, but for the sheltered situations in which they are placed, and other circumstances of a no less favourable nature, the structures would be unfit to serve the ends for which they were intended. However, hasty conclusions on all such matters are dangerous; and when we come to inquire into the reasons for this difference between the construction of the European and American harbours, they soon become apparent and satisfactory. The difficulties and expense encountered in the formation of most European harbours, have arisen chiefly either from the necessity of constructing works of a sufficient strength to withstand the violence of a raging sea to which they are exposed, or in obtaining a sufficient depth of water, by the construction of docks or other means, to enable the vessels frequenting them to lie afloat at all times of tide. In Britain, these difficulties in a great measure arise from the narrowness of our country, which necessarily contains but a small extent of inland waters, whose quantity and currents, when compared with the bays and rivers on the American coast, are agents too unimportant and feeble to produce, without recourse to artificial means, the depth or shelter required in a good harbour. The Americans, on the contrary, among the numerous large bays and sounds by which their coasts are indented, have been enabled to select, as situations for their harbours, places which are perfectly defended from the surge of the ocean, and which require no works, like the breakwaters of Plymouth and Cherbourg, for their protection; and the basins formed and scoured by their large navigable rivers afford, without resorting to the construction of docks like those of Liverpool, London, Leith, or Dundee, natural havens, where their largest vessels lie afloat at all times of tide within a few paces of their warehouse doors.

The kind of workmanship which has been adopted in the formation of the American harbours is almost the same in every situation; and the harbours generally bear a strong resemblance to each other in the arrangements of the quays, and even in their physical characteristics, being generally formed along the margin of projecting tongues of land or projecting coast lines, which are protected from the direct action of the sea by islands or outlying stretches of coast. This renders a detailed description of the works of more than one harbour unnecessary; and for the purpose of giving an idea of an American port, I select that of New York, because it undoubtedly ranks as the first harbour in America, and is, in fact, the second commercial city in the world, the aggregate tonnage of the vessels belonging to it being exceeded only by that of London.

The island of Manhattan, in the state of New York, is about fifteen miles in length, and from one to three miles in breadth. The city of New York is situate on the southern extremity of this island, in north latitude 40° 42′, and west longitude 74° 2′ from Greenwich. It was founded by the Dutch in the year 1612, and it now contains a population of about 500,000 inhabitants,* and measures about ten miles in circumferance. On the east, the shore of Manhattan Island is washed by the sound which separates it from Long Island, and on the west by the estuary of the River Hudson, which, as far up as Albany, is more properly an arm of the sea than a river, the stream itself being comparatively small. These waters, which have received from the Americans the appellation of the East and North Rivers, meet at the southern extremity of the island of Manhattan, and at their junction form the spacious bay and harbour of New York, that great emporium of the western hemisphere.

The Bay of New York, which extends about nine miles in length and five miles in breadth, has a communication with the Atlantic Ocean through a strait of about two miles in breadth, between Staten Island and Long Island. This strait is called "The Narrows;" and on either shore stands a fort for protecting the entrance to the harbour. This magnificent bay, which is completely sheltered from the stormy Atlantic by Long Island, forms a grand deep-water basin, and offers to almost any extent, a spacious and safe anchorage for shipping, while the quays which compass the town on its eastern, western, and southern sides, afford the necessary facilities for loading and discharging cargoes. The shipping in the harbour of New York, therefore, without the erection of breakwaters or covering-piers, is, in all states of the wind, protected from the roll of the Atlantic. Without the aid of docks, or even dredging, vessels of the largest

* The population of towns have been corrected up to the present time.

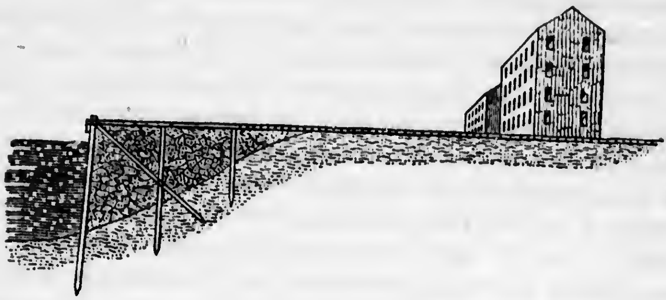
class lie afloat during low water of spring-tides, moored to the quays which bound the seaward sides of the city; and, by the erection of wooden jetties, the inhabitants are enabled, at a very small expenditure, to enlarge the accommodation of their port, and adapt it to their increasing trade.

The situation of New York is peculiarly favourable for the extensive trade of which it has become the seat, by the nearness of its harbour to the ocean—the quays being only about eighteen miles from the shore of Sandy Hook, which is washed by the waters of the Atlantic. This naturally makes the communication both direct and easy, as a very short time elapses between making land and mooring at the quay; and all the anxiety which is experienced after falling in with the European land, in a coasting navigation of several days, before the mariner terminates his cares by docking his vessel in Liverpool or London, or in any other port of Great Britain, is thus avoided. I may mention, in illustration, that I left the quays of New York at half-past eleven on the forenoon of the 8th of July 1837, in the "François Premier" packet-ship, Captain Pell, for Havre, with a very light breeze from the north-west; and, at seven o'clock on the evening of the same day, our vessel was gliding through the Atlantic with nothing in sight but sky and water. This case is strongly contrasted with what took place on my outward passage, on which occasion I left Liverpool, under no less advantageous circumstances, on the 12th of March of the same year, in the "Sheffield" packet-ship, Captain Allen; but we did not clear the Irish land till two days after our leaving port.

The perpendicular rise of tide in the harbour of New York is only about five feet. The tidal wave, however, increases in its progress northwards along the coast, till at length, in the Bay of Fundy, it is said to attain the maximum height of 90 feet. Towards the south, on the contrary, its rise is very small; and, in the Gulf of Mexico, it is reduced to eighteen inches; while on the shores of some of the West India Islands it is said to be quite imperceptible.

A bar extends from Sandy Hook to the shore of Long Island, across the entrance to the harbour. Over this there is a depth of about twenty-one feet at low water.

The wharfs erected for the accommodation of the shipping of New York are formed entirely of timber and earth, in a very rude and simple manner. A row of wooden piles, driven close to each other into the bottom, forms the face-work of the quay, which is projected from the shore as far as is necessary to obtain a depth of water sufficient to float the largest class of vessels at all times of the tide. The situation of New York, in this respect, is very favourable, as deep water is generally obtained at the distance of from forty to fifty feet from the margin of the water. The piles, of which the face-work of the piers is composed, are driven perpendicularly into the ground, and are secured in their places by horizontal wale-pieces or stretchers, bolted on the face of the quay, and running throughout its whole extent. Diagonal braces are also bolted on the inside of the piles, and beams of wood are connected to the face-work, and extend behind it to the shore, in which they are firmly embedded. These beams act both as struts and ties, serving to counteract the tendency of lateral pressure, whether acting externally or internally, to derange the line of quay. The void between the perpendicular piles, which form the face-work and the sloping bank rising from the margin of the water, is generally filled up with earth, obtained in the operation of levelling sites and excavatingfoundations for the dwellings and warehouses of the city. This hearting of earth is carried to the height of about five feet above high water of spring-tides, at which level the heads of the piles, forming the face-work, are cut off, and the whole roadway or surface of the quay is then planked over. The planking used in forming the roadway of the quay is, in some cases, left quite exposed; but, in general, where there is a great thoroughfare, the surface is pitched with round water-worn stones, and corresponds, in appearance and level, with the adjacent streets. The accompanying cross section of one of the wharfs, will show more clearly the manner in which they are constructed.



A continuous line of wooden quay-wall, constructed in this manner, surrounds the city of New York on its eastern, western, and southern sides; and the inhabitants are still rapidly extending their harbour accommodation to meet the wants of increasing trade, which has now become so great, that these wooden wharf-walls have attained a length of no less than seven miles. Numerous jetties, of the same construction as the continuous quay-wall already described, project into the harbour at distances of from three to four hundred feet apart. —The jetties are generally from two to three hundred feet in length, and from fifty to sixty feet in breadth. The vessels frequenting the harbour are moored in the bays formed between these projecting jetties, where they lie closely penned together, waiting their turn to get a berth alongside the wharfs.

The wood-work in the quays and jetties is of a very rough description. The timbers employed in their construction are seldom squared, and never, in any case, protected by paint or coal-tar from the destroying effects of the atmosphere. Wood is so plentiful in America, that to repair, or even to construct works in which timber is the only material employed, is generally regarded as a very light matter.

The fixed crane for raising great weights, which is so generally used in the quays of Europe, is not employed in

New York, nor, in fact, in any of the American ports. There, vessels discharge and take in cargo with a purchase hung from the yard-arm. Tackling, attached to moveable sheer-poles or derricks, is also pretty much used in some of the ports; but this apparatus proves a very poor substitute for fixed quay-cranes, which are certainly of great convenience and utility in a shipping-port.

The want of proper accommodation for vessels requiring repair is much felt by the shipping frequenting the American ports. The construction of an effective graving dock, is, under any circumstances, an operation of considerable expense; but, in situations where the rise of tide is small, the difficulties encountered in its construction, and the inconvenience and expense attending the use of it when completed, prove a great bar to the introduction of this useful appendage to a dock-yard. It is, in a great measure, owing to these circumstances that graving docks, for the repair of trading vessels, are not used in the American ports; in the most important of which, the perpendicular rise of tide is so small, as to lessen, in a great degree, the advantages which, under more favourable circumstances, would be derived from their introduction.

The only graving docks existing in North America, at the time of my visit, were those which have been erected for the use of the Navy by the Government of the United States, in the navy-yards of Boston in Massachusetts, and Norfolk in Virginia. These docks have been formed of such a size, as to admit, with ease, the largest class of government vessels belonging to the American Navy. The dock of Boston measures 306 feet in length, and 86 feet in breadth, and has a depth of water of 30 feet. But, although the depth of water in the dock is 30 feet at high water of spring tides, the fall of the tide is only 13 feet, which leaves 17 feet of water to be pumped out, by means of a steam-engine, every time a vessel is admitted for repair, an operation both tedious and expensive. The stone used in their construction is a grey-coloured granite from Quincy in Massachusetts, and, as far as regards workmanship and general execution, they are inferior to no marine works which I have ever seen. These graving docks are believed to have cost about L.152,000 each. They are the finest specimens of masonry which I met with in America, and are equally creditable to the government of the United States, and to Mr Baldwin, the engineer under whose direction they were constructed.*

In the American harbours, the method of careening or laying vessels on their sides to get at their lower timbers, is still often resorted to. I, however, met with three different mechanical arrangements for raising vessels from the water, when decay or damage renders this operation necessary. In one of these arrangements, the requisite object is attained by the use of an inclined plane (on the well-known principle of Morton's patent slip, but of a very rude description), on which vessels are drawn ashore by means of a system of wheel-work driven by a steam-engine.

The second method, which savours more of originality, is called the Screw-dock, the operation of which I witnessed on one occasion in the harbour of New York. The vessel to be raised by this apparatus was floated over a platform of wood, sunk to the depth of about ten feet below the surface of the water, and suspended from a strongly built wooden frame-work by sixteen iron screws four and a half inches in diameter. This platform has several *shores* on its surface, which were brought to bear equally on the vessel's bottom, to prevent her from *kanting* over on being raised out of the water. About thirty men were employed in working this apparatus, who, by the combined action of the lever, wheel

* A large graving dock has also been constructed in the Navy-yard at New York. It measures 350 feet in length within the caisson-groove, and the main chamber is 98 feet in breadth at the top. The width of entrance is 68 feet, and the depth of water 26 feet. It was commenced in 1841, and completed in 1851. Great difficulty was experienced in its execution, occasioned mainly by the softness of the foundations—upwards of 8000 piles, varying from 25 to 40 feet in length, having been employed in the work, which is stated to have cost the very large sum of L.400,000. It is built of granite, and is furnished with iron gates, and an iron cassion or floating gate. An interesting account of the different docks in the Navy-yards of the United States will be found in Stuart's *Naval Dry-docks of the United States*. C. Norton, New York, and J. Weale, London, 1852.

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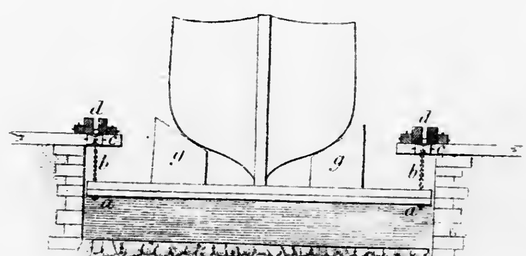
PLATE I.

Sketch shewing the principle of the Hydraulic Dock at New York.

Fig. 1.

Fig. 2.



and pinion, and screw, succeeded, in the course of half an hour, in raising the platform, loaded with a vessel of 200 tons burden, to the surface of the water, where she remained high and dry, suspended between the wooden frames. At Baltimore, I saw a large screw-dock, constructed on the same principles, on which the platform for supporting the vessel was suspended by forty screws of about five inches in diameter.

The third of those methods to which I have alluded, is an apparatus called the Hydraulic-dock, a beautiful application of the principle of Bramah's press, to raise vessels of 800 tons burden. In this apparatus, as in the screw-dock, the vessel is raised on a platform swung between two frames. In the hydraulic-dock, however, the platform is suspended by forty chains, twenty on each side, which pass over cast-iron pullies, supported on the top of the wooden frame-work. The lower ends of the chains are fixed to the platform, and the upper ends to a horizontal beam of wood, which is attached by means of a crosshead to the ram of a hydraulic engine. When the ram, therefore, which is placed in a horizontal position, is moved, by the injection of water into the cast-iron cylinder in which it works, the motion is communicated to the horizontal beam, and thence, by the suspending chains, to the platform bearing the vessel, which is thus slowly raised to the surface.

Plate I. is a sketch illustrative of the principles on which this apparatus is constructed. Fig. 1 is a longitudinal view, and Fig. 2 an end view, of the platform and vessel. In both of these views, *a* represents the platform; *b*, the suspending chains; *c*, the pullies on which they run; *d*, the horizontal beam to which the chains are attached; *e*, the hydraulic engine; and *f*, the injection-pipe by which the water is forced into the ram *l*.

The cylinder and ram of the particular apparatus, which I saw, were made in England, at the works of Messrs Bolton and Watt. The fixtures of the cylinder are embedded in a large mass of masonry, so as to render it quite immoveable. The perfect stability of this part of the apparatus is obviously of the highest importance, as the safety of the suspended vessel depends in a great measure on this being secured. The external diameter of the water-cylinder is twenty-eight inches, and its internal diameter is twelve inches. The ram which works in it is eleven inches in diameter and ten feet in length. There are several racks attached to the apparatus, for supporting the platform, and taking part of the weight off the ram after the vessel is suspended. When she is ready to be lowered, these racks are unshipped, and the water being permitted to escape through a small aperture provided in the cylinder for that purpose, the vessel slowly descends into the water. The water is injected into the cylinder by a high-pressure steam-engine, of six horses' power, and the attendance of four persons is all that is necessary to raise a vessel of 800 tons register. The perpendicular *lift* of these docks is ten feet, which is found to be sufficient: the rise of tide in New York harbour being only five feet at spring tides, renders a greater height unnecessary.

The Screw and Hydraulic docks belong to a party of private individuals, called the "New York Screw-Dock Company," who derive a considerable revenue from raising vessels by their ingenious apparatus. The following are their terms:—

For vessels under 75 tons, £3 per day.
Single-decked vessels of 75 tons and upwards, 10d. per ton per day.
Double-decked vessels of 75 tons and upwards, 1s. 0½d. per ton per day,

After the first day the charge is

For vessels under 170 tons, £3 per day.
For all vessels of 170 tons and upwards, 4½d. per ton per day.
Cargo or ballast is charged at the rate of 1s. 0½d. per ton.*

The wharfs in the harbour of New York, are in general the property of private individuals, possessing the land on the margin of the river. Some of them also belong to the

* Since 1837 another device has been introduced at New York, for the repair of vessels, called the Patent Sectional Dock. It is described in detail by Mr Hyde Clarke, C.E., in Weale's engineering papers, . It consists of a series of caissons connected with a platform which is introduced below the vessel, and the water being pumped from these caissons by means of two steam-engines, the vessel is raised by their floatation. This apparatus can be towed to any place where it is desired to apply it.

Corporation of New York. The wharfage dues are collected by the owners of the respective quays, and vary in their rates according to the local advantages which the sites possess, and the pleasure of the persons to whom they belong.

Vessels have, occasionally, been damaged while lying at the quays of New York, by the vast masses of floating ice which, upon the breaking up of the frost, are brought down from the interior of the country by the waters of the Hudson. For the protection of shipping against the recurrence of such accidents, which, however, are liable to affect only the vessels lying on the western side of the town, the erection of a break-water in the river above New York harbour, has been for some time contemplated.

The trade of this great port is generally more or less interrupted by ice for about a month every winter, and the River Hudson at New York has, once or twice, been covered by a coating of ice so thick as to afford a safe road for carriages. This, however, happens very rarely; but such is the severity of the New York winter, that the omnibuses, and other wheel-carriages employed in running in the city, are always laid up for the space of five or six weeks during the depth of winter, and their places supplied by sledges which run on the hardened snow.

The large suburb called Brooklyn occupies the shore of Long Island, directly opposite to New York. It is separated from the town by Long Island Sound, which at this point is about one-third of a mile in breadth, and forms part of the harbour of New York. One of the United States' Navy-yards has been established at Brooklyn, which is also in other respects a place of considerable trade and importance. A constant communication is kept up between it and New York, by means of numerous steamboats, which cross every five minutes, adding greatly to the bustle and confusion of this busy and crowded part of the harbour.

The stoppage and inconvenience which a bridge across the sound in this situation would occasion to the shipping, has prevented its erection, but the spirited inhabitants have had designs under their consideration for connecting the opposite shores by means of such a work, and also by the formation of a tunnel passing under the bed of the river, similar to that under the Thames at London. The steam ferry-boats, however, are so well managed, that the want of a more constant means of communication is not much felt. They are twin boats with the paddle-wheel placed in the centre, and in their general construction resemble those at one time used on the ferries of the Tay at Dundee, and the Mersey at Liverpool.

The landing slips between which they ply are very convenient and suitable for situations where the rise of tide is not great. The slip consists of a large platform of wood, the landward extremity of which is attached to the edge of the quay by moveable hinge-joints, admitting of its free motion. The seaward extremity of this platform rests on a floating tank, and has the same elevation above the surface of the water as the deck of the ferry-boat. The outer extremity of the platform which rests on the floating tank, is thus elevated or depressed with the rise and fall of the tide, but always remains on a level with the steamboat's deck, and affords during high-water a level road, and during low-water an inclined plane, for the passage of carriages and passengers between the vessel and the land.*

Before quitting the subject of Harbours, I shall make a few general remarks on some of the other American ports of consequence.

Boston, in Massachusetts, is generally supposed to rank next in importance to New York and New Orleans. The town is situated at the head of Massachusetts Bay, which extends over about fifty miles of coast between Cape Ann and Cape Cod, and contains within its limits many excellent anchorages. Boston Bay, in which the harbour has been formed, is a sheltered inlet of about seventy-five square miles in extent, enclosed by two necks of land, which so

* This arrangement has, since the date of my visit to America, been carried out on a large scale by Sir William Cubitt, in the steamboat landing-stages constructed by him on the Mersey at Liverpool.

nearly approach each other as to leave only a very narrow entrance communicating directly with the Atlantic. The exports from Boston are of a varied nature, consisting chiefly of the produce and manufactures of that part of the United States called New England. The population of the town is about 93,000. Its situation is curious. Placed on a peninsula having deep water close in-shore, and almost entirely surrounding it, it is connected with the adjoining country by means of a dam and seven wooden bridges, of which the most extensive is about a mile and a half in length. The dam consists of an embankment of earth 8000 feet in length, enclosed between two stone retaining-walls. It serves the double purpose of affording a means of communication, and of forming a large basin, in which the tide-water being collected, a water-power is created for driving machinery.

The quays at Boston are constructed in the same style, and of the same materials, as those of New York, but more attention has been paid by the builders to the durability of the work. Some of the wharfs extend about a quarter of a mile into the harbour, and are of sufficient breadth to have a row of warehouses built on them. The rise of tide in Boston harbour is thirteen feet in spring, and nine feet in neap, tides. In the suburb called Charlestown, which is connected with Boston by means of three wooden bridges, is situate the Navy-yard of the United States, and the graving-dock already noticed.

Philadelphia is a town of about 400,000 inhabitants, and stands on a peninsula between the rivers Delaware and Schuylkill, in the state of Pennsylvania. Its harbour is at the head of the ship navigation of Delaware Bay, a vast arm of the sea, which is navigable for vessels of the largest class as far as Philadelphia, a distance of about a hundred miles from the Atlantic Ocean. In the Bay of Delaware the tide has generally a rise of only three feet, but it is sometimes much increased by the state of the winds—the highest known tide being 9 feet.*

* In 1829 a commission, composed of Commodore Rogers, United States Navy, Brigadier-General Bernard, United States Engineers, and William

The town of Baltimore contains a population of about 100,000 inhabitants, and lies on the north side of the River Patapsco, about fourteen miles from its mouth. The basin forming the harbour is a splendid sheet of water, in which it is said 2000 vessels could ride at anchor with ease.

Chesapeake Bay, which receives the River Patapsco, on which Baltimore stands, is navigable for 200 miles from the ocean, and forms an outlet for the trade of the ports of Baltimore, Annapolis, Washington, Fredericksburgh, Richmond, and Norfolk, and receives the waters of the Susquehanna, Patapsco, Potomac, and James rivers. The rise of tide at Baltimore is about five feet, but is much influenced by the state of the wind, which has a great effect upon the waters of Chesapeake Bay.

Charleston, in North Carolina, is a port of considerable size, built on a tongue of land formed by the Rivers Ashley and Cooper. There is a bar at the entrance of the harbour, with only twelve feet of water on it at low tides, but within the bar there is a good anchorage. The rise of tide in this harbour is about six feet.

As I was unable to visit New Orleans, I cannot speak of it from personal knowledge; but as it is by far the most important place in the Southern States, I felt unwilling to

Strickland, Esq., architect, after fully considering the works at Plymouth and Cherbourg, reported to Congress in favour of the construction of a breakwater in Delaware Bay at Cape Henlopen. The rep[illegible] states that the objects to be gained by the proposed breakwater are, to she[illegible] the action of the waves caused by the winds blowing from east t[illegible] round by north, and also to protect them from injuries arising fr[illegible] ice descending from the north-west. That the harbour will se[illegible] be used by vessels descending the river and bound to sea, its chief purpose being, to provide a safe refuge for vessels from sea designing to ascend the river. Twelve hundred yards was estimated as the length of that portion of it which was destined for a breakwater, and 500 yards for the part designed more particularly to act as an ice-breaker, making the whole length of the two 1700 yards. In 1837, when I visited the country, I could not learn that anything had been accomplished to justify the hope of the work being carried to a successful issue. I am happy to observe that in 1840 Mr Strickland writes, "that the work may be considered now so far finished as to have accomplished materially the purposes for which it was projected." (*Public Works in the United States.* London: John Weale. 1841.)

omit all mention of it in this sketch, and therefore applied to my friend Captain Basil Hall, now, alas, no more, who kindly sent me the following notice on the subject:—

"You are quite right," says Captain Hall, "to include New Orleans in your list of American harbours; for, though it is not strictly a seaport, it answers all the purposes of one in a remarkable degree. New Orleans lies at the distance of about a hundred miles from the Gulf of Mexico, and the ebb and flow of the tide do not reach so high as the city. The level of the river is, however, subject to fluctuations, in consequence of the changes in the supply of water from the upper countries through which it flows. It rises from January to May, remains full all June and a part of July, after which it begins to fall, and goes on decreasing in height till September and October, when it is lowest. The perpendicular difference in height of the surface of the Mississippi at New Orleans, is about thirteen or fourteen feet, and when at its lowest, it is nearly on a level with the sea at the mouth of the river, so that the flow is then scarcely perceptible.

"In former times, before steam-navigation was known, there was great delay, and considerable difficulty as well as danger, in getting from the sea to New Orleans, in consequence of the opposing stream, the numerous shoals, and the very tortuous nature of the course, which rendered it scarcely possible to sail up all the way with the same wind. To these annoyances may be added the very bad nature of the anchoring ground everywhere, and the difficulty as well as risk of lashing large vessels to the banks of such a river. All these things rendered New Orleans a harbour highly objectionable in a nautical point of view.

"Now, however, that steam has got command of 'time and space,' New Orleans may be considered an excellent sea-port, safe, and as easy of access as of egress. I need not mention that there are at all times any number of steam-tugs ready to take ships down the river, or to bring them up. When I was there in April 1827, eleven years ago, several steamboats left the city every evening about sunset, each having in tow one or more vessels astern, besides one, two, or three lashed on each side, so that the boat was often quite hid by the cluster round her. In this way they proceeded down, and at daylight came to the bar which lies across the mouth of the river opening into the Gulf of Mexico. On reaching the sea, or rather before they reached it, the steamboats cast off their companions, and left them to be taken in charge by their respective pilots, unless in cases of calm or contrary wind, when, of course, they got a tow into the offing.

"The most important service of these steamboats, however, is to tow ships up the river; for, although it is always troublesome, and often very dangerous, to drop down with the current from New Orleans to the sea, it can be and is done, even without the help of steam. But to make way upwards against the Mississippi is a most heart-breaking work without such aid, and now-a-days the attempt would be considered absurd. Accordingly, the steam-vessels which have carried down the ships during the night, and have launched them in safety over the bar into the salt sea, look about them for others, which having made the land, are ready to enter the river. These they seize upon, and either take in tow, or lash alongside of them, and tow up to New Orleans. Of course they cannot, as in the downward case, carry along with them such a cluster as they brought down, nor is it likely that they will often be called upon to exert their strength so far, for the ships arrive off the entrance of the river by one or two at a time, and are not prepared, as within the port, to start in bodies at a given time.

"In this way, it may be fairly stated, that New Orleans, though a hundred miles from the sea, is virtually one of the best and most accessible ports in the Union. It may be added, that, as all the ships lie alongside of the levée or embankment which separates the river from the city, and which serves the purpose of a perfectly commodious wharf, and as the water is always smooth, nothing can be more easy and secure than the communication, both for loading and unloading goods. The ships lie alongside of each other, in tiers, and I have seldom seen, in any country, such a forest of masts.

"Abreast of the upper part of the city may be seen, in like manner, numerous tiers of steamboats of gigantic dimensions, just arrived from, or preparing to start for, the upper countries, through which the Mississippi and its innumerable tributaries pass. And farther up in this most extraordinary of harbours, lie crowds of huge rafts, or arks, as they are called,—rude vessels without masts, which have dropped down the river, and are loaded with that portion of the produce of the interior which will not bear the expense of steam carriage.

"At every hour,—I had almost said at every minute,—of the day, the magnificent steamboats which convey passengers from New Orleans into the heart of the western country, fire off their signal guns, and dash away at a rate which makes me giddy even to think of.

"I must now conclude this brief notice by regretting, that the limitation in your time did not allow you to visit, and to describe in detail, this most remarkable of all the wonderful commercial phenomena,—as it may be called,—which the great western confederacy of states presents to the traveller, namely, a mighty city built in the midst of one of the most unhealthy swamps on earth, and a port, 100 miles from the sea, which rivals, in all essential respects, that of New York or London; possessing, moroever, an uninterrupted and ready communication with the interior parts of a vast continent, to the distance of thousands upon thousands of miles, everywhere rife with civilization, though, but a few years ago, the whole was one vast wilderness, the exclusive abode either of alligators, wild beasts, or savages!"

These are the most considerable ports in the United States; but, in addition, it may not be amiss to notice shortly the following bays and sounds, which deserve attention, as many of them afford good anchorage and sheltered lines of navigation.

Passamaquoddy Bay is situate at the boundary between the British dominions and the United States. It receives the waters of the River St Croix, the boundary line between the two countries. The tide in it rises twenty-five feet.

Penobscot Bay, into which the River Penobscot flows, has a rise of tide of ten feet.

Narragansett Bay is navigable for vessels drawing sixteen feet of water to the town of Providence, which is about thirty-five miles from the sea. The town of Newport in this bay, though a place of little importance, has one of the finest natural harbours in America.

Long Island Sound lies between the mainland and Long Island, and extends in a north-easterly direction from New York harbour. It affords a sheltered line of navigation of about 120 miles in extent.

Albemarle and Pamlico Sounds, in North Carolina, are more remarkable for their curious geological formation than for any advantages held out by them for navigation, for which the difficulties of their entrance, and shallow water, wholly unfit them. The narrow strips of land, by which these Sounds are separated from the Atlantic Ocean, stretch along the coast for a distance of about 200 miles, and extend about 40 miles south of Pamlico Sound.

Chatham, Appalachee, and Mobile Bays, in the Gulf of Mexico, are not reported as possessing, in any extraordinary degree, the qualifications of good havens, and, as already noticed, there is very little rise of tide on this coast. It may also be mentioned, that the hot and unhealthful climate of all the southern ports of the United States, from Charleston to New Orleans inclusive, as well as the nature of the slave population of the southern states, renders them very unsuitable for the growth of that hardy race of seamen, of which the northern ports of the country are the true and only nurseries.

The naval-yards belonging to the Government of the United States are established at Boston, Portsmouth in New Hampshire, New York, Philadelphia, Washington, Norfolk in Virginia, and Pensacola in the Gulf of Mexico; and those of them which I had an opportunity of visiting seemed to be very well regulated. Considering the natural advantages held out by that country, and the abundance of fine timber produced in it, it is not surprising that the Americans have bestowed so much attention upon naval affairs, or that their efforts should have been crowned by so great success in the improvement both of inland and maritime navigation. The genius of the people for naval affairs is doubtless the birthright of their British origin, and their patrimony has been improved by the energy which characterises all their efforts.

Quebec is the seat of government of Lower Canada, and, in a commercial point of view, is the first port in the British dominions in America. It is situate at the junction of the River St Charles with the St Lawrence; and, though distant fully 700 miles from the Atlantic Ocean, the spacious and beautiful Bay of Quebec, formed by the junction of the two rivers, affords a noble deep-water anchorage for vessels of all sizes, and almost in any numbers.

The bay measures about three miles and three quarters in length, and two miles in breadth, and the water in some parts of it is twenty-eight fathoms in depth. The population of the town is about 40,000, and its trade consists in the export of wood, potash, and furs, the produce of Upper and Lower Canada. The rise of tide at Quebec is twenty-three feet in spring-tides, and the quays and wharfs there, as well as in the harbours of the United States, are constructed entirely of wood.

The ferry-boats at Quebec, plying between the opposite sides of the river, which is about a quarter of a mile in breadth, are propelled by horses and oxen. These animals are secured in small houses on the decks of the vessels; and the effort they make in the act of walking on a circular platform, fixed on the circumference of a large horizontal wheel, produces a power which is applied to drive the paddle-wheels of the ferry-boat, in the same manner as the motion of the wheel in the tread-mill is applied to the performance of different descriptions of work. I have seen horse ferry-boats in Holland, and, I believe, they have also been used in America, in which the power was more advantageously applied by means of an apparatus like the gin of a thrashing-mill, in which case the horses are not stationary, but are made to walk in a circle, and the motion communicated by them to an upright shaft, is conveyed, by means of wheel-work, to the paddle-wheels of the vessel. A boat of this kind was used for some time in England, between Norwich and Yarmouth.

Montreal, which is 180 miles to the westward of Quebec, and 880 miles from the ocean, is a town of about 60,000 inhabitants, at the head of the ship navigation of the St Lawrence, and considerably above the influence of the tide. The town is built on the island whose name it bears, which is situate at the junction of the Ottowa or Grand River with the St Lawrence. The quays and landing-slips at Montreal are built of stone; and in this respect it differs from the other American ports which I have noticed. The material used in their construction is a blue limestone, which is very abundant throughout the greater part of Canada, and is much used in all building operations in that country. The trade of Montreal is of the same description as that of Quebec, though not so extensive.

Halifax harbour is considered one of the finest in the world, and is calculated to afford anchorage for upwards of a thousand vessels of the largest class. It is a place of very considerable importance; for through it comes much of the trade of Nova Scotia; and it is the British post-packet station for Canada.

Such is a brief sketch of the construction and capabilities of some of the principal harbours of America, in the formation of which nature has done so much, that little has been left for the labour of man, and works of an extensive and massive description, and operations such as are found to be indispensable in rendering European harbours accessible or commodious, have there been found to be unnecessary. By erections of a temporary description, constructed of the wood produced in the operation of clearing their lands, the inhabitants have been enabled, along the whole line of coast, to afford, at a very small cost, accommodation for an extent and class of shipping, to obtain which, in any other quarter of the globe, would have involved an enormous investment of capital, and a much greater consumption of time.

CHAPTER II.

LAKE NAVIGATION.

Great Western Lakes—Ontario—Erie—Huron—Michigan—Superior—Welland Canal—Lake Harbours—Construction of Piers, Breakwaters, &c. —Buffalo—Erie—Oswego—Toronto—Kingston—Vessels employed in Lake Navigation—Violent Effects of Storms on the Lakes—Ice on the Lakes—Effects of Ice on the Climate—Lake Champlain.

The great chain of inland lakes, whose vast expanse might justly entitle them to the name of seas, are the largest bodies of fresh water in the known world, and constitute an important feature in the physical geography of North America. When viewed in connection with the River and Gulf of St Lawrence, by which their surplus waters are discharged into the Atlantic Ocean, ideas of magnitude and wonder are excited in the mind which it is impossible to describe. But the effects which they produce on the commercial and domestic economy of the country are considerations far more important and striking. With the aid of some short lines of canal, formed to overcome the natural obstacles presented to navigation by the Falls of Niagara and the Rapids of the St Lawrence, these great lakes are converted into a continuous line of water-communication, penetrating upwards of 2000 miles into the remote regions of North America, and affording an outlet for the produce of a large portion of that continent, which, but for these valuable provisions of nature, must, in all probability, have remained for ever inaccessible.

The great western lakes of America are five in number:—Ontario, Erie, Huron, Michigan, and Superior. The extent of these lakes has been variously stated, and the several accounts which have been given of them, differ very considerably; but the dimensions which I shall quote are taken partly from the work of Mr Bouchette, the Surveyor-General of Canada, and partly from the charts constructed by Captain Bayfield of the Royal Navy.

Lake Ontario, the most eastern of the chain, lies nearest to the Atlantic. The River St Lawrence, which has a course of about a thousand miles before reaching the ocean, is its outlet, and flows from its eastern extremity. This lake is 172 statute miles in length, 59¼ miles in extreme breadth, and about 483 miles in circumference. It is navigable throughout its whole extent for vessels of the largest size. Its surface is elevated 220 feet above the medium level of the sea; and it is said to be, in some places, upwards of 600 feet in depth. The trade of Lake Ontario, from the great extent of inhabited country surrounding it, is very considerable. Many sailing vessels and splendid steamers are employed on its waters. Owing to its great depth, it never freezes, except at the sides, where the water is shallow; so that its navigation is not so effectually interrupted as that of the comparatively shallow Lake Erie.

The most important places on the Canadian or British side of Lake Ontario, are the city of Toronto, which is the capital of Upper Canada, and the towns of Kingston and Niagara, and, on the American shore, the towns of Oswego, Genesee, and Sackett's Harbour. Lake Ontario has a direct communication with the Atlantic Ocean, in a northerly direction by the St Lawrence, and in a southerly direction by the River Hudson and the Erie Canal, with which it is connected by a branch canal, leading from Oswego to a small town on the line of the Erie Canal, called Syracuse.

Lake Erie is about 265 miles in length, from thirty to sixty miles in breadth, and about 529 miles in circumference. The greatest depth which has been obtained in sounding this lake is 270 feet, and its surface is elevated 565 feet above the level of the Hudson at Albany. Its bottom is composed chiefly of rock. Lake Erie is said to be the only one of the chain in which there is any perceptible current, a circumstance which may, perhaps, be occasioned by its smaller depth of water. This current, which runs always in the same direction, and the prevailing westerly winds, are rather against its navigation. The shallowness of the water also, which varies from 100 to 270 feet in depth, renders it more easily and more permanently affected by frost—its navigation being generally obstructed by ice for some weeks every spring, after that of all the other lakes is open and unimpeded.

The principle towns on Lake Erie are Buffalo, Dunkirk, Ashtabula, Erie, Cleveland, Sandusky, Portland, and Detroit. Between forty and fifty splendid steamboats, and many sailing vessels, were in 1857 employed in its trade, which was even then very extensive; and several harbours with stone-piers have been erected on its shores for their accommodation.

The surface of Lake Erie is elevated 322 feet above Lake Ontario, into which its water is discharged by the River Niagara. In the course of this river, which is only thirty-seven miles in length, the accumulated surplus waters of the four upper lakes descend over a perpendicular precipice of 152 feet in height, and form the far-famed "Falls of Niagara." These falls, with the rapids which extend for some distance both above and below them, render seven miles of the river's course unfit for navigation. The unfavourable nature of the bed of the River Niagara,—the connecting link between Lakes Erie and Ontario,—for the purposes of navigation, induced a company of private individuals, assisted by the British Government, to construct the Welland Canal, by which a free passage from the one lake to the other is afforded for vessels of 125 tons burden.

This undertaking was commenced in the year 1824, and completed in 1829, five years having been occupied in its execution. The expense of the works connected with it is said to have been about L.270,000.

The canal extends from Port Maitland on Lake Erie to a place called Twelve-Mile Creek on Lake Ontario. Its length is about forty-two miles; its breadth at the surface of the water is fifty-six feet, and at the bottom twenty-six feet, and the depth of water is eight feet six inches. The whole perpendicular rise and fall from the surface of Lake Ontario to the summit level, and thence to Lake Erie, is 334 feet, which is overcome by means of thirty-seven locks of various lifts, measuring one hundred feet in length and twenty-two feet in breadth, most of which are formed of wood. The most considerable work occurring on the Welland Canal is an extensive excavation of forty-five feet in depth, from which 1,477,700 cubic yards of earth, and 1,890,000 cubic yards of rock, are said to have been removed.

Lake Erie is connected by the Erie Canal with the River Hudson and the Atlantic Ocean, and again by the Ohio Canal with the River Ohio and the Gulf of Mexico. The Erie Canal is 363, and the Ohio Canal 334, miles in length. I shall advert more particularly, however, to the construction and details of the canal works in North America in another section.

Lake Huron is about 240 miles in length, from 186 to 220 miles in breadth, and 1000 miles in circumference. The outline of this lake is very irregular, and Mr Bouchette says of its shores, that they consist of "clay cliffs, rolled stones, abrupt rocks, and wooded steeps." Its connection with Lake Erie is formed by the River St Clair, which conveys its water over a space of thirty-five miles into a small lake of the same name, of a circular form, and about thirty miles in diameter, from whence the River Detroit, having a course of twenty-nine miles, flows into Lake Erie. The communication between the two lakes is navigable for vessels of all sizes.

Lake Michigan is connected with Lake Huron by the navigable strait Michillimackinac, in which is situate the island of Mackinaw, now the seat of a custom-house establishment, and a place of considerable trade. Lake Michigan is about 300 miles in length, seventy-five miles in breadth, and 920 miles in circumference, having a superficies of 16,200 square miles. It is navigated by many steamers throughout its whole extent. The principal towns on the lake, the southern shore of which has now become the seat of many prosperous settlements, are Michigan, Milwawkie, and Chicago.* The Illinois River takes its rise near the shores of Lake Michigan, and flows into the Mississippi; and a canal, for the purpose of connecting their waters, is now in progress; an improvement which, when completed, will form a second water-communication, extending from the Gulf of St Lawrence to the Gulf of Mexico, a distance of upwards of 3000 miles,—the other communication being that already alluded to between Lake Erie and the Ohio by a canal from Cleveland to Portsmouth.

Lake Superior is connected with Lake Huron by the River St Mary. This river, which is about forty miles in length, has a fall of twenty-three feet on the whole length of its course, and is navigable only for small boats. As yet the march of improvement has not penetrated to this remote region; but ere long Lakes Superior and Huron, like Erie and Ontario, will probably be connected by a canal. Lake Superior is about 360 miles in length, 140 miles in breadth, and 1116 miles in circumference; the depth is in some places said to be 1200 feet, and its surface is 627 feet above the level of the sea. Its bottom consists of clay and small shells. This lake is the largest body of fresh water known to exist; and although surrounded by a comparatively desert and uncultivated country, at a distance of nearly 2000 miles from the ocean, and at an elevation of 627 feet above its surface, it is navigated by steamboats and sailing vessels of great burden, which are reported to be not inferior to the craft navigating the lower lakes.

From what has been said regarding the great western lakes, it will easily be believed that, notwithstanding the secluded position which they occupy in the centre of North America, far removed from the ocean and from intercourse with the world at large, their waters are no longer the undisturbed haunt of the eagle, nor their coasts the dwelling of the Indian. Civilization and British habits have extended their

* Chicago, of which I speak farther in the chapter on Railways, has increased with great rapidity. It is now the focus of a vast net-work of railways, its population being upwards of 80,000, and it claims the title of the New York of the Western States.

influence even to that remote region, and their shores can now boast of numerous settlements, inhabited by a busy population, actively engaged in commercial pursuits. The white sails of fleets of vessels, and the smoking chimneys of numerous steamers, now thickly stud their wide expanse; and beacon-lights, illuminating their rocky shores with their cheering rays, guide the benighted navigator on his course. Every idea connected with a *fresh-water lake*, must be laid aside in considering the different subjects connected with these vast inland sheets of water, which, in fact, in their general appearance, and in the characteristics of their navigation, bear a much closer resemblance to the ocean than the sheltered bays and sounds in which the harbours of the eastern coast of North America are situated, although these estuaries have a direct and short communication with the Atlantic Ocean.

The whole line of coast formed by the margins of the several lakes above enumerated extends to upwards of 4000 statute miles. There are several islands in Lake Superior, and also at the northern end of Lake Michigan, but the others are, generally speaking, free from obstructions. They have all, however, deep water throughout their whole extent, and present every facility for the purposes of navigation.

It was not till the year 1818, that the navigation of the lakes had become so extensive, and assumed so important a character, as to render the erection of lighthouses necessary and expedient for insuring the safety of the numerous shipping employed on them. Since that period the number of lighthouses has been gradually increasing, and, on the American side of the lakes they, at the time of my visit in 1837, amounted to about twenty-five in number, besides about thirty beacons and buoys, which have been found of the greatest service.

About the same period at which the introduction of lighthouses was considered necessary, some attention was also bestowed on the subject of lake harbours. Many which formerly existed were then improved and enlarged, and others were projected. I visited several of these ports on Lakes

Erie and Ontario, which have good sheltered anchorages, with a sufficient depth of water at their entrances for the class of vessels frequenting them. But good harbour accommodation is by no means so easily obtained on the shores of the lakes, as, generally speaking, on the sea-coast of the United States. Most of the lake harbours are formed in exposed situations, and as regards the expense and durability of the several works executed in their formation, are much better calculated to resist the fury of the winds and waves than the wooden wharfs of the sea-ports on the eastern coast of the country of which I have given a description. In connection with what has already been said on the subject of the harbours of the American coast, I shall give a brief sketch of some of those which came immediately under my notice on the shores of the lakes.

The town of Buffalo stands at the eastern corner of Lake Erie in the state of New York, and contains a population of about 30,000. As regards the number of its inhabitants and the extent of its commercial transactions, it is the most important place on the lakes. From the month of June till the month of December inclusive, during which period the navigation of the lakes is generally open and unimpeded by ice, I found in 1837 that between forty and fifty steamboats, varying from 200 to 700 tons register, were constantly plying between Buffalo and the several ports on the shores of the lakes. Some of these steamers made regular voyages once a month to Chicago in Lake Michigan, a distance of no less than 965 miles; and one left the harbour of Buffalo twice every day, during summer, for Detriot, a distance of 325 miles. The New York and Erie Canal, the earliest, and perhaps the most important public work executed in the United States, which enters the lakes at Buffalo, has a great effect in increasing its trade and importance.

Buffalo is built at the mouth of a creek communicating with the lake, in which the harbour is formed. The wharfs in the interior of the harbour are made of wood, but the covering pier, and other works exposed to the wash of the lakes, are built of stone, and cost about L.40,000. The depth of water in the harbour is nine feet when the lake is in its lowest or summer-water state. The following diagram represents a cross section of the covering pier, which has been erected for the purpose of protecting the shipping and tranquillizing the water within the harbour during heavy gales. It measures 1452 feet in length, and its form and construction are so very substantial, that one may fancy himself in some sea-port, forgetting altogether that he is on the margin of a fresh-water lake, at an elevation of more than 300 feet above the level of the ocean.

The top of the pier on which the roadway is formed measures eighteen feet in breadth, and is elevated about five feet above the level of the water in the harbour. On the side of the roadway which is exposed to the lake, a parapet-wall, five feet in height, extends along the whole length of the pier, from the top of which a talus wall, battering at the rate of one perpendicular to three horizontal, slopes towards the lake. This sloping wall is formed of a description of masonry, which is technically termed coursed pitching. Its foundations are secured by a double row of strong sheeting piles driven into the bed of the lake, and a mass of rubble *pierres perdues*, resting on the toe of the slope. The quay or inner side of the pier is perpendicular, and is sheathed with a row of sheeting piles, driven at intervals of about five feet apart from centre to centre, to prevent the wall from being damaged by vessels coming alongside of it.

The entrance to the harbour is marked by a double light, exhibited from two towers of good masonry built on the pier.

The workmanship and materials employed in erecting many of the other lake harbours are of a much less substantial description than that adopted at Buffalo. The breakwater for the protection of Dunkirk Harbour on Lake

Erie, for example, was formed in a most ingenious manner, by sinking a strong wooden frame-work filled with stones. The frame or crib was erected during winter on the ice over the site which it was intended to occupy. The ice was then broken, and the crib being filled with small stones, sunk to its resting-place in the bottom of the lake.

Presque-Isle Bay, in which the town of Erie stands, is formed by the peninsula of Presque-Isle on the shore of Lake Erie. This bay measures about one mile in breadth, and three miles in length, and affords a splendid anchorage for vessels of the largest size. It opens toward the north-west, and is sheltered from the waves of the lakes by two covering breakwaters, measuring respectively 3000 and 4000 feet in length, projecting from the shore, and leaving a space between their outer extremities of 300 feet in breadth, for the ingress and egress of vessels. Some other works of considerable extent are contemplated, to render this harbour still more safe and convenient.

Oswego, situate at the mouth of the Seneca River, on the southern shore of Lake Ontario, is a town of 12,000 inhabitants, having a good harbour. It stands at the commencement of the branch canal, which connects the great New York and Erie Canal with Lake Ontario, and is the seat of several manufactories and mills driven by the Seneca River, on which there are some very valuable falls. The pier, which has been built at this place for the protection of the harbour, is a very good specimen of masonry, finished somewhat in the same style as that at Buffalo, and cost about L.20,000. The depth of water in the harbour is twenty feet, and it has a good harbour-light placed in a substantial tower of masonry at the extremity of the pier.

The works required in the construction of Buffalo, Erie, and Oswego harbours were done at the expense, and under the direction, of the Government of the United States, who have also executed harbour-works of great extent, varying according to the nature of their situations, at the towns of Chicago, Michigan, Milwawkie, and Green Bay, in Lake Michigan; Detroit, Sandusky, Ashtabula, Portland, and Dunkirk, on Lake Erie; and at Genesee and Sackett's Harbour on Lake Ontario. Sackett's Harbour is remarkable as having been the United States' Navy-yard during the war.

The harbours on the Canadian or British shores of the lakes, are, as yet, not so numerous. The principal ones are those of Toronto, Port Dalhousie, Burlington, Hungry Bay, and Kingston, on Lake Ontario; and Amherstburgh, and Put-in Bay on Lake Erie.

Toronto, the capital of Upper Canada, lies in a bay which is nearly circular, and measures about a mile and a-half in diameter. It is sheltered from the lake by a projecting neck of land called Gibraltar Point, on which the harbour light is erected. This bay has a considerable depth of water, and affords an extensive and safe anchorage. Port Dalhousie is at the entrance of the Welland Canal, and has two piers, measuring respectively 200 and 250 feet in length, and also some pretty extensive works, connected with a basin for receiving timber. Kingston, situate at the eastern end of Lake Ontario, just at the point where the river St Lawrence flows out of the lakes, is the British Government Naval Yard. Navy Bay, in which it stands, is a good anchorage for vessels drawing eighteen feet of water, but is exposed to south and south-west winds. The British Government have also executed works in some of the other harbours on the Canadian side of the lakes.

The tonnage of most of the craft employed in the lake navigation is regulated by the size of the canals which have been constructed for the purpose of connecting the lakes, and facilitating the navigation of the St Lawrence. The locks of these canals are formed of such dimensions as to admit vessels of 125 tons burden, and consequently the lake craft, with a few exceptions, do not exceed this size. The steamboats, however, and all the vessels which are employed exclusively in the navigation of one lake, are never required to enter the canals, and many of these are of great size; some of the new steamers, at the time I visited the country, being no less than 700 tons burden. The art of ship-building, which is practised to a considerable extent in almost every port, derives a great stimulus from the abundance of fine timber produced in the neighbourhood of the lakes; and to so great an extent has it been carried on, that during the war a vessel called the St Lawrence, of 102 guns, was launched by the British at Kingston, and another by the Americans at Sackett's Harbour, which measured 210 feet in length on her lower gun-deck.

The vessels used in the lake navigation, and more especially the steam-boats, which I had frequent opportunities of examining, possess in a much greater degree the character of *sea-boats* than the same class of vessels employed in the sounds and bays on the shores of the Atlantic; and the substantial masonry of which the piers and breakwaters on the lakes are composed renders these works also, as before noticed, much more capable of resisting the fury of the winds and waves than the wooden wharfs of the eastern coast of the country. The strength and durability of material which both the piers and the vessels present are, at first sight, apt to appear superfluous in works connected with lake navigation. I was certainly impressed with this conviction when I first saw the stone-piers of Buffalo, which I have already described; and the sight of the steamer "James Madison," a strongly built vessel of 700 tons burden, drawing about ten feet of water, which plied between Buffalo on Lake Erie and Chicago on Lake Michigan, was in no way calculated to lessen the impression which the harbour had left; an impression which was heightened by the circumstance of my having a short time before examined the harbours on the eastern coast, and seen many of the slender fabrics, drawing from three to five feet of water, which navigate the bays and sounds in that part of the country. But, on inquiring more particularly into this subject, I was informed that these lakes are often visited by severe gales of wind, which greatly disturb the surface of their waters, and give rise to phenomena which one hardly expects to find in a fresh-water lake. In the opinion of many of the captains of the steamers with whom I conversed on this subject, the undulations created during some of these gales are no less formidable enemies to navigation than the waves of the ocean, so that great strength in the hydraulic works and naval architecture of the lakes is absolutely necessary to insure their stability. I had no opportunity, while in America, of witnessing the effects produced on the lakes by a gale of wind; but in many situations where their shores were exposed to a large expanse of water, and consequently with an in-shore wind, to the action of waves having a long *fetch* and ample scope to develop themselves, I found many interesting indications of their occasional violence when under the action of a hurricane. In the harbour of Buffalo, for example, which is situated in the north-east corner of Lake Erie, and has an unobstructed expanse of water extending before it for a distance of about 180 miles, the effects of the waves are very remarkable. The pier at this place, as already noticed, is built of blue limestone. The materials are small, and no mortar is used in its construction; but the stones are hammer-dressed, well jointed, and carefully assembled in the walls; and the structure, as before remarked, both as regards the materials of which it is built, and its general design, is calculated to stand a good deal of fatigue. On examining this pier, however, I was a good deal surprised to find that it was in some places very much shaken, and, more particularly, that several stones in different parts of the work had actually been raised from their beds; and I was told that this pier, as well as most of the harbours on the lakes, has annually to undergo some repair of damage occasioned by the violence of the waves. I measured several of the stones which had been moved, and one of the largest of them, weighing upwards of half a ton, had been completely turned over, and lay with its bed or lower side uppermost.

I met with another striking example of the violence of the lake-waves on the road leading from Cattarangus to Buffalo, which winds along the side of Lake Erie, in some places close to the water, and in others removed several hundred feet from its margin. Although the surface of this road is elevated several feet above the level of the lake; many of the fine large trees, with which the whole country is thickly covered, have been rooted up and drifted across it by the violence of the wind and waves, and now lie along its whole line piled up in the adjoining fields. Every winter's storm adds to these heaps of drifted timber, and they will doubtless continue to be enlarged till the increasing value of the lands on the margin of the lake, which, in their present state, are wholly useless for agriculture, renders the erection of works for their protection a matter of pecuniary interest to the proprietors.

The following extract also, from the Annual Report of the Board of the New York State Canals for 1835 shows the severity of lake storms:—"The method of towing barges by means of steamboats has been very successfully practised on the Hudson River; but on the lakes, though a great many steamboats have been in use for several years, the plan has not been adopted, because the steamboats cannot manage barges in a storm. We have been informed of a proposition made to the proprietors of a steamboat to take some canal boats from Buffalo to Cleveland; and it was accepted *only* on the condition, that, in the event of a storm, they should be at liberty to cut them loose at the risk of the owners.

"An intelligent gentleman, of several years' experience in navigating steamboats, and the two last seasons on Lake Ontario, informs us, that he considered it impracticable, as a regular business, for steamboats on the lakes to tow vessels with safety, unless the vessels were fitted with masts and rigging, and sufficiently manned, so as to be conducted by sails in a storm; that storms often rise very suddenly on these lakes, and with such violence as would compel a steamboat to cut loose vessels in tow in order to sustain herself."

The great area of the lakes prevents any material variation from taking place in the level of their surfaces, a result which, in small bodies of water, would no doubt be caused by the torrents annually poured into them from the melting snow. It is stated that a periodical rise of about two feet on the level of the lakes occurs every seven years; but the facts connected with this singular phenomenon do not appear to be very satisfactorily established. The water of the lakes and the River St Lawrence is remarkably pure and clear. Mr

M'Taggart mentions, in his work on Canada, that a white object, measuring a foot square, may be seen at the depth of forty feet below the surface. From my own observation, however, I cannot say that the American lakes are, in this respect, more remarkable than the Lake of Geneva, the waters of which are certainly very transparent.

The rigour of a Canadian winter, covering the face of the country with snow, and congealing every river, lake, and harbour, produces a stagnation in trade, which cannot fail to have a bad effect on the commerce of the country and the habits of the people, who are compelled to complete their whole business transactions during the summer and autumn months, and remain in a state of comparative indolence during the remainder of the year. When this unfortunate state of things is kept in view, it is astonishing, and in the highest degree creditable, particularly to the inhabitants of the British colonies, who are situated on the least favourable side of the lakes, as far as climate is concerned, that they have made such rapid advances in agriculture and public works. Considering the lakes in a commercial point of view, it is impossible not to regret that their navigation is open for so very limited a period. For the space of at least five months in the year the greater part of their surface is covered with a thick coating of ice; and the same sheet of water which, in summer, floats the vessel of 700 tons, and devastates the shores with its waves, becomes, in winter, a *highway* for the Canadian sledge. The centre of the lakes, where the water attains a considerable depth, is not frozen every season; but a vast sheet of ice is annually formed round their margins, which almost entirely puts a stop to navigation. Mr M'Taggart mentions that, in the year 1826, the ice at the margin of Lake Ontario was within half an inch of being two feet in thickness; and that, during the winter of the same year, Lake Chaudière was covered with a coating which measured no less than three feet six inches in thickness. He also made several experiments to ascertain the densities of lake and river ice, from which it appeared that the volumes of six cubic feet of lake, and eight cubic feet of river ice, were each equal, when melted, to five cubic feet of water. The ice on the rivers and lakes does not long retain a level surface. Large flaws make their appearance soon after it is formed, and the whole sheet gradually splits into pieces, which, being united together in great masses or hummocks, resist the action of the sun long after the disappearance of frost.

The period at which the lake navigation closes is generally about the end of November or beginning of December, and this interruption is never removed before the first week of May. In 1837, the year in which I visited America, the navigation was not wholly open till the last week of May. On the 20th of that month, I passed down Lake Erie, on my way to Buffalo, in the steamboat "Sandusky," on which occasion, even at that late period in summer, we encountered a large field of floating ice, extending as far as the eye could reach. Our vessel entered the ice about seven o'clock in the morning, and at twelve in the forenoon she had got nearly half way through it, when a breeze of wind sprung up, which, from its direction, had the effect of consolidating the field into a mass so compact, that our vessel being no longer able to penetrate it, was detained a prisoner, at the distance of about ten miles from Buffalo, the port for which she was bound. During the two following days, the efforts of our crew to free the vessel were unavailing, and so thick was the field of ice by which we were surrounded, that several of our less patient and perhaps more adventurous fellow-passengers, made many fruitless attempts to reach the shore, which was only two or three miles distant, by walking over its surface. On the morning of the 23d, a breeze of wind fortunately loosened the ice, and our captain, after having seriously damaged his vessel in attempting to extricate her, succeeded in making his escape, and landed his unfortunate passengers, during a torrent of rain, on the shores of the lake, far from any house, and ten miles from Buffalo, the place of our destination. The circumstance of there being upwards of two hundred passengers on board, and a great scarcity of provisions, together with the coldness of the weather, rendered our situation during the forty-eight hours of our imprisonment far from agreeable.

The country through which I travelled for some days before reaching the shores of the lakes, on my way from the Ohio River to Lake Erie, and also that part of it through which I afterwards passed on my route from the lakes to Quebec, presented all the indications of summer, every tree and shrub being in full foliage. In the immediate neighbourhood of Lake Erie, however, no signs of the approach of spring or returning vegetation were visible, though it was towards the end of May. The country surrounding the margin of the lake was bleak, and the trees were leafless, while the atmosphere was exceedingly damp, and the temperature indicated by the thermometer ranged from 32° to 35° of Fahrenheit. Such was the effect produced on the climate by this huge cake of floating ice, that it was almost impossible, from the state of the lake atmosphere, and the appearance of the surrounding country, to divest oneself of the idea that winter was not yet gone, although, in truth, the first month in summer was drawing to a close. This fact affords a striking example of the degree in which climate may be influenced by local circumstances; for, while the shores of Lake Erie presented this sterile appearance, and were still plunged in the depths of winter, the country in the neighbourhood of Quebec, although lying three degrees farther north, was richly clothed with vegetation.

The transition from winter to summer in the northern parts of North America is very sudden. There is no season in that country corresponding to our spring. The vast heaps of hardened snow and ice which have accumulated during the winter remain on the ground long after the sun has attained a scorching heat, but it is not until his rays have melted and removed them that the climate becomes really warm, and then the foliage, being no longer checked by the cold produced by these masses of snow and ice, instantly bursts forth, and at that particular time it is stated that a single day makes a marked difference on the face of the country.

The only other body of fresh water in North America demanding attention, is Lake Champlain, which lies nearly north and south, dividing the States of Vermont and New York. It is about 150 miles in length, and measures fourteen miles at the point where it attains its greatest breadth. The banks of the lake are in general low and marshy, and for about twenty miles at its southern extremity it assumes the appearance of a river, hardly affording sufficient space to permit a vessel to turn. This lake is navigable throughout its whole extent for vessels drawing five feet of water, and several fine steamboats ply on it while the navigation is open. The principal towns on its shores are St John's, Plattsburg, Ticonderoga, Whitehall, and Burlington, at which last place the steamboats for its navigation are built. It is connected with the River Hudson by the Champlain Canal, but it discharges its surplus water into the St Lawrence by the River Richlieu, called also the Sorell, on which the towns of St Dennis, St Charles, and Sorell, are situated. The chief trade of Lake Champlain consists in exporting iron-ore and timber; the iron is sent to New York by the canal, and the timber to the St Lawrence by the River Richlieu. Its waters are exceedingly pure, and are subject, during the wet seasons of the year, to great augmentation. The captain of the steamer by which I travelled informed me that, in the spring of 1816, when the snow was leaving the ground, the surface of the lake rose to the height of nine feet above its summer water level. Its navigation, like that of the other lakes, is suspended for five months in the year by ice, and transport is carried on during that period by sledges, which run on its surface.

CHAPTER III.

RIVER NAVIGATION.

The sizes and courses of the North American Rivers influenced by the Alleghany and Rocky Mountains.—Rivers flowing into the Pacific Ocean.—Rivers flowing into the Gulf of St Lawrence.—River St Lawrence.—Lakes, Rapids, and Islands on the River.—Lachine Canal.—St Lawrence Canal.—The Ottowa.—Rideau Canal.—Towing vessels on the St Lawrence.—Tides.—Freshets, Pilots, &c.,—Rivers rising on the east of the Alleghany Mountains, and flowing into the Atlantic Ocean, and north-east corner of the Gulf of Mexico.—The Connecticut.—Hudson.—Delaware.—Susquehanna.—Patapsco.—Potomac, &c.—Mississippi and its tributaries.—The Yazoo.—Ohio.—Red River.—Arkansas.—White River.—St Francis.—Missouri.—Illinois, &c.—State of the Navigation.—"Snags," "Planters," "Sawyers," and "Rafts."—Construction of Vessel for removing "Snags," &c.

The rivers of North America are no less interesting features in the hydrography of that country than her inland sounds and lakes; and the great lines of navigable communication which so many of them afford, extending in all directions from the shores of the ocean to the very heart of the country, and forming great public highways for the easy and quick transport of the most bulky produce of the interior, as well as the sea-borne manufactures and luxuries of foreign lands, entitle them, in a commercial point of view, to an equal share of attention.

It is impossible to convey to the reader an adequate idea of those vast bodies of moving water, or to describe the feelings of the traveller, when, for instance, after crossing the Alleghany Mountains, and completing a fatiguing land journey from the eastern coast of several hundred miles into the interior of the country, he first comes in sight of the Ohio River at Pittsburg. Here, in the very heart of the continent of North America, the appearance of a large shipping port, containing a fleet of thirty or forty steamers moored in the river, cannot fail to surprise him; and his astonishment is not a little increased if he chances to witness the arrival of one of those steamers, whose approach is announced long before it makes its appearance by the roaring of its steam, and the volumes of smoke and fire which are vomited from the funnels; but his wonder only attains its height when he is told that this same vessel has come direct from New Orleans, in the Gulf of Mexico, and that fifteen days and nights have been occupied in making this inland voyage, of no less than two thousand miles, among the meanderings of the Mississippi and Ohio.

The continent of North America may be said to be divided into four distinct portions by the ranges of the Alleghany and the Rocky Mountains, which run from north to south, in directions nearly parallel to each other, and regulate the lengths of the various rivers by which the country is drained, and, as it were, assign to each the quantity of water which is due to it, and the direction it must follow in its progress to the ocean. I shall consider the rivers, therefore, under four distinct heads—*First*, Those which rise on the west of the Rocky Mountains, and flow into the Pacific Ocean; *second*, Those which take their rise to the north of the mountain ranges, and discharge themselves into the Atlantic Ocean by the River and Gulf of St Lawrence; *third*, Those which have their sources on the east of the Alleghany Mountains, and discharge themselves into the Atlantic and the north-eastern part of the Gulf of Mexico; and, *fourthly*, The rivers comprehended under the head of the Mississippi and its tributaries, which have their rise in the great valley stretching between the Alleghany and the Rocky Mountains.

Our information respecting the rivers comprising the first of these divisions, or those which discharge themselves into the Pacific Ocean, is very limited, owing to the comparatively unexplored state of the country lying to the westward of the Rocky Mountains, through which they flow. It is certain, however, that their courses are short, as the base of the Rocky Mountains, which are said to be abrupt and lofty, extends to within a few hundred miles of the shore, which renders it not unlikely also that the declivity of their beds is considerable, and their currents in general too rapid to admit of easy navigation.

The rivers which flow into the great western lakes, and those joining the St Lawrence in its course from Lake Ontario to the sea, form the second division.

Although the St Lawrence does not assume its name until it issues from Lake Ontario, it nevertheless takes its rise to the westward of Lake Superior. Between Lakes Superior and Huron, it is called St Mary's River. From Lake Huron it flows under the name of the St Clair into the lake of that name, from whence to Lake Erie it is called the Detroit River, and between Lakes Erie and Ontario the Niagara; but still it is essentially the same stream, in the same way as the Rhone, both above and below the Lake of Geneva, is considered the same river, and, indeed, retains the same name. When viewed in this light, the St Lawrence may be said to have a course of upwards of two thousand miles, and to receive the waters of about thirty rivers of considerable size. After leaving Lake Ontario, it assumes the name of the St Lawrence, and receives, in its progress to the ocean, by the river Richlieu or Sorell, the water of Lake Champlain, and is also augmented by the streams of the Ottowa, St Francis, St Maurice, Chaudière, and Charles Rivers.

Receiving the whole surplus waters of the North American lakes, and the drainage of a great tract of country traversed by the numerous streams which join it in its course to the ocean, the St Lawrence, as regards the quantity of its discharge, presents abundant advantages for safe and easy navigation. The stream of the upper part of the river, however, is much distorted by numerous expansions and contractions of its banks, and also by declivities or falls in its bed, and clusters of small islands, which render its navigation exceedingly dangerous, and in some places wholly impractible for all sorts of vessels excepting the Canadian *batteaux*, which are strong flat-bottomed boats, built expressly for its navigation. In several parts of its course the river expands into extensive lakes; and in those places numerous shoals occur, among which the ship-channel is generally tortuous and narrow, and only navigable by daylight. In some places, again, the St Lawrence forces its way between high banks which encroach on its bed, and leave a comparatively narrow gullet for its passage, and in others it flows over a steep and rugged bottom. These sudden contractions and declivities interrupt the peaceful flow of the stream, and produce *chutes*, as they are there called, or rapids, some of which are wholly impassable for vessels of large size, and others can be navigated only in certain states of the tide. The islands, which occur chiefly in the upper part of the river between Montreal and Lake Ontario, also distort the channel, and give rise to rapids which are no less obstructive to shipping, although they impart to the river scenery a variety and beauty, and, in some places, a grandeur, which I certainly have never seen equalled.

Notwithstanding the numerous impediments to navigation, occasioned by the form of its bed, the River St Lawrence, between Montreal and Quebec, presents a scene of constant animation and bustle, until the approach of winter causes a suspension of its trade. On its stream the whole exports of Upper and Lower Canada were, when I visited the country, borne to the ocean, and by its current the valuable timber from the interior was floated from its native forests to Quebec, where it was shipped for exportation.* After passing the island of Orleans (on which the great timber ship Columbus was built), is the city of Quebec, the first place of importance that occurs in ascending the St Lawrence. The banks of the river at this place are high and precipitous. The fort of Quebec, built on Cape Diamond, is elevated 350 feet above the surface of the water, and commands a view of the river

* In how far the construction of the Grand Trunk Railway, which is intended to extend from Halifax in Nova Scotia, to Quebec and Montreal, and thence to Chicago and the Western States, and which I shall notice in the chapter on Railways, may affect the traffic on the St Lawrence, is difficult to say; the probability is, that the "lumber" or timber trade will still be conducted, as formerly, by means of rafts, as being the cheapest mode of transport for that bulky description of merchandise.

and surrounding country, which, for extent and grandeur, is perhaps unequalled in any part of the world. The River St Charles joins the St Lawrence close to the town, and the Chaudière flows into it a few miles farther up.

The first obstacle to navigation are the Richlieu Rapids, about eighty miles above Quebec, where the banks approach each other, and leave a narrow channel of only about half a mile in breadth, which contracts the vast body of water, and produces a current of such strength that vessels, unless aided by steam, have great difficulty in stemming it. The rapids extend over several miles, and sometimes, it is said, run with a velocity of six miles per hour, and, notwithstanding this, the water, owing to its great depth, presents a smooth and unbroken surface.

From the Richlieu Rapids to Montreal, the banks are low, and the country, for some distance on each side, is flat and monotonous; and were it not for many beautiful villages, with their churches and polished tin spires which meet the eye in close succession, and tend to diversify and enliven the scenery, the sail from Quebec to Montreal would not prove very inviting. About mid-way between those places the bed of the river expands, and at last attains the breadth of nine miles, forming the large sheet of water called Lake St Peter, which is twenty-one miles in length. In this lake there is very little current, and but a small depth of water, the natural consequence of so great an expansion of the river's width. A deep channel winds through the middle of the flat, affording an intricate passage for vessels, which, in their progress through it, are compelled to cast anchor after sunset. The course of this narrow channel is marked by buoys; and lights are exhibited at its two extremities, for guiding vessels out of it which happen in the course of their voyage to reach either termination immediately after night has set in, in which case they are enabled to proceed on their course without requiring to anchor all night in the lake.

The Rivers St Maurice and Richlieu or Sorrell, flow into Lake St Peter. At the mouth of the St Maurice stands the town of Trois Rivieres, which contains about 3000 inhabitants, and ranks as the third town in Lower Canada. The Richlieu enters the lake at its southern extremity, and at its mouth stands the town of William Henry or Sorell. The Richlieu, as formerly noticed, flows from Lake Champlain, from which a great deal of timber is annually floated by its current to the St Lawrence.

About a mile below Montreal, the navigation encounters a great impediment in the rapids of St Mary, caused by St Helen's Island, which lies in the middle of the river. Here the current, it is said, runs with a velocity of six miles an hour; and before the powerful and well-constructed steam vessels which now navigate the St Lawrence were built, a relay of oxen was kept at this place for assisting the steamers to ascend the rapids. It is unfortunate for Montreal, nautically or commercially speaking, that it is situate above instead of below these rapids, as it renders the port difficult of access to all classes of vessels.

Montreal, as before noticed, is 180 miles from Quebec, and 580 miles from the Gulf of St Lawrence. It is at the head of the ship navigation; and although upwards of 880 miles distant from the Atlantic Ocean, vessels of 600 tons ascend the river, and lie afloat at the quays.

The Lachine Rapids, extending over about seven miles of the river's course, lie immediately above Montreal. As the velocity with which the water runs at this place renders navigation impracticable, the Lachine Canal has been executed, at an expense of L.115,000, in order to avoid this obstruction to the navigation. This canal was completed in the year 1824, and was the first work of the kind formed in Canada. It extends from Montreal to a place called Lachine, a distance of nine miles, and measures forty-eight feet in breadth at the water line, twenty-eight feet at the bottom, and five feet in depth. The rise is forty-eight feet, which is overcome by means of six locks of eight feet lift each. The locks and other works on the line of the canal, which are subject to much tear and wear, and require more than ordinary strength and durability, are constructed of red sandstone, in a well-finished and substantial manner.

The St Lawrence is navigable from Lachine to the "Cascades," where the "Cedar Rapids" again stop its navigation for about sixteen miles. Above this the river expands, and forms the navigable lake of St Francis, which is twenty-five miles in length, and in some places attains the breadth of five and a half miles. The town of Regis stands at its northern extremity, and is inhabited by part of a large tribe of Indians, who have a settlement here on a tract of land granted to them by the British Government. Above Lake St Francis are the Longue Saut Rapids. These are nine miles in length, and flow with greater velocity than any of the others which have been mentioned. At their head stands the town of Cornwall, from which the river is navigable to Kingston, at the entrance to Lake Ontario. The towns of Ogdensburg, Prescott, and Brockville, are situate on the banks of the river, between Cornwall and Lake Ontario.

A few miles below Kingston is the celebrated "Lake of the Thousand Isles." At this part of its course, the St Lawrence assumes a great breadth, and its surface is thickly studded with small rocks and wooded islands, varying from a few square feet to several acres in extent. There are said to be upwards of 1500 of them in the lake; and, though they form an interesting and splendid object in the scenery of the river, they prove very detrimental to its navigation. A channel, having a sufficient depth of water for ships of the largest size, winds among the islands, but it is in some places so narrow, that, when the wind is high, vessels have often difficulty in passing each other.

These various obstructions in the St Lawrence, though injurious to its character as a navigable river, impart to the scenery on its course a degree of grandeur and variety which is peculiarly pleasing to the traveller. In passing over some of the rapids which have been mentioned, the water is violently agitated and tossed into the air, covering the whole surface with a sheet of white foam, and forming a fine contrast to the clear blue of the untroubled part of the river. The fearless Canadians, however, daily descend these impetuous streams with their *batteaux* and rafts of timber, without encountering the least accident or inconvenience. The batteaux are strong flat-bottomed boats, well suited to the navigation of the rapids, and are generally manned by skilful navigators. They descend from Ogdensburg to Montreal, a distance of ninety-five miles, heavily laden with the produce of the country, and generally occupy about three days in making the voyage. Steamboats ply regularly on those parts of the river which lie between the rapids; but the batteaux, as formerly observed, are the only description of vessels that can, with any degree of safety, be taken over the rapids.

The province of Upper Canada has executed a gigantic work, to supply these deficiencies in the navigation of the river, called the St Lawrence Canal. The first compartment of this work, extending from Cornwall, on the left bank of the St Lawrence, to a place called Dickinson's Landing, is twelve miles in length, and overcomes the Longue Saut Rapids. This work was in a very advanced state when I visited the country. Two additional short canals, and an alteration in the dimensions of the Lachine Canal, complete the whole line of communication between the lower part of the St Lawrence and the lakes. The St Lawrence Canal has a breadth of 100 feet throughout its whole extent, and is believed to be capable of admitting the passage of all vessels under 100 feet in length, which do not draw more than eight feet of water. The locks are built of limestone, which is obtained in fine blocks, and great abundance, in the surrounding country.

The Ottowa, after a course of about 500 miles, joins the St Lawrence immediately above the island of Montreal. It is navigable to Bytown, 120 miles from its mouth; and the Grenville Canal, the locks and works connected with which have been formed on the same scale as those of the Lachine Canal, was constructed to obviate some of the rapids which occur on the river.

The Rideau Canal, leading from Bytown on the Ottowa to Kingston on Lake Ontario, was constructed by the British Government, chiefly with the view of providing a sheltered passage, at a secure distance from the frontier, for the transport of military stores to the lakes, in the event of war with the United States; and, notwithstanding the establishment of the easy communication it affords, a great deal of trade is still carried on by the batteaux which continue to navigate the rapids of the St Lawrence.

About seventy miles of the Rideau Canal consist of what is technically called *slackwater* navigation, which is formed by damming up the waters of the Rideau River and Lake, and increasing their depth, so as to fit them for steamers of a pretty large size. The entrance of the canal at Bytown is 283 feet below Rideau Lake, which is the summit level, and 129 feet below Lake Ontario. There are several bold and arduous works on the line of this canal, the execution of which in so rough and unfavourable a country confers great credit on Colonel By, the principal, and Mr M'Taggart, the assistant, engineers, under whose directions they were conducted. The length of the canal is 135 miles; seventy miles of this, as before noticed, are slackwater navigation, and its cost is said to have been about L.600,000. The works are constructed on a scale sufficient to admit vessels of 125 tons burden.

The Lachine Canal, the Rideau Canal, and the Welland Canal, constructed by the British subjects, together with the Ohio Canal, constructed by the inhabitants of the United States, amount in all to four hundred and fifty-one miles in extent. These interesting works connect the Gulfs of St Lawrence and Mexico by a water communication, forming, with Lakes Ontario and Erie, and the rivers St Lawrence, Ohio, and Mississipi, a gigantic line of inland navigation upwards of no less than *three thousand miles in length.*

Vessels bound for Montreal were in 1837 generally towed up the river from Quebec by large and powerful steamboats, belonging to the "St Lawrence Steamboat Tow Company." The company's charge for towing a vessel of 20 feet beam and 9 feet draught of water, from Quebec to Montreal, was L.33, 6s. 8d., and for a vessel of 28 feet beam and 15 feet draught of water (the largest size that ever penetrates so high as Montreal), the charge was L.83, 4s. Vessels of intermediate sizes were charged proportionally.

The towing of vessels by steam-tugs is practised very extensively, and has been brought to great perfection on the Mississippi, as formerly noticed, and on the St Lawrence. On both of these rivers, the narrowness of the navigable channels, the currents of the streams, and the great distance at which the ports are removed from the sea, render some other means than sails, for propelling the vessels navigating them, absolutely necessary. The most powerful tow-boat on the St Lawrence when I visited the country was the "John Bull." By this vessel I passed from Quebec to Montreal, a distance of 180 miles, in forty hours, being at the rate of four and a half miles an hour, against a current averaging about three miles an hour. Upon this occasion she had no fewer than five vessels in tow; one of these drew twelve and a half, another ten and a half, two of them drew nine, and the fifth about seven, feet of water. The vessels were all towed by separate warps, and were ranged astern of each other in two lines, three of them being made fast to the larboard, and two to the starboard side of our vessel. The management of a steamer with so great a fleet of vessels in tow, in the intricate navigation and strong current of the St Lawrence, requires no small degree of caution and skill on the part of the captain, who on this occasion had his whole charge most perfectly under command: when it was necessary to stop the steamer's progress for the purpose of taking in fuel or goods, he dropped the vessels astern, and picked them up again, on resuming his course, with the greatest dexterity. Captain Vaughan, who commanded the "John Bull," informed me, that it was by no means uncommon, at certain seasons of the year, to have six vessels in tow, and from 1200 to 1500 passengers on board of his vessel at the same time. He tows every vessel by a separate line, and generally keeps them all astern, in preference to taking any of them alongside of the steamer, an arrangement which, in the St Lawrence, where the navigable channel is in many places very contracted, and often impeded by large rafts of timber on their downward voyage from the upper country, would be very apt to occasion accidents.

There is a rise of twenty feet at spring tides at the quays of Quebec; and when there is not much flood-water in the river, it is said to be affected by high tides to the distance of fifty miles above the city, or about 750 miles from the Atlantic Ocean at the entrance of the Gulf of St Lawrence. The floods or freshets which occur at the breaking up of winter, are chiefly caused by the melting snow, and occasion a periodical rise in the surface of the river, which is sometimes from this cause raised as much as ten feet above its summer water-level. When I visited the St Lawrence in May 1837, the river was under the influence of a freshet produced by the melting of the snow; and it was said to have risen to a greater height than usual, the water being at that time several feet above the level of some of the quays in Montreal. Mr M'Taggart, who had a good opportunity, during his residence in Canada, of making accurate observations, states, that the whole quantity of water annually discharged into the sea by the St Lawrence may be estimated at 4,277,880 millions of tons, and also, that the quantity of water annually discharged *into* the St Lawrence from the melting of the snow may amount to 2,112,120 millions of tons. As the whole of this great body of water is poured into the stream in a short space of time, it materially affects the level of the water, causing it to overflow the banks, and cover every low lying tract of ground in the vicinity of the river.

The severe and protracted winter of Canada, so hostile to the interests and prosperity of the country, puts a stop to the navigation and trade of the St Lawrence for at least four and a half months annually, and during great part of that period the ice at Quebec often forms a spacious and safe bridge across the river.

The navigation of the Gulf of St Lawrence, through which the river discharges itself into the Atlantic, is very hazardous. In addition to the dangers arising from the masses of ice which are constantly to be met with floating on its surface for nearly one-half of the year, it is subject to dense fogs, and its rocky shores and desolate islands afford neither comfort nor shelter to the shipwrecked mariner. One of the most desolate and dangerous of the islands in the Gulf is Anticosti, which lies exactly opposite the mouth of the St Lawrence, and is surrounded by reefs of rocks and shoal water. Two lighthouses have been erected on it, and also four houses of shelter, containing large stores of provisions for the use of those who have the misfortune to be shipwrecked on its inhospitable shores.

The lighthouses, buoys, and pilots, belonging to the St Lawrence were, when I visited the country, under the control of the Trinity House of Quebec. The lights were by no means so numerous or efficient as the dangerous and crowded navigation of the river required. There were at that time ten lighthouses between Montreal and Anticosti, a distance of 580 miles, and these were nightly illuminated while the navigation of the river is open. The number of the licensed pilots was about 250, who are compelled to serve an apprenticeship, and to make at least one trip across the Atlantic previously to obtaining a licence to act in this capacity.

The rivers belonging to the third division, which take their rise on the east of the Alleghany Mountains, and flow into the Atlantic Ocean and the north-east corner of the Gulf of Mexico, are upwards of one hundred in number. They are distributed over the whole eastern part of the country; and, notwithstanding the shortness of their courses, extending only from the sea-coast to the base of the Alleghany Mountains, they afford an aggregate amount of upwards of 3000 miles of ship and boat navigation. The following are the most important of these streams:—

The St Croix is a short river, having a course of about sixty miles, and is remarkable only as being the boundary between the United States and the British dominions in North America.

The Penobscot has a course of about 300 miles, and flows into the sea at Penobscot Bay in the State of Maine. It is navigable for vessels of large burden to the town of Bangor, which is situate fifty miles from the sea at the head of tide-water. Large quantities of valuable timber are annually exported from the towns on this river and bay.

Kennebeck River is the outlet of a small sheet of water called Moosehead Lake; it flows into the sea at Augusta in the State of Maine, after a course of about 230 miles, and is navigable for a distance of forty miles from the sea.

The Merrimac, flowing into the sea at Newburgh Port in Massachusetts, has a course of upwards of 200 miles; but, in consequence of several falls which occur in its bed, is navigable only for a distance of twenty miles from the sea. It affords very valuable water-power, and on its banks is situate the large manufacturing town of Lowell.

The Thames falls into Long Island Sound at New London, and is navigable to the town of Norwich, fifteen miles from its mouth.

The Connecticut, after a course of 450 miles through a highly cultivated and fertile country, discharges itself into Long Island Sound. It is navigable for steamers and vessels of large burden to Hartford, a distance of forty miles, and, by means of some short canals, for steamers of a small size, to Barnet in Vermont, which is upwards of 250 miles from the sea.

The Hudson rises in the neighbourhood of Lake Champlain, and pursuing an almost straight course of about 250 miles in a southerly direction, flows into the sea at the city of New York. Although that portion of the Hudson which is strictly a river, or in which the tide does not act, is by no means so remarkable for its size as many others in the United States, yet it is very interesting to the traveller, as well on account of the beauty of its scenery, as the importance and extent of its trade; and in this respect it holds a very high rank among the American rivers. It passes through a beautiful and sheltered tract of country, and the populous towns of Newburgh, Hudson, Albany, and Troy, and the military college of West Point, stand on its banks. The produce of the large State of New York and the great western lakes, as well as the imports for the supply of an extensive and populous district of the United States, are borne to and from the harbour of New York by the Hudson; and a large fleet of vessels is constantly engaged in its navigation.

This river is navigable, for ships of large burden, to the town of Hudson, about 120 miles from New York, and for vessels of smaller draught of water to Troy, about forty-four miles farther. By means of the Erie, Oswego, and Champlain canals, it is connected with Lakes Erie, Ontario, and Champlain. A large part of the trade of the River Hudson is carried on by sailing vessels of about 150 tons burden, having a great breadth of beam, and carrying masts of from 90 to 100 feet in height. These vessels, being dependent on the state of the winds, make tedious and uncertain voyages; but many of them, notwithstanding the introduction of steam-navigation, still enliven the river scenery with their white sails. The transport of goods, however, at the time of my visit, was more generally carried on in large barges, towed by steamers which are exclusively devoted to this trade, as passengers go only by the larger and swifter boats built expressly for the purpose. The current of the Hudson is said to average about two and a half miles an hour, and the influence of the tide extends as far as Albany, 150 miles above New York. The only obstacle to navigation occurs a little below Albany, where there is a considerable shoal, called the Overslaugh, caused by several small islands lying in the fairway of the river. It is, however, at present passable for vessels drawing five or six feet of water, and is still capable of being much improved.

The Delaware has a course of about 310 miles, and falls into Delaware Bay near Newcastle; it is navigable, for vessels of the largest class, for forty miles, to Philadephia. From Philadelphia it is navigated by sloops, for a distance of thirty-five miles, to Trenton, which is at the head of tide-water, and above this it is navigable for boats of nine tons, which ascend the river about one hundred miles farther into the interior.

The Susquehanna flows into Chesapeake Bay. It is the largest river in the productive State of Pennsylvania, but is more celebrated for the beauties of its scenery than the facilities it affords for communication. Excepting for about five miles from its mouth, the navigation is completely stopped by the rugged and shelving formation of the rocky bed in which it flows. The course of this river is about 460 miles, and works were in progress, at the time of my visit, for the improvement of its navigation, by the formation of short canals, and the construction of dams, so as to form an extensive line of slack-water navigation.

The Patapsco discharges itself into Chesapeake Bay, and is navigable, for vessels drawing eighteen feet of water, to Baltimore, which is at the head of tide-water, and is about fourteen miles from Chesapeake Bay. The whole course of the Patapsco is only about one hundred miles.

The Patuxent rises to the west of Baltimore, and flows into Chesapeake Bay. It has a course of about one hundred miles in length, and is navigable to the distance of sixty miles from its mouth.

The Potomac has its source in the Alleghany Mountains, and is 335 miles in length. It is seven and a half miles in breadth at its entrance into Chesapeake Bay, and is navigated, by vessels of the largest class, as far as Washington, the seat of government of the United States, which is situate about 103 miles from its mouth. The tide flows three miles above Washington, but beyond this point the river is obstructed by shoals, and several short canals have been constructed for the improvement of its navigation.

The Rappahannock has a course of 176 miles, and is navigable to the town of Fredericksburg, about 110 miles from its junction with Chesapeake Bay.

York River also flows into Chesapeake Bay, and has a course of one hundred miles, thirty miles of which are navigable for large vessels.

The James River has a course of upwards of 400 miles, and discharges itself into the Atlantic, at the southern extremity of Chesapeake Bay. It is navigable, for vessels of 125 tons burden, to the town of Richmond, situate 122 miles from its mouth, where the navigation is obstructed by falls in the river. By means of a canal which has been formed to overcome this obstacle, batteaux are now enabled to ascend the river to a distance of 352 miles from the sea.

The Roanoke flows into Albemarle Sound in North Carolina, after a course of 370 miles. It is navigable, for vessels of forty-five tons, to Halifax, seventy miles. Batteaux ascend the river to the distance of 300 miles from its mouth.

The Pamlico falls into Pamlico Sound. It has a course of 200 miles, and is navigable for forty miles.

The River Neuse has a course of 271 miles; Cape Fear, 288; Pee Dee, 415; Santee, 370; and Edisto, 161 miles. These rivers are in North and South Carolina, and are said to be capable of affording, by means of some small improvements, about 630 miles of boat-navigation.

The Rivers Ashley and Cooper, in South Carolina, have courses of forty-three and forty-four miles, and, at their junction, form the harbour of Charleston.

The Savannah River flows between the States of South Carolina and Georgia. It has a course of 340 miles, and is navigable, for vessels of the largest size, to the town of Savannah, situate eighteen miles from the sea. Above this, steam-navigation extends as far as Augusta, 140 miles.

The great Ogeetchee is navigated by small vessels for 300 miles, the Alatamaha for 220, the Santilla for 180, and the St Mary for 150 miles from the sea. The Rivers St John and Suwanee, in Florida, are said to have courses of about 250 miles. Many of the streams in the southern part of the United States, however, and more particularly in Florida, have never been fully explored.

The Appalachicola has a course of 425 miles. It is formed by the junction of the Chattahoochee and Flint Rivers, and discharges its waters into the Gulf of Mexico. It is navigated by steamers to the town of Columbus, 160 miles from its mouth.

The Mobile River is formed by the junction of the Alabama and Tombeckbee. The Alabama has a course of 500, and the Tombeckbee of 350 miles. The Alabama affords ship-navigation to Clairbone, 100 miles, and batteaux-navigation to Fort-Jackson, 200 miles. The Tombeckbee is navigated by ships as far as St Stephens, 100 miles, and by boats to the falls of the Black Warrior, 250 miles from the Gulf of Mexico.

The part of North America which extends from north to south between the great northern Lakes and the Gulf of Mexico, and from east to west between the ranges of Alleghany and Rocky Mountains, includes within its limits the valleys of the Mississippi, Missouri, and Ohio, and is remarkable for the extreme richness and fertility of its soil, which, after being brought into cultivation, yields, with little labour, a very abundant harvest. These fertile valleys include nine of the United States of America, and a great part of them is now in a high state of cultivation, and thickly peopled. In the state of Louisiana, the crops grown are sugar, cotton and tobacco; and in Mississippi and Arkansas cotton is produced in great abundance, and of fine quality. Tennessee affords cotton and tobacco, and Kentucky produces hemp, tobacco, wheat, and Indian corn. The states of Ohio, Indiana, Illinois, and Missouri, are too far removed from the equator for the growth of cotton, sugar, or tobacco, and their inhabitants confine all their attention to raising grain. The geographical structure of North America shuts up this immense tract of land from any direct communication with the seas which wash its eastern and western coasts; for if we trace upwards, in their course of many hundred miles through the eastern states, those numerous large navigable rivers which discharge themselves into the Atlantic, we find them holding the character of rivulets long before we penetrate even to the verge of these fertile valleys; and on the western coast of the country, the range of the Rocky Mountains extending along the shores of the Pacific, presents an insurmountable barrier to any direct water communication with that ocean.

The Mississippi, however, and its numerous navigable tributaries, afford a perfect and easy access to the remotest corners of these states. The produce which annually descends the river was, in 1837, valued at the enormous sum of fourteen millions of pounds sterling, and its four mouths pour into the Gulf of Mexico the drainage-water of a district of country which has been estimated at no less than 1,226,600 square miles in extent. The source of the Mississippi is said to have been discovered in the year 1832. It is situate to the westward of the great lakes, at a distance of upwards of 3000 miles from the Gulf of Mexico, and at an elevation of 1500 feet above its surface. The river flows from its source as a small stream, and, gradually gathering strength, precipitates itself over the Falls of St Anthony, after which it swells in importance at every step of its course, gaining accessions of strength from the numerous small rivers which pour in their tributary streams from all directions, until it is at length joined by the great Missouri. The character of its waters, formerly clear and tranquil, is here completely changed, and the combined streams of the two rivers flow on in a deep and muddy current. The Ohio, the Arkansas, the Red River, and many other large streams, fall into this giant of rivers, which, swelled by the waters of its various tributaries, whose aggregate length is upwards of 44,000 miles, at last pours itself into the Gulf of Mexico.

New Orleans, the most important town on the river, has already been noticed. The town of Natchez, which is about 380 miles from its mouth, stands on the left bank; it is a place of considerable importance, and is the highest point visited by sailing vessels; above this, the Mississippi is navigated only by steamboats. St Louis, on the right bank of the river, about eighteen miles below its junction with the Missouri, is also a place of great trade.

The Mississippi forms a striking contrast to the St Lawrence, which, as has been already observed, flows in a rocky bed, occasionally expanding into extensive flats, or contracting its limits, and thus presenting great impediments to navigation. The bed in which the Mississippi flows is of a soft alluvial formation, maintaining a nearly uniform breadth throughout its whole course, and affording, at every point below the Falls of St Anthony, a sufficient depth of water for vessels of large size. The principal mouth of the Mississippi has a bar, on which the depth of water in 1722, according to Malte Brun, was twenty-five, in 1767 twenty, and in 1826 sixteen, feet. Captain Hall mentions that in 1828 it was only fifteen feet. The vast tract of Delta land at the mouth of this river, estimated at 40,000 square miles, caused by the deposition of the earthy matter carried down by its current, is gradually extending its limits, and stretching into the Gulf of Mexico, a circumstance which has led some to remark that, in the course of time, the whole Gulf of Mexico, at present occupied by the sea, may be filled up by these alluvial deposits, and become a flat plain watered by an extension of the Mississippi.

In enumerating the tributaries of the Mississippi, I shall first notice those flowing into it from the east, and afterwards those which have their rise in the western country, in the order in which they occur in ascending the river.

The Yazoo, flowing through the state of Mississippi, joins the river about 450 miles from the sea, and is navigable for 150 miles.

The Ohio, the largest of its eastern tributaries, is, excepting at one or two parts of its course, a smooth running stream. It is formed by the junction of the Monongahela and Alleghany Rivers. The Monongahela is navigable, for small boats, for 200 miles, and the Alleghany is navigable, for boats of ten tons, for 260 miles. The Ohio flows over a course of 945 miles, and discharges itself into the Mississippi about 1000 miles above New Orleans. Its banks, which rise rather precipitously, are thickly covered with fine timber, and the country through which it passes is highly cultivated, and very productive. The navigation of the river is stopped for about four months every year by ice. The principal towns on the Ohio are Louisville, Cincinnati, Wheeling, and the manufacturing town of Pittsburg, which stands at the head of the navigation, on a point of land formed by the junction of the Rivers Monongahela and Alleghany.

During the spring months, when the Ohio is swollen, steamboats of large class, drawing from eight to ten feet of water, ascend from the Gulf of Mexico to Pittsburgh, a distance of nearly 2000 miles. But when the water is low, steamers cannot ascend higher than Louisville, in Kentucky, which is situate on the left bank of the river, 560 miles below Pittsburgh. Here the river has a fall, occasioned by an irregular ledge of limestone rock, of twenty-two feet six inches in two miles, which produces rapids that can only be passed when the river is high. The Louisville and Portland Canal, constructed with a view to remove the obstruction to navigation occasioned by this fall, is rather more than two miles in length, and is excavated in rock nearly throughout its whole extent. It is sixty-eight feet in breadth, and sixteen feet in depth, affords a passage for all steamboats under 180 feet in length, and is used by them when the low state of the water in the river renders the rapids impassable.

The canal has three lift-locks, measuring 183 feet in length, and fifty feet in breadth, and one guard-lock, measuring 190 feet in length, and fifty feet in breadth, all of which are built of stone.

Several shoals occur in the upper part of the river, which are also very inconvenient, as the current on many of them runs with considerable velocity. In ascending the Ohio, the steamer by which I travelled was very deeply loaded, and we were detained several hours in attempting to pass one of these shoals called the "White Ripple." Many unsuccessful efforts were made, but the power of the engines could not surmount the obstacle, until some of the crew ascended the stream in a boat, and dropped an anchor with a strong cable attached to it, in the middle of the channel; the other end of the cable was made fast to the capstan of the steamboat, and the vessel was at length, after much labour and detention, warped through the rapid.

The principal tributaries flowing into the Ohio from the north, are the Muskingum, which is navigable for 120 miles, the Miami, navigable for seventy-five miles, the Scioto, which is navigable for 120 miles, and the Wabash. The Tennessee River flows into the Ohio from the south. It is 850 miles in length, and is navigable to Florence, a distance of 250 miles.

At this place there is an expansion in the bed of the river; and a collection of stones, called "the Mussel Shoal," terminates the navigation. The other tributaries flowing into the Ohio from the south, are, the Cumberland River, navigable for 440 miles, Green River, for 150 miles, Kentucky River, for 130 miles, and Licking River, for seventy miles. The aggregate length of the Ohio and its tributaries is about 7300 miles.

The Illinois enters the Mississippi about 160 miles above the Ohio, and is navigable for steamboats for about 200 miles.

Wisconsin and Chippewa Rivers take their rise in the neighbourhood of the lakes, and are both navigable for some distance.

The most southern tributary of any importance which flows into the Mississippi from the west is the Red River. This river takes its rise at the base of the Rocky Mountains, and is 1500 miles in length; but its navigation is obstructed by a huge pile of wood, composed of large trees, which having been from time to time swept away in floods, and floated down the stream, have finally found a resting-place in the bed of the river, among their former neighbours of the forest. This obstruction, which is called the "Red River Raft," has been accumulating for ages. It commences about 500 miles above its mouth, and is said to extend about seventy miles. Measures have been adopted for effecting its removal, and should this arduous undertaking, which is at present in progress of execution, be successful, the navigation of the river will be extended 500 miles farther into the interior of the country. The Washita, one of the tributaries of the Red River, has a course of 450 miles.

The Arkansas has its source in the Rocky Mountains, and is said to be upwards of 2500 miles in length, and with its tributaries 4500 miles. Steamers can ascend this river for 640 miles from the Mississippi.

The White River, after a course of upwards of 1200 miles, including its tributaries, flows into the Mississippi, twenty miles above the Arkansas, and is navigable for 400 miles.

The St Francis has a course of 450 miles, but its entrance is choked by a large stationary raft of drift timber, which puts an effectual stop to the navigation of the river.

The Merrimeg is navigable for 200 miles.

The Missouri joins the Mississippi eighteen miles above the town of St Louis, and about 1200 miles from the Gulf of Mexico. It is, in every respect, the greater of the two rivers, but the Mississippi having been first discovered, the original name has been retained. The sources of the Missouri are in the Rocky Mountains, its whole course is 3217, and in connection with all its tributaries upwards of 10,000 miles. Its navigation is uninterrupted for 2532 miles from its mouth, and is there broken by the falls of the Missouri, which are said to vie in grandeur with those of Niagara; but the river is navigable above the falls for 500 miles.

The lead mines on the River Missouri are of very great value. The district in which the lead occurs is about seventy miles in length, and forty-five miles in breadth. The government of the United States have reserved 150,000 acres of land in the state of Missouri as government property. This is let in small lots to persons who undertake to open the mines; they are now very extensively worked, and a large quantity of lead is prepared on the spot, and brought down the Missouri for the market.

The tributaries of the Missouri are the Gasconade, navigable for 150 miles; the Osage, said to be navigable for 500 miles: the Chariton for 300 miles; the Tauzas for 200; and the Yellowstone for 800 miles.

The Moine flows into the Mississippi, 130 miles above the Missouri, and is supposed, with its tributaries, to be navigable for a distance of 1500 miles.

The St Peter's, which is the most northern of the tributaries, has a course of 500 miles, and is navigable only for boats.

With the exception of the falls at Louisville, and the White Ripple on the upper part of the Ohio River, the Mississippi, and the navigable tributaries which have been enumerated, are perfectly free from all obstructions caused by irregularities in the beds or banks of the stream. In some places, as has been already noticed, shoals or rapids occur, but these do not affect the passage of steamers to a greater extent than by retarding their progress a little in ascending the river. Some dangers, however, exist, which are peculiar to the navigation of the western waters of America, and are even more to be dreaded than currents and rapids produced by permanent obstructions in the bed of the stream, as they are constantly changing their positions, and springing up afresh every day, so that they cannot be guarded against by any previous knowledge of the navigation of the river. These dangers are caused by large trees, which, being precipitated into the water, by the river undermining its banks, are borne away on the current, and occasionally get entangled, and even become firmly fixed, in the bed of the stream. Sometimes a branch of the tree is seen projecting from the water, but often no part of it is visible, the only indication of its existence being a slight ripple on the surface of the water. They have received from the boatmen of the Mississippi the names of "Snags," "Planters," and "Sawyers"—bearing one or other of these designations, according to their positions and the manner in which they are fixed in the river. The term "snag" is applied to a tree firmly imbedded in the bottom, and lying at a considerable angle, with its top inclined down the stream. A "planter" is a tree firmly fixed in a nearly perpendicular position; and a "sawyer" is the name applied to a tree whose roots or branches have become entangled in the bed of the river, and, whose trunk being loose, is kept constantly swinging up and down by the current, alternately showing its head, and plunging it under the surface. Sometimes several of these trees collect together in the same place, and form a small islet, which, after maintaining its position for some time, and gradually increasing its dimensions, at length attains an enormous magnitude, and often becomes an impassable barrier, extending along the river's course for many miles. This is what the boatmen call a "raft." It generally occurs in the tributaries of the Mississippi, and not in the river itself. One instance of this is afforded by the Red River, already mentioned, and another by the Atchafalaya, a river flowing *out* of the Mississippi, at a point about 250 miles from the sea. The Atchafalaya raft, which is particularly noticed in Captain Hall's work on North America, extends over a space of twenty miles; but the river's bed, for the whole of this distance, is not filled up with drift timber; the actual length of the raft itself being only about ten miles. The Atchafalaya is 220 yards in width, and the raft extends from bank to bank, and is supposed to be about eight feet in thickness.

All these obstructions are most injurious to the navigation of the Mississippi and its tributaries, and have, on many occasions, caused great loss, both of lives and property, by sinking steamers. The "snags" are more dangerous than any of the other obstructions. They are generally encountered by vessels on their upward passage. Vessels descending the river keep in the middle of the stream, where the water is deep and the current is strongest, while those ascending the river keep as close to the shore as possible, where they have a more gentle current and shoaler water, and of course are more apt to be injured by impediments in the bottom. Besides, as the "snags" are always inclined down the stream, vessels, going in the direction of the current, slide easily over them, if they happen to come in contact with them; but their inclined position renders them exceedingly dangerous for vessels ascending the river, which obviously encounter them in their most destructive position. The strongest vessels in the western waters are unable to withstand the shock occasioned by running against a "snag." It almost invariably pierces their bows, when they generally fill with water and go down. Several steamers are built with false bows, called "snag-chambers," as a palliative of the danger arising from accidents of this kind. In the event of the bow being stove in, the small compartment called the "snag-chamber," in the fore part of the vessel, is all that is filled with water, and her buoyancy is thus very little affected—a contrivance which has more recently been carried out on a larger scale, in the water-tight compartments into which our iron steamers are now divided.

Some grants of money have been voted by the Government of the United States for the improvement of the western water navigation. The money has been expended in removing, from different parts of the Mississippi and its tributaries, the stationary rafts of timber and snags by which their streams are obstructed. For this purpose, an apparatus called a "snag-boat," has been used with much success. The machine consists of two hulls, firmly secured to each other, at a distance of a few feet apart; and over the intervening space a deck is thrown, having an aperture left in the centre. A powerful crab is placed over this aperture, from which strong chains and grapplings are suspended in the space between the two vessels. The "snag-boat" is propelled by paddle-wheels, which, with the gearing for raising the snags, are worked by a steam-engine placed on its deck. In using the apparatus, the vessel is brought to an anchor over the snag or obstacle to be removed, and the grapplings are made fast to the pieces which are to be raised. The paddle-wheels being thrown out of gear, the engine is applied to work the crab, by which the snag is torn from its hold in the bottom of the river, and, after being cut in short pieces, is allowed to float down the stream. This "snag-boat" has been extensively used on the Red River, in the partial removal of the large stationary "raft" formerly noticed, which at present obstructs the navigation of the stream.

The Mississippi and Ohio Rivers are perfectly pure and limpid; but after being mingled with the water of the Missouri, which holds a large quantity of alluvial matter in suspension, they assume a red and muddy appearance. A quantity of water, taken from the lower part of the Mississippi, and allowed to settle for fifteen or twenty minutes, deposits a thick cake of mud on the bottom of the vessel containing it; but, notwithstanding this, the water is supposed by many persons to be healthful, and, after undergoing the process of filtration, is very generally used for domestic purposes by the inhabitants of all the towns on its banks.*

* Mr Ellet estimates the sedimentary matter transported by the Mississippi at $\frac{1}{3000}$ part of the volume discharged by the river.

The average height of the annual rise in the waters of the Ohio is fifty feet, the lowest state of the river occurring in September, and the highest in March; but I was informed that the waters of the Mississippi and Missouri are not subject to so remarkable a change of level.

The level of the land on the banks of the Mississipi, for some distance before it discharges itself into the sea, is considerably below that of the surface of the river. Extensive embankments, similar to those of Holland and Belgium, have been erected for its protection, and form a continuous line on both sides of the river from New Orleans to St Francisville. Above this, and all the way to Natchez, which is about 380 miles from the sea, they occur only at intervals, where the flatness of the land has rendered their erection necessary. Captain Hall, in his work on North America, says,—"The swollen river looked so like a bowl filled up to the brim, that it seemed as if the smallest shake, or the least addition, would send it over the edge, and thus submerge the city. The footpath on the top of the levee or embankment was just nine inches above the level of the stream. The colour of the water was a dirty, muddy, reddish sort of white, and the surface everywhere strongly marked with a series of curling eddies or swirls, indicative, I believe, of great depth."

These embankments, or *levees*, as they are termed, are composed entirely of earth. They are from five to fifteen feet in height, and are made of sufficient breadth at the top to allow of a footpath being formed on them. They occasionally yield to the pressure of the river when in a flooded state, and give vent to its water, which on such occasions never fails to overflow and lay waste a large portion of the adjacent country.

The most recent information which we possess regarding the Mississippi is contained in an elaborate work by Mr Charles Ellet on the Mississippi and Ohio Rivers, of which we give the following digest taken from the article "Inland Navigation" in the eighth edition of the "Edinburgh Encyclopædia:"*—

* The Mississippi and Ohio Rivers, by Charles Ellet, New York. Canal

"It appears, from the information given in Mr Ellet's work, that the Mississippi varies from 2200 to 5000 feet in width, the average width being assumed as 3300 feet. It is from 70 to 180 feet in depth, the average being 115 feet. The area of the cross section varies from 105,544 square feet to 268,646 square feet, the average being 200,000 square feet. The length, from its junction with the Ohio to the Gulf of Mexico, is 1178 miles, and its average descent at full water is $3\frac{1}{4}$ inches per mile, and in absence of floods (or during summer and autumn) $2\frac{8}{10}$ inches per mile. The length of the Ohio, from its junction with the Mississippi to Pittsburgh (the head of the navigation for large vessels), is 975 miles, and the average inclination is about $5\frac{1}{5}$ inches per mile. From Pittsburgh to Olean Point the distance is 250 miles, and the inclination 2 feet 10 inches per mile. When the water is high steamboats have ascended to Olean Point, which is 2400 miles from the Gulf of Mexico; and in doing so, have had to overcome a current which at some places runs with a velocity of five miles per hour. The discharge of the Mississippi is computed by Mr Ellet, at high water, at 1,280,000 cubic feet per second; and its drainage he estimates at 1,226,600 square miles. When the autumnal rains set in, the river rises above its summer level to the enormous extent of about 40 feet at the mouth of the Ohio, and 20 feet at New Orleans. In investigating the physical characteristics of this mighty stream, Mr Ellet found—1*st*, That the average surface velocity in the centre of the river was five miles per hour, and occasionally the speed reached seven miles per hour; 2*d*, By using under-current floats, he found that the speed of a float, supporting a line of fifty feet long, was always greater than that of the surface float—the average increase of velocity being 2 per cent.; 3*d*, The results of the experiments made, lead him to conclude that the mean velocity of the Mississippi is about 2 per cent. greater than the mean surface velocity; 4*th*, In coming to this conclusion, no ac-

and River Engineering: being the article "Inland Navigation," from the eighth edition of the "Encyclopædia Britannica," by David Stevenson, Civil Engineer. A. & C. Black. Edinburgh, 1858.

count is taken of such observations as show remarkable undercurrents, the velocity of which were in some places found to be 17 per cent., and 20⅓ per cent. greater than the surface velocities; *5th*, While the mass of water which the channel of the Mississippi bears is running downwards with a central velocity, the current next the shore is sometimes found to be running upwards, or in the opposite direction, at the rate of one to two miles per hour; *6th*, While the water is running downwards in the one side of the river, it is often found with an appreciable slope, and visible current running upwards on the other side of the river; *7th*, The surface of the river is therefore not a plane, but a peculiarly complicated warped surface, varying from point to point, and inclining alternately from side to side.

"The chief object of the investigations made by Mr Ellet was the prevention of floods, which have recently increased both in number and extent. This he attributes—

"*First*, To extended cultivation, by which evaporation is supposed to be diminished, the drainage increased, and the floods hurried forward more rapidly into the country below.

"*Secondly*, To the extension of the embankments along the banks of the Mississippi and its tributaries, by which water that was formerly allowed to spread is now confined to the channel of the river.

"*Thirdly*, To what are termed cut-offs, or straight cuts, by which the distance is shortened, and the slope and velocity increased, so that the water is brought down more rapidly from the country above.

"*Fourthly*, To the gradual extension of the delta into the sea, so as to lengthen the lower course of the river, to diminish the slope and velocity, and thus to throw back the water on the land above.

"The works suggested for protecting the country against floods are—

"*First*, More sufficient embankments.

"*Second*, The prevention of further cut-offs, or works for straightening the upper parts of the tributaries of the river.

"*Third*, The enlargement of the seaward channels or out-lets; and,

"*Fourth*, The creation of large artificial reservoirs, by placing dams across the out-lets of the lakes or distant tributaries, so as to compensate for the loss of the natural overflow of the water, which is checked by the embankments for protecting the country in the lower part of the river."

CHAPTER IV.

STEAM NAVIGATION.

Introduction of Steam Navigation into the United States—Difference between the Steam Navigation of America and that of Europe—Three classes of Steamers employed in America—Eastern Water, Western Water, and Lake Steamers—Characteristics of these different classes—Steamers on the Hudson—Dimensions of the "Rochester"—Construction of the Hulls of the American Vessels—Arrangement of the Cabins—Engine Framing—Engines—Beams—Mode of Steering—Rudder—Sea-Boats—Dimensions of the "Naragansett"—Cabins—Engines—Paddle-Wheels—Boilers—Maximum speed of the "Rochester"—Power of the Engines—Mississippi Steamers—Their arrangement—Engines—Boilers—Lake Steamers—St Lawrence Steamers—Explosions of Steam-Boilers—Table of the Dimensions of several American Steamers.

Since the following chapter was written, a vast revolution has taken place in the art of steam navigation. The practicability of performing long ocean voyages in steamers is now no longer a problem to be solved, while the invention of screw propulsion has rendered steam-power applicable, and even advantageous, for our colliers and other vessels used for carrying heavy goods. No doubt the same revolution has, to a greater or less degree, affected steam navigation in America, in so far as its extension to sea-going vessels is concerned; but the remarks contained in the following pages refer entirely to the river and lake navigation. and seem to me to possess an interest from the fact, that since the date at which they were written, we have in this country introduced fast-sailing river steamers, in which the high speed is attained by means of the same arrangements which were originally introduced in the United States, viz.,—a light build of hull, fine lines, a long stroke, large paddle-wheels, and powerful engines. I think it best, therefore, to give this chapter as it was originally written, reminding the reader that it does not embrace the subject of American ocean steamers, and that it refers to the river steam navigation of 1837, the general management and arrangement of which, I have no doubt, is pretty much the same at the present time.

Whatever differences of opinion may exist as to the actual invention of the steamboat, there is no doubt that steam navigation was first fully and successfully introduced into real use in the United States of America, and that Fulton, a native of North America, launched a steam-vessel at New York in the year 1807; while the first successful experiment in Europe was made on the Clyde in the year 1812, before which period steam had been, during four years, generally used as a propelling power in the vessels navigating the Hudson.

The steam navigation of the United States is one of the most interesting subjects connected with the history of North America, and it is strange that hitherto we should have received so little information regarding it, especially as there is no class of works, in that comparatively new and still rising country, which bear stronger marks of long-continued exertion, successfully directed to the perfection of its object, than are presented by many of the steamboats which now navigate its rivers, bays, and lakes.

It would be improper to compare the present state of steam navigation in America with that of this country, for the nature of things has established a very important distinction between them. By far the greater number of the American steamboats ply on the smooth surfaces of rivers, sheltered bays, or arms of the sea, exposed neither to waves nor to wind; whereas most of the steamboats in this country go out to sea, where they encounter as bad weather and as heavy waves as ordinary sailing vessels. The consequence is, that in America a much more slender *built*, and a more delicate mould, give the requisite strength to their vessels, and thus a much greater speed, which essentially depends upon these two qualities, is generally obtained. In America, the position of the machinery and of the cabins, which are raised above the deck of the vessels, admits of powerful engines, with an enormous length of stroke being employed to propel them; but this arrangement would be wholly inapplicable to the vessels on our sea-coasts, at least to the extent to which it has been carried in America.

But perhaps the strongest proof that the American vessels are very differently circumstanced from those of Europe, and therefore admit of a construction more favourable for the attainment of great speed, is the fact that they are not generally, as in Europe, commanded by persons possessed of a knowledge of seamanship. In this country steam navigation produces hardy seamen; and British steamers, being exposed to the open sea in all weathers, are furnished with masts and sails, and must be worked by persons who, in the event of any accident happening to the machinery, are capable of sailing the vessel, and who must therefore be experienced seamen. The case is very different in America, where, with the exception of the vessels navigating the Lakes, and one or two of those which ply on the eastern coast, there is not a steamer in the country which has either masts or sails, or is commanded by a professional seaman. These facts forcibly show the different state of steam navigation in America, a state very favourable for the attainment of great speed, and a high degree of perfection in the locomotive art.

The early introduction of steam navigation into the country, and the rapid increase which has since taken place in the number of steamboats, have afforded an extensive field for the prosecution of valuable inquiries on this interesting subject; and the builders of steamboats, by availing themselves of the opportunities held out to them, have been enabled to make constant accessions to their practical knowledge, which have gradually produced important improvements in the construction and action of their vessels. But on minutely examining the most approved American steamers, I found it impossible to trace any *general* principles which seem to have served as guides for their construction. Every American steamboat-builder holds opinions of his own, which are generally founded, not on theoretical principles, but on deductions drawn from a close examination of the practical effects of the different arrangements and proportions adopted in the construction of different steamboats, and these opinions never fail to influence, in a greater or less degree, the built of his vessel, and the proportions which her several parts are made to bear to each other.

In 1825, about thirty hours were occupied by the steamboats on the Hudson in making their passages from New York to Albany, a distance of about one hundred and fifty miles, which is at the rate of only five miles per hour. Passengers were then conveyed in barges, towed by steamboats, to avoid the danger which, according to the following extract from an advertisement of the sailing of the vessels, seems at that time to have attended the steam navigation of the country :—" Passengers on board the safety barges will not be in the least exposed to any accident which may happen by reason of the fire or steam on board of the steamboats. The noise of the machinery, the trembling of the boat, the heat from the furnace, boilers, and kitchen, and everything which may be considered as unpleasant or dangerous on board of a steamboat, are entirely avoided." These "safety barges," however, have been entirely laid aside, and the voyage between Albany and New York was, in 1837, when I visited the country, generally performed in ten hours, exclusive of the time lost in making stoppages, being at the rate of fifteen miles per hour. They have effected this great increase of speed by constantly making experiments on the form and proportions of their engines and vessels—in short, by a persevering system of *trial and error*, which is still going forward; and the natural consequence is, that, no two steamboats are alike, and few of them have attained the age of six months without undergoing some material alterations.

These observations apply more particularly to the steamers navigating the Eastern waters of the United States, where the great number of steamboat-builders, and the rapid increase of trade, have produced a competition which has led to the construction of a class of vessels unequalled in point

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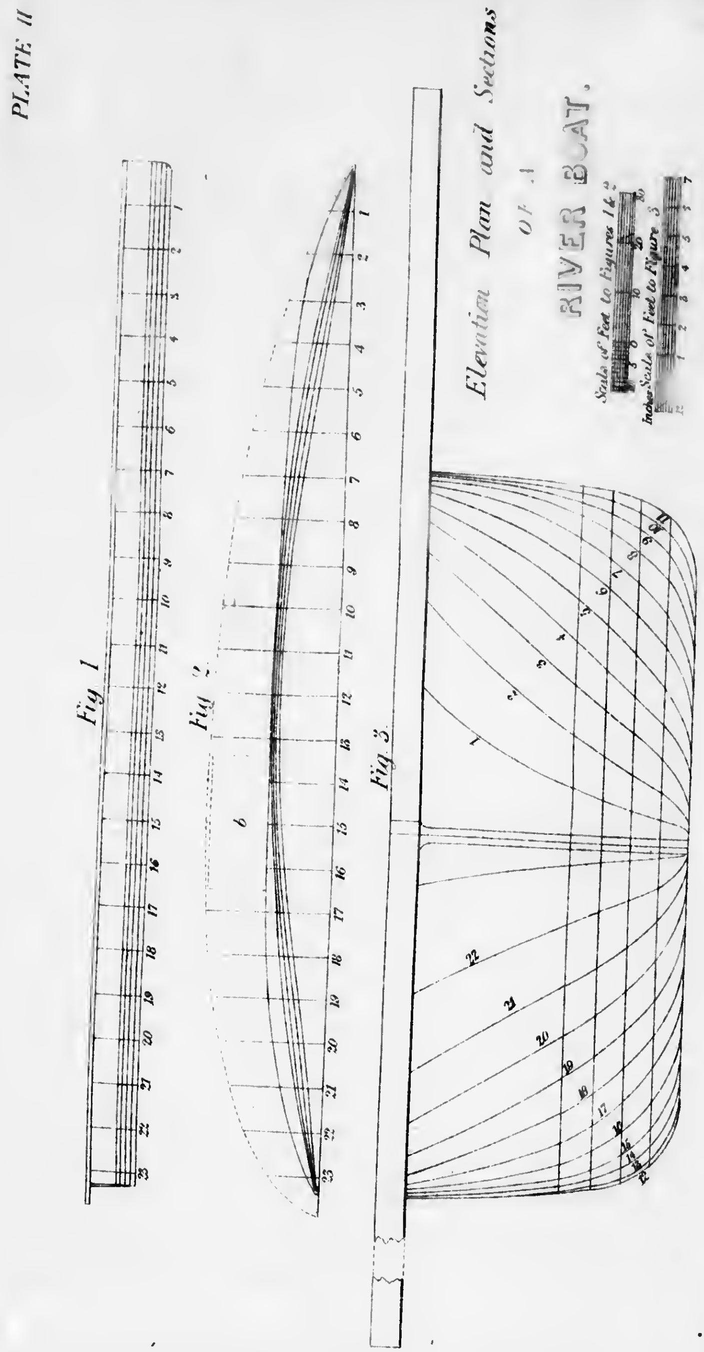

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of speed by those of any other quarter of the globe. The original construction of most of these vessels has, as already stated, been materially changed. The breadth of beam and the length of keel have in some vessels been increased, and in others they have been diminished. This mode of procedure may seem rather paradoxical; but in America it is no uncommon thing to alter steamboats by cutting them through the middle, and either increasing or diminishing their dimensions as the occasion may require. It is only a short time since many of the steamboats were furnished with false bows, by which the length of the deck and the rake of the cutwaters were greatly increased. On some vessels these bows still remain; from others they have been removed, subsequent experiments having led to the conclusion, that a perpendicular bow without any rake, as shown in Plate II., fig. 1, is best adapted for a fast sailing boat. When I visited the United States in 1837, the "Swallow" held the reputation of being one of the two swiftest steamers which had ever navigated the American waters, and this vessel had received an addition of twenty-four feet to her original length, besides having been otherwise considerably changed. Before these alterations were made on her, she was considered, as regards speed, to be an inferior vessel.

The inferences which I was led to draw from these facts are, that the great experiment for the improvement of steam navigation, in which the Americans had been engaged for thirty years, was not completed, and the speed at which they had succeeded in propelling their steam-vessels was likely to be still further increased; and also that, in the construction of their vessels, they had been governed by experience and practice alone, without attempting to introduce theoretical principles, in the application of which, to the practice of propelling vessels, by the action of paddle-wheels on the water, numerous difficulties have hitherto been experienced.

There are local circumstances connected with the nature of the trade in which the steamboats are engaged, and the waters which they are intended to navigate, that have given rise to the employment of three distinct classes of vessels in


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American steam navigation, all of which I had an opportunity of sailing in and particularly examining.

These steamboats may be ranged under the following classification :—*First*, Those navigating the Eastern waters. This class includes all the vessels plying on the River Hudson, Long Island Sound, Chesapeake and Delaware Bays, and all those which run to and from Boston, New York, Philadelphia, Baltimore, Charleston, Norfolk, and the other ports on the eastern coast of the country, or what the Americans call the Sea-board. *Second*, Those navigating on the Western waters, including all the steamers employed on the River Mississippi and its numerous tributaries, including the Missouri and Ohio. *Third*, The steamers engaged in the Lake navigation. These classes of vessels vary very much in their construction, which has been modified to suit the respective services for which they are intended.

The general characteristics by which the Eastern water boats are distinguished, are, a small draught of water, great speed, and the use of condensing engines of large dimensions, having a great length of stroke. On the Western waters, on the other hand, the vessels have a greater draught of water and less speed, and are propelled by high-pressure engines of small size, worked by steam of great elasticity. The steamers on the Lakes, again, have a very strong built and a large draught of water, possessing in a greater degree the character of *sea*-boats than any of those belonging to the other two classes. They also differ in having masts and sails, with which the others are not provided.

The steamboats employed on the Hudson River are the first belonging to the class of vessels navigating the Eastern waters of which I shall make particular mention.

The shoals in the upper part of the river, produced by the Overslaugh which I formerly mentioned, have rendered it necessary that the steamboats employed on it should have a small draught of water. The great trade of the river, and the numerous passengers who are constantly travelling between New York and Albany and the intermediate towns, have also led to the adoption of separate lines of boats, one for towing barges loaded with goods, and another devoted exclusively to the conveyance of passengers. The attainment of great speed naturally became an important desideratum in the construction of the vessels employed in carrying passengers; and the success which has attended the efforts of the steamboat-builders to produce vessels, combining swiftness with efficiency and perfection of workmanship, is truly wonderful, and in the highest degree creditable.

A table will be found at the end of this chapter, containing the dimensions of several of the steamboats running in America, which I had an opportunity of examining when I visited the country in 1837. Among these the dimensions of several of the Hudson boats are given; but in order to explain more clearly the general arrangement of their parts and mode of operation, I shall give in detail the dimensions of the steamboat "Rochester," plying between New York and Albany. The elevation, plan, and water-lines of this vessel are shown in Plate II.* The most satisfactory observations which I was able to make relative to the maximum speed at which the American steamboats are capable of being propelled, were made during a passage in the "Rochester," which serves as a further motive for particularly describing her construction.

The "Rochester" measures 209 feet ten inches in length on her deck. This measurement applies also to the length of her keel, her stern-post and cut-water being perpendicular, as shown in Plate II. The maximum breadth of beam is 24 feet. The projection of that part of the deck called the wheel-guards, shown in dotted lines in fig. 2, beyond the hull of the vessel, is 13 feet on each side. The maximum breadth of the vessel, measured to the outside of the paddle-wheels, is 47 feet. The depth of hold is 8 feet 6 inches. The draught of water, with an average number of passengers, is four feet. The diameter of the paddle-wheels is 24 feet. The length of the float-boards, which are twenty-four in number, is 10 feet, and their dip is 2 feet 6 inches. This

* The lines of the steamers in Plates II. and III. were laid down by my friend Mr Andrew Murray, from models which I brought from New York.

vessel is propelled by one engine, having a cylinder of 43 inches in diameter, and the length of stroke 10 feet. The engine condenses the steam which works expansively, and is cut off at half stroke.

The great competition that exists in the navigation of the Hudson produces constant *racing* between boats belonging to different companies; and this is not unfrequently attended with serious accidents. When the "Rochester" is pitched against another vessel, and at her full speed, the steam is often carried as high as forty-five pounds on the square inch of the boiler; and the piston makes twenty-seven double strokes, or, in other words, moves through a space of 540 feet per minute, or 6·13 miles per hour. In this case the circumference of the paddle-wheels moves at the rate of 23·13 miles per hour. In ordinary circumstances, however, the engine is worked by steam of from twenty-five to thirty pounds pressure on the square inch; and in this case the piston makes about twenty-five double strokes per minute, moving through a space of 500 feet per minute, or 5·68 miles per hour; and the circumference of the paddle-wheel moves at the rate of 21·42 miles per hour. The rate at which the pistons of marine engines in this country (1837) move, seldom exceeds 210 feet per minute. The pistons of locomotive engines generally move at the rate of about 300 feet per minute; but both of their speeds are very far short of the velocity of the "Rochester's" piston.

The hulls of almost all the American steamboats, especially those which ply on the rivers, carrying no freight excepting the luggage belonging to passengers, are constructed in a very light and superficial manner. They are built perfectly flat in the bottom, and perpendicular in the sides; a cross section in the middle of the vessel, having the form of a parallelogram, with its lower corners rounded off, as shown by the cross sections in Plate II. This construction of hull is well adapted to a navigation where the depth of water is small, and the attainment of great speed is an object of importance, as it insures a smaller draught of water, and consequently affords less resistance to the motion of the vessel than any other mould which has an equal area of cross section below the water-line; but vessels built in this way, without a deep keel, having no hold of the water, are not well adapted for making sea-voyages, as they cannot resist the effect of the wind, which causes them to make lee-way. It is only the great breadth of the paddle-wheels and power of the engines which enables the American boats to move steadily through the water. The breadth of the paddle-wheels is, in fact, so much additional breadth added to the beam of the vessel; for the reaction of the float-boards striking the water tends, in some measure, to counteract any tendency that the vessel may have to roll, which would otherwise be very apt to take place in the American steamers, where the machinery and boilers are placed above the level of the deck. There is no rolling motion felt in these fast boats. The rectilinear motion, however, is by no means regular. Every stroke of the engine produces a momentary acceleration in the speed, giving rise to a *see-saw* motion, resembling that of a row-boat, in which the impulse produced by every stroke of the oars is distinctly felt.

In the American steamers the keel generally projects from two to six inches from the bottom of the hull, and is level from stem to stern. Its principal service, when the projection is so small, consists in strengthening the hull. The deck-lines of the hull, in general, begin to fall in at a distance of a few feet from the middle of the vessel. They approach each other with a gentle curve, as shown in Plate II., fig. 2, towards the stern and bow, where they meet, and are connected by the stern-post and cutwater of the vessel. The cutwater is generally perpendicular, and the sides of the vessel, diverging from it, present a very acute angle to meet the resistance offered by the water. The angle formed by the sides of the "Rochester" is about twenty degrees at the level of the water, and decreases to about ten degrees at the level of the keel.

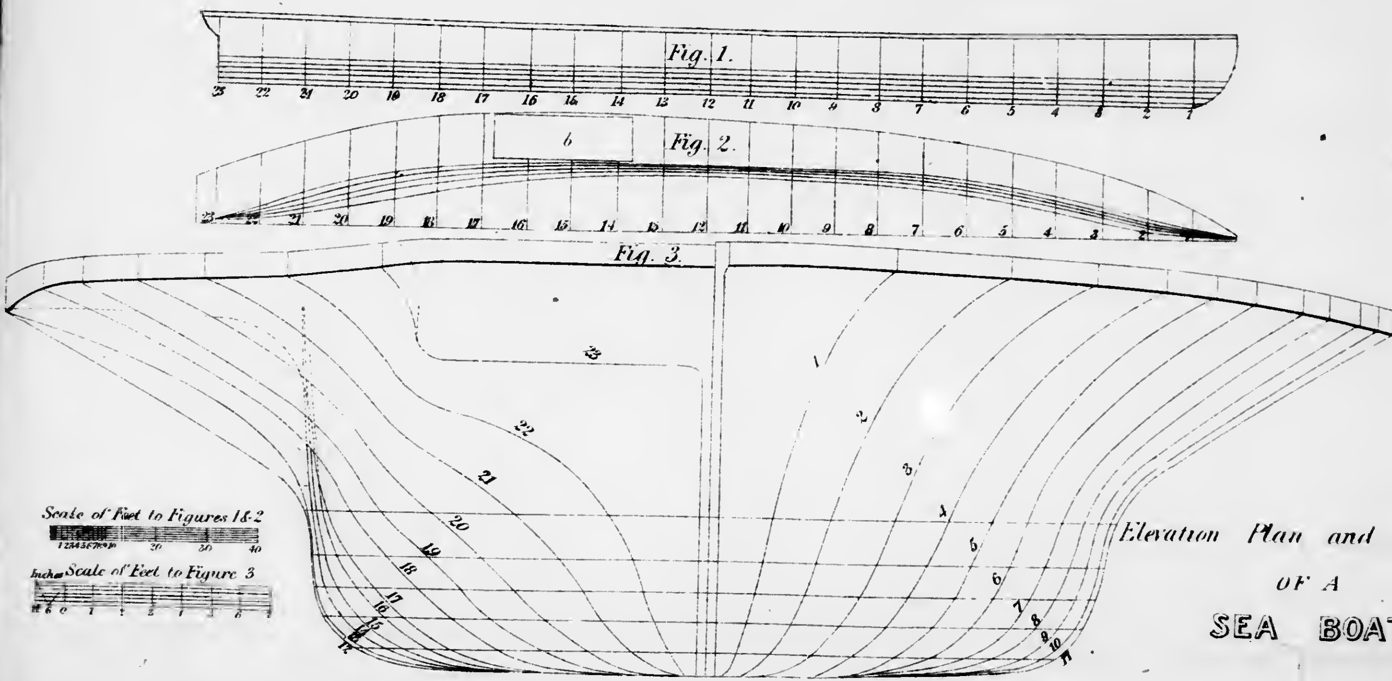
The engine and paddle-wheels are placed in a frame-work of wood, to which they are attached by strong fixtures.

This frame-work is generally a specimen of substantial and excellent workmanship. The timbers of which it is composed are arranged so as to form the frustum of a pyramid. The apex of the framing is elevated above the deck and paddle-wheels, and supports the beam of the engine, while its base rests on the flooring timbers of the hull. In this way the weight of the machinery is distributed over a large surface of the bottom, the weak construction of that part of the vessel rendering such an arrangement absolutely indispensable to her safety. Iron rods, fastened to the timbers of the vessel, extend fore and aft from the upper part of the beams forming the engine framing. These iron ties give support to the bow and stern, which, if not braced up in the manner described, invariably sink or settle down in the course of a few months, owing to the slim built and great length of the hull. Screws and nuts are generally provided, by which the ties can be tightened up, should any yielding take place in the wood-work of the vessel.

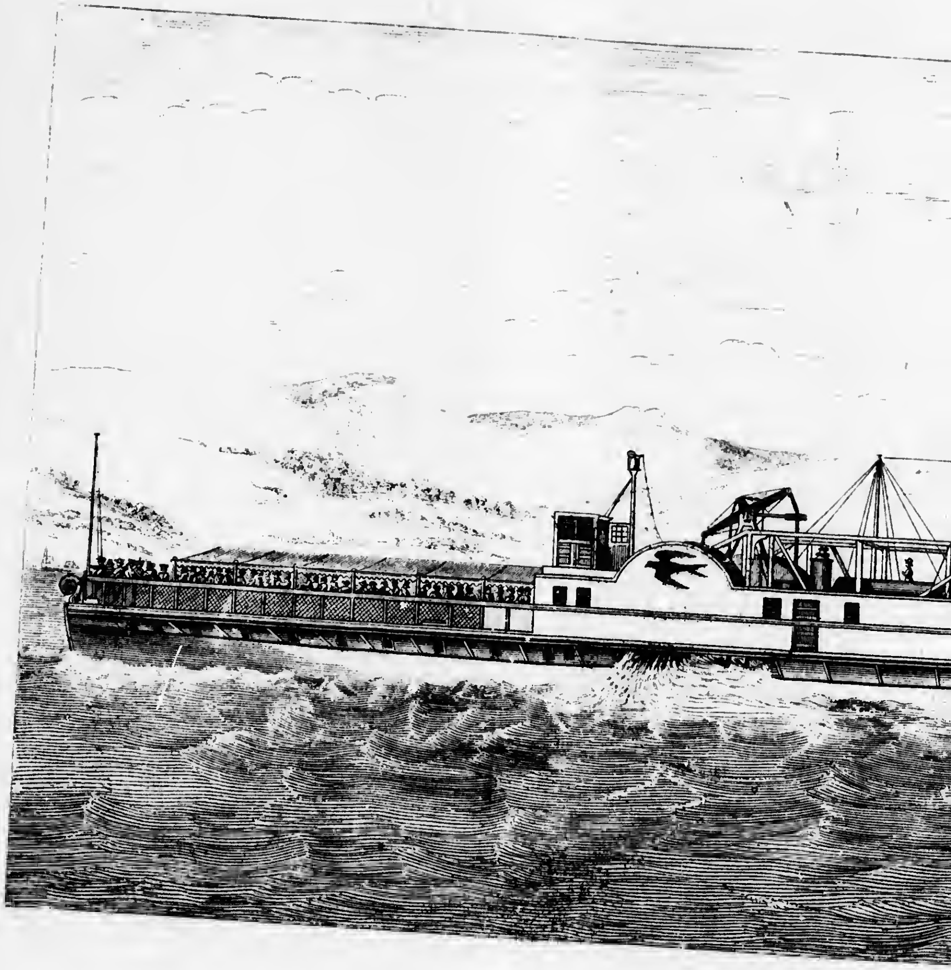
At the height of about five feet above the surface of the water, the hull is covered with a deck. It is made somewhat in the form of an ellipse, as shown by the dotted lines in Plate II. Its vertices rest on the stern-post and cut-water of the vessel, while its sides, expanding beyond the hull, overhang the water, and the bulwarks of the vessel are erected on its circumference. The part of the deck overhanging the water is called the "wheel-guards," and in some vessels it has a projection of 18 or 20 feet from the sides. In the "Rochester," the projection, as I have already said, is 13 feet. The wheel-guards are formed so as to enclose the paddle-wheels, which work in spaces left in them for that purpose, marked *b* in Plates II. and III. The inner plumber-blocks and paddle-wheel axles rest on the timbers of the vessel, and the exterior ones on the outer edges of the guards.

A large cabin, serving the double purpose of the gentlemen's sleeping apartment and the public dining-room, is formed in the hull of the vessel. It is entered by a stair leading from the first deck. It generally extends nearly

PLATE III

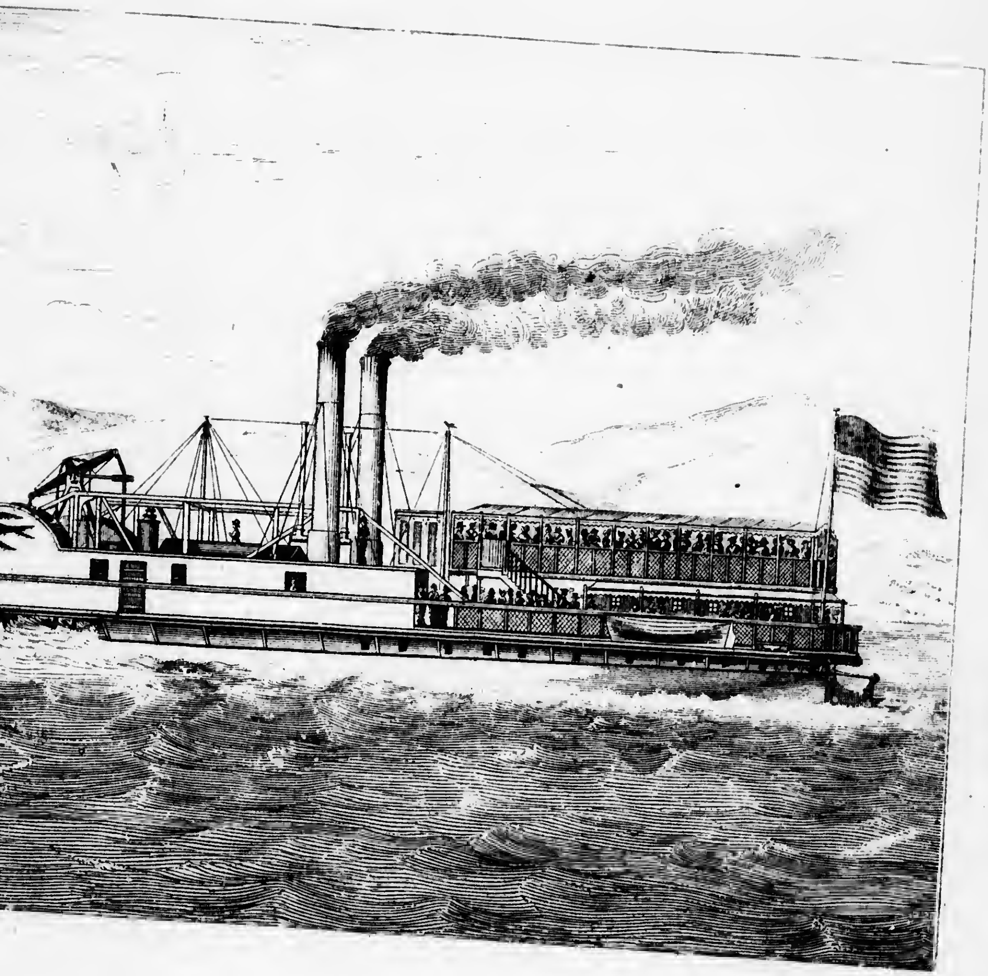


Elevation Plan and Sections OF A SEA BOAT.

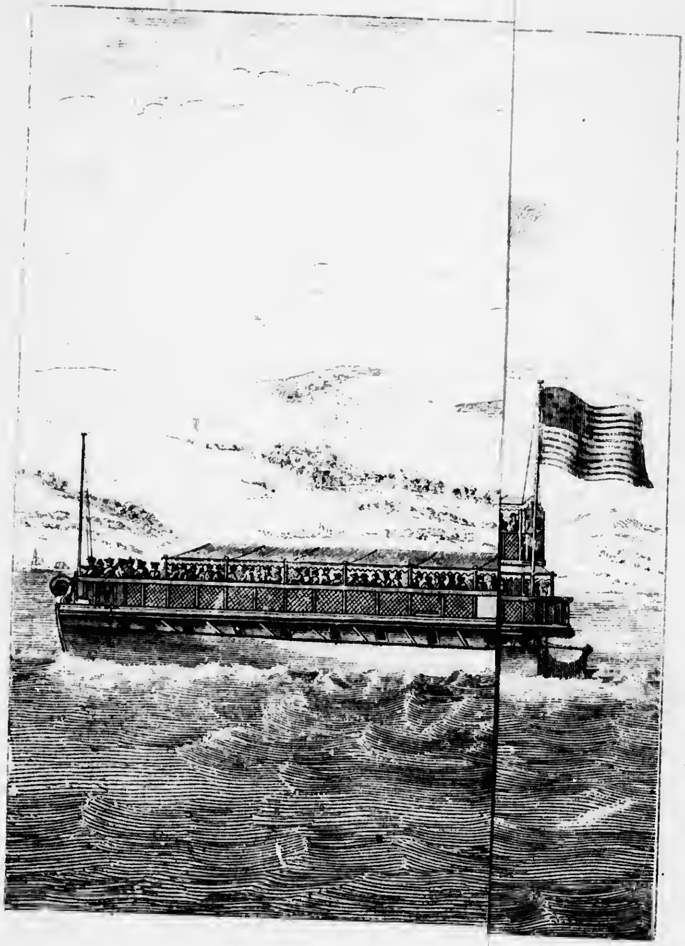


STEAM BOAT SWALLOW, PLYING ON THE I

PLATE IV



LLOW, PLYING ON THE RIVER HUDSON.



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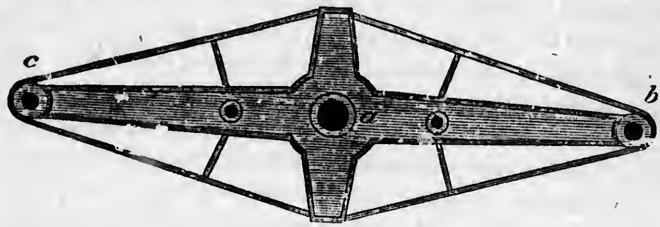
from stem to stern, and is elegantly fitted up. The ladies' cabin is on a level with the first deck, from which it enters. This deck is covered with a roof extending from the paddle-wheels to the stern of the vessel, the top of which forms a higher deck, raised about sixteen feet above the level of the water, called the promenade-deck. The general arrangement of these vessels will be best understood by referring to Plate IV., which is a perspective view of the steamboat "Swallow."

The vessels propelled by two engines carry two boilers and four funnels, and have a very extraordinary appearance. The vessels of modern construction, however, have generally only one engine, with two boilers and two funnels, as shown in the Plate of the "Swallow." The boilers are on a level with the lower deck, and rest on the wheel-guards, one being placed on either side of the vessel. The cylinder, which also stands on a level with the first deck, is placed in the centre of the vessel, between the two boilers. The condenser and pumps are situate in the hull of the vessel, in the middle of the large cabin, from which they are separated by a partition.

Engines working with side-rods, connected by a cross-head, which is attached to the end of the piston-rod, and moves in vertical slides, are occasionally employed in the steamboats which navigate the Eastern waters. The beam-engine is, however, much oftener used. The length of stroke adopted by the Americans for their marine engines is very much greater than I have ever found in Europe. This renders it necessary that the main centres of the engine, or the pivots on which the beam performs its motion, should be placed at a considerable elevation above the promenade-deck. The working-beam, therefore, is quite exposed, and is elevated above every other part of the vessel, excepting the tops of the funnels, as is shown in Plate IV., forming one of the most prominent and striking parts of an American steamboat, and presenting, as may naturally be supposed, a strange effect to those accustomed to see European steamboats only, in which no part of the machinery is visible even from the deck of the vessel. The beams are constructed wholly of malleable iron, in the manner shown in the following diagram—in which *a* is the main centre,

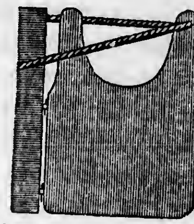


and *b* and *c* the points to which the piston and connecting rods are attached. This construction combines lightness with strength and rigidity, and is found to act very well.

The arrangement of the decks and machinery which I have just described, and which is represented in Plates IV. and V., renders the vessel's course, when she is under weigh, quite invisible from her stern, and consequently it is impossible to steer her from that part of the ship; but the wheel by which the rudder is moved is placed in a wheel-house, erected for the pilot on the fore part of the promenade-deck, and in some instances at a distance of nearly 200 feet from the stern of the boat. The steersman, by this arrangement, stands so far forward in the vessel, and in so elevated a situation, that he cannot easily discover when the vessel swerves from her course, without the assistance of a tall perpendicular pole, placed at the bow, in the manner shown in the plates. On this he keeps his eye, and by narrowly observing its position in relation to some fixed object at a distance, he readily detects the smallest deviation from the course.

The motion produced by moving the wheel is communicated to the rudder by ropes working in a series of grooved pulleys. The application of ropes for this purpose has, on several occasions, in cases of fire, been attended with most unhappy results. During my stay in America, a steamboat on the Mississippi, called the "Ben Sherod," took fire, and upwards of one hundred lives were lost, in consequence of the vessel's becoming unmanageable, owing to the rudder ropes being burned. Iron rods and chains have lately been introduced instead of ropes, and will doubtless soon come into general use.

The rudder in general measures about 6 feet in depth, and 8 feet in length. It moves on pivots, which work in gudgeons fixed to the stern of the vessel, and thus far resembles the rudder used in all sea-vessels. The ropes, however, by which it is put in motion, are made fast to the outer extremity of the rudder, in the manner shown in the annexed diagram; and in this way the tiller, which takes up much room, is altogether dispensed with.



This mode of steering in an elevated situation, near the bow of the vessel, is peculiarly well adapted for steamers navigating narrow rivers, such as the Thames, on which, indeed, it is now sometimes employed, but on the whole, it seems strange that its adoption in this country is not more general.

The foregoing remarks regarding the construction of the steamers refer particularly to those vessels which ply on the rivers on the eastern coast of the United States. Those used on the bays and sounds, called sea-boats by the Americans, are somewhat different in their construction, their hulls and machinery being more strongly made, and their draught of water considerably greater. The river-boats draw from four to six feet of water, and the sea-boats from five feet six inches to nine feet; but still the machinery and boilers, as well as a great part of the cabin accommodation in that class of steamers, is elevated above the level of the deck; an arrangement which seems very ill adapted for vessels exposed to the heavy gales and rough seas of the ocean. The best specimens of the American sea-boats are those which ply between New York and the ports of Providence and Charleston.

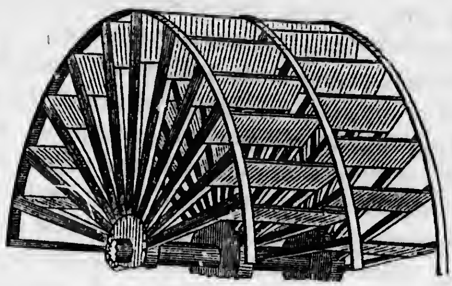
The finest of these sea-boats, and indeed the finest steamer which I saw in the United States, is the "Narragansett," plying between New York and Providence, which is shown in Plate III. Fig. 1 is an elevation of the hull; fig. 2 a plan; and fig. 3 shows her water-lines. It could hardly be credited, from a mere examination of the drawings, that this vessel plies regularly from New York to Providence. By inspecting the map, it will be seen that, during the fifty miles of this voyage, extending between New London and Newport, she is quite exposed to the roll of the Atlantic Ocean; and notwithstanding this, she makes her passages with great speed and regularity.

The "Narragansett" measures 210 feet in length of keel, and 26 feet in maximum breadth of beam. The depth of her hold is 10 feet 7 inches, and her draught of water is 4 feet 6 inches without the keel, and 5 feet with the keel, when she has her average load on board. She is built entirely of oak, and is strengthened by diagonal straps or ties of iron which connect her timbers. The vessel is propelled by one condensing engine, which works expansively, cutting off the steam at half stroke. The condensation of the steam in this engine, as well as in most of the American marine engines, is produced by the injection of a jet of cold water into the condenser. She carries two boilers, in which an aggregate amount of 3000 square feet of surface is exposed to the fire, and works with steam of a pressure varying, according to circumstances, from twenty to twenty-five pounds on the square inch. The cylinder is placed horizontally, and is 56 inches in diameter; the length of the stroke is 11 feet 6 inches, and the piston makes twenty-four double strokes per minute, so that its average motion in the cylinder is at the rate of no less than 6·27 miles per hour. The diameter of the paddle-wheels is 25 feet, and, as they perform twenty-four revolutions in the minute, the motion of the periphery is at the rate of 21·4 miles per hour. The breadth of the "Narragansett's" paddle-wheels is 11 feet, and their dip 2 feet 2 inches. The diameter of the paddle-wheel axle on which they are keyed is 13 inches.

The cabins of the sea-steamers are of great size, and their accommodation for passengers is excellent. In most of them about four hundred berths are provided. The principal cabin in the "Massachusetts," a vessel running on the line between New York and Providence, is 160 feet in length, about 22 feet in maximum breadth, and 12 feet in height;

and, what adds greatly to its convenience and capacity, it is entirely unbroken by pillars or any other obstruction throughout its whole area. I have dined with 175 persons in this cabin; and, notwithstanding this numerous assembly, the tables, which were arranged in two parallel rows extending from one end of the cabin to the other, were far from being fully occupied; the attendance was good, and everything was conducted with perfect regularity and order. There are 112 fixed berths ranged round this cabin, and about 100 temporary berths can be erected in the middle of the floor. Besides these, there are 60 fixed berths in the ladies' cabin, and several temporary sleeping-places can be erected in it also. The cabin of the "Massachusetts" is by no means the largest in the United States; some steamers have cabins upwards of 175 feet in length. Those large saloons are lighted by the argand lamps suspended from the ceiling, and their appearance, when brilliantly lighted up and filled with company, is very remarkable. The passengers generally arrange themselves in parties at the numerous small tables (into which the large tables are converted after dinner), and engage in different amusements. The scene resembles much more the coffee-room of some great hotel than the cabin of a floating vessel.

I found no variety in the construction of the paddle-wheels of the different American steamboats. They are all made in the manner represented in the following diagram. The spokes are made of wood, and bolted into cast-iron flanges which are keyed to the axle of the paddle-wheel; their outer ends are connected together by bands of iron encircling the circumference of the wheel. The float-boards, which are formed of hard wood, are attached to the spokes simply by bolts. The float-boards do not extend across the whole breadth of the paddle-wheel, as is always the case in this country. They are divided into two, and sometimes three compartments, and the wheel is furnished with three and sometimes four sets of spokes arranged in parallel planes. "This construction was introduced by Mr Stevens of New York, and may be described," says Dr Renwick, "by supposing a common paddle-wheel to be sawn into three parts in planes perpendicular to its axis. Each of the two additional wheels that are thus formed, is then moved



back, until their paddles divide the interval of the paddles on the original wheel into three equal parts.

"In this form the shock of each paddle is diminished to one-third of what it is in the usual shape of the wheel; they are separated by less intervals of time, and hence approach more nearly to a constant resistance; while each paddle, following the wake of those belonging to its own system, strikes upon water that has been but little disturbed."*

In some of the Western water boats, which are often very deeply laden, the paddle-wheels are constructed with moveable float-boards, so that their dip may be increased or diminished to suit the draught of water; but this construction, so far as I know, is not in use in any other part of the country.

The American steamers have usually only one engine, and a counter-balance, attached to the paddle-wheels, is in some cases found necessary, to enable it to turn its centres. The great length of the stroke, however, allows time for a degree of momentum to be generated, which is sufficient in most cases to carry the engine past its centres, and failing this, the paddle-wheels, from their large diameter, become good generators of momentum, and act in the same way as the fly-wheels of land engines in regulating their motion. Even in those vessels where two engines are employed, their connecting-rods are not attached to the same axle;

* Treatise on the Steam-Engine, by James Renwick, LL.D., New York, 1830.

each engine works quite independently of the other, and drives only one of the paddle-wheels; whereas in this country the connecting-rods of both engines are attached to the same axle, by cranks placed at right angles to each other, so that one engine is exerting its full power at the very moment when the other is expending none of its force, and the power is thus employed in the most advantageous manner for keeping up the speed. The short stroke and comparatively small diameter of the paddle-wheels in European boats, render this construction necessary to enable engines to pass their centres.

The general construction of the boilers, and the arrangement of the flues, in the steamboats on the Eastern waters, resemble in a great measure those of European steamers. The flame and smoke from the fire-place pass through flues in the interior of the boiler, and are afterwards discharged into the funnel. The boilers are strengthened in the usual manner, by means of iron braces or ties, arranged so as to form a strong connection between the interior surfaces, and thus render them more capable of resisting the expansive force of the steam, which has a tendency to tear them asunder. Copper was, until lately, very generally employed in America for the construction of the boilers of sea-going vessels, this metal being less liable than iron to be acted on by the saline deposits. By means of some improvements which have lately been introduced, these deposits are prevented from collecting in iron boilers to any dangerous extent, and the difference of expense is so much in favour of iron, that it has now been adopted instead of copper, in the sea, as well as in the river boats. The means used in America for checking the deposit which takes place in boilers from the use of salt-water is the same as that generally employed in this country, namely, by "blowing off," an operation which is performed every two or three hours, while the boat is running, without stopping her progress. A valve in the bottom of the boiler being opened, part of the water is permitted to escape, which, in its rush from the boiler, disturbs any deposit that may have taken place on its bottom, and carries it off.

The speed of the American steamboats has excited considerable wonder in this country; and some people have been inclined to doubt the accuracy of the statements that have frequently been made regarding the extraordinary feats performed by them. Fast sailing is a property, however, which is not possessed by all American steamboats; but that a few of those navigating the River Hudson and Long Island Sound perform their voyages safely and regularly, at a speed which far surpasses that of any European steamer hitherto built (1837), every impartial person, who has had an opportunity of seeing the performances of the vessels in both countries, must be ready to admit.

Some difficulties at present exist, which preclude the attainment of more than an approximation in ascertaining the maximum rate at which the steamboats on the Hudson are propelled in still water. One of these is caused by the currents of the flowing and ebbing tide, which are felt as far as Albany, and whose velocity has never been accurately ascertained, and the other by the doubt that exists as to the actual distance of the route between New York and Albany, which has been variously stated at from 145 to 160 miles. The road between these towns runs nearly parallel to the river, and is said to be 162 miles in length. In the American Almanac for 1837, the town-house of New York is stated to be in north latitude 40° 42′ 40″, and west longitude (from Greenwich) 74° 1′ 8″, and that of Albany in north latitude 42° 39′ 3″, and west longitude 73° 44′ 49″, which makes the distance between the two places, as the crow flies, 134·5 statute miles. The navigable channel of the Hudson, however, is by no means straight; its direction ranges over fifteen points of the compass, from W. to E.N.E., including an angle of 157° 30′. Mr Redfield of New York, who has bestowed much attention on the subject of steam navigation, is of opinion that the length of the steamboat route is 150 miles, being 15·5 miles greater than the distance measured by a straight line drawn between the two places.* This may be regarded as a near approxi-

* Professor Silliman's Journal, vol. xxiii. p. 312.

mation to the truth. The same difficulties occur regarding the length of the routes performed by the boats on Long Island Sound, and the strength of the tidal currents encountered by them. It is quite evident that until these facts are accurately ascertained, it is impossible, without a series of experiments made solely with that object in view, to discover what is the actual speed attained by American steamboats. A very general opinion exists in America on this subject, in which many persons possessing the best means of information concur, that the fast steamboats can be propelled at the rate of eighteen miles an hour in still water, a feat which it is said has of late been often performed. I cannot vouch for the accuracy of this statement, however, from personal experience or observation; but this I can state positively, that the average length of time occupied by the steamers in making the voyage from New York to Albany is ten hours, exclusive of time lost in making stoppages, which, taking the distance at 150 miles, gives fifteen miles an hour as their average speed.

The "Rochester" and the "Swallow" were said to be the two swiftest boats running on the Hudson in 1837. I made a trip from Albany to New York in the "Rochester," on the 14th of June, on which occasion, with a view to test the vessel's speed, I carefully noted the hour of departure from Albany, the times of touching at the several towns and landing places on the river, with the reputed distances between them, the number of minutes lost at each place, and the hour of arrival at New York. Thirteen stoppages, which I found to average three minutes each, were made to land and take on board passengers. The "Rochester" performed the voyage in ten hours and forty minutes. From this, thirty-nine minutes must be deducted for the time lost in making the thirteen stoppages, which leaves ten hours and one minute as the time during which the vessel was actually occupied in running from Albany to New York. Assuming the distance between those places to be 150 miles, the average speed of the vessel throughout the trip was 14·97 miles per hour, but even if we assume the distance to be only 145 miles (the shortest distance I have ever heard stated), which there is every reason to believe is too small, the average rate is still 14·47 miles per hour, the difference of five miles in the length of, the route, producing a diminution in the vessel's average rate of sailing of but half a mile per hour. The current was in the "Rochester's" favour during the first part of the voyage, but the Overslaugh shoals, and the contracted and narrow state of the channel of the river for about thirty miles below Albany, checked her progress very much; and, consequently, for the first twenty-seven miles her speed was only 12·36 miles per hour. This was her average rate of sailing during the part of her course when her speed was slowest. After the first thirty miles the river expanded, affording a better navigable channel, when her speed gradually increased, and before the flowing tide checked her progress the vessel attained the maximum velocity indicated by my observations, which, between two of the stopping places, was 16·55 miles per hour. When going at this speed it is possible that she was influenced by some slight degree of current in her favour, although it was quite imperceptible to the eye, as the flow of the tide appeared to produce a stagnation in the water of the river. At West Point we encountered the flood tide, as was very distinctly proved by the swinging of the vessels which lay at anchor in the river. After this we had an adverse current all the way to New York, a distance of about fifty miles, and the vessel's speed during this part of the voyage averaged 14·22 miles an hour. About one-half of the voyage was thus performed with a favourable current, and the other half was performed under unfavourable circumstances, owing partly to the shallowness of the water and the narrowness of the channel in the upper part of the river, and partly to an adverse tide in the lower part of it. When the Rochester is pitched against another vessel, and going at her full speed, her piston, as formerly stated, makes twenty-seven double strokes per minute. On the voyage above alluded to, however, the piston, on an average, made about twenty-five double strokes per minute, so that the speed of 14·97 miles per hour, which she attained on that occasion, cannot be taken as her greatest rate of sailing. During the time, however, at which her speed was 16·55 miles per hour, her piston was making twenty-seven double strokes per minute, and at that time the vessel could not be far from having attained the maximum speed at which her engines are capable of propelling her through the water.

The rate of sixteen and a half miles an hour is very great, but perhaps not more than is due to the form of the vessels, and the power of the engines by which they are propelled. The "Rochester" draws only four feet of water, but the power of her engine is greater than that of any steamer in this country (1837). The construction of the American marine engines is so different from that adopted in Europe, that it is doubtful if the same rule for calculating the power is applicable in both cases. In the following calculations, the deductions for the friction and for the difference between the pressure exerted by the steam in the boiler and in the cylinder, as well as the advantage that is derived from the use of a condenser, are in accordance with what has been stated by American engineers, who are best able to judge of the power of their own engines.* The diameter of the Rochester's piston is 43 inches, and its area is 1452·2 square inches. The pressure of the steam in the boiler is 45lb. on the square inch; and the engine works expansively, and cuts off the steam at half stroke. The half of that pressure, or 22·5lb., is assumed as the pressure acting on the square inch of the piston. To this, 10lb. is added as the pressure of the atmosphere obtained by the use of the condenser, making the whole effective pressure on every square inch of the piston's area 32·5lb. The length of the stroke is 10 feet, and, when going at full speed, the piston makes 27 double strokes, or, in other words, moves through the space of 540 feet every minute. Estimating the power of a horse as equal to that exerted in raising 33,000lb. 1 foot per minute, the power of the engine is obtained by the following expression:

$$\frac{1452{\cdot}2 \times 32{\cdot}5 \times 540}{33000} = \frac{25486110}{33000} = 772{\cdot}3$$

From this it appears, that a force is exerted upon the engine

* Professor Silliman's Journal, vol. xxiii ... 315.

equal to that of 772·3 horses; but one-third of this power is supposed to be expended in working the pumps and overcoming the friction of the machinery, and a power of 514·8 horses remains as the true force exerted in propelling the vessel. The "Narragansett," as formerly noticed, draws five feet of water, and the power of her engine, calculated on the same principles, and with the same deductions, is equal to that of 618 horses. If the calculation generally adopted in this country were applied to those engines, and only one-fourth of the power deducted, which appears to be an ample allowance for engines of that construction, the power of the "Rochester" would be equal to 748, and that of the "Narragansett" to no less than 772 horses.

The disturbance created by the passage of the fast American steamers through the water is exceedingly small. The water, at the distance of twelve inches in front of their bows, presents a perfectly smooth and untroubled surface. A thin sheet of spray, composed of small globules of water, from apparently about an eighteenth of an inch in diameter, rises nearly perpendicularly in front of the cut-water to the height of three, and, in some cases which I have observed, as much as four feet, and falls again into the water on either side of the vessel. There is little or no commotion at the stern; and the diverging waves which invariably follow the steamers in this country, and break on the banks of our rivers with considerable violence, are not produced by the fast boats in America. The waves in their wake are very slight, and, as far as I could judge, seem to be nearly parallel; and the marks of the vessel's course cannot be traced to any great distance. These facts are quite in accordance with the result of some of Mr Russell's experiments, by which he was led to conclude that "the commotion produced in a fluid by a vessel moving through it, is much greater at velocities less than the velocity of the wave" (which is proportioned to the depth of the water), "than at velocities which are greater than it."*

* Researches on Hydrodynamics, from the Transactions of the Royal Society of Edinburgh for 1837. By John Scott Russell, Esq.

Steamboats were first introduced on the Mississippi in the year 1811, and in 1831 no less than 348 steamers had been built for the Western water navigation, 198 of which were then in actual operation. Since that time their number has rapidly increased, with the increasing population and trade of the country, and in 1837 was said to be between 350 and 400; but, so far as I know, no official statement regarding the Western water navigation has appeared since the publication of the following table, which is taken from the American Almanac for 1832, and contains a list of steamers up to that date, specifying those which have been worn out or have been lost to the service.

WHOLE NUMBER OF STEAMBOATS BUILT ON THE WESTERN WATERS.

When Built.	Whole Number.	Now Running.	Lost or Worn Out.
1811	1	...	1
1814	4	...	4
1815	3	...	3
1816	2	...	2
1817	9	...	9
1818	23	...	23
1819	27	...	27
1820	7	1	6
1821	6	1	5
1822	7	...	7
1823	13	1	12
1824	13	1	12
1825	31	19	12
1826	52	36	16
1827	25	19	6
1828	31	28	3
1829	53	53	...
1830	30	30	...
1831	9	9	...
	348	198	150

Of the 198 boats now running—

68 were built at Cincinnati.		
68	...	Pittsburg.
2	...	Louisville.
12	...	New Albany.
7	...	Marietta.
2	...	Zanesville.
1	...	Fredericsburg.
1	...	Westport.
1	...	Silver Creek.
1	...	Brush Creek.
2	...	Wheeling.
1	...	Nashville.
2	...	Frankfort.
1 was built at Smithland.		
1	...	Economy.
6	...	Brownsville.
3	...	Portsmouth.
2	...	Steubenville.
2	...	Beaver.
1	...	St Louis.
3	...	New York.
1	...	Philadelphia.
10	...	(Not known where.)
198		

Of the whole number, 111 were built at Cincinnati, 68 of which were running in 1831.

Of the 150 lost or worn out, there were—

Worn out,	63
Lost by snags,	36
Burned,	14
Lost by collision,	3
By other accidents not ascertained,	34
Total,	150

Most of the vessels at present employed have been built on the banks of the Ohio, and a few at St Louis, on the upper part of the Mississippi, but, according to the above list, the building-yards which have produced the greatest number are those of Pittsburg and Cincinnati, on the Ohio. Pittsburg, although about 2000 miles from the Gulf of Mexico, is a place of great trade. Its population is 30,000 persons, a great part of whom are employed in the construction and management of steamboats; and some idea may be formed of the extent of their trade, when I state that I have counted no less than thirty-eight steamboats moored opposite the town in the Monongahela, all of which were engaged in plying to and from the port.

The vast number of vessels on the Western waters, the peculiarity of their construction, and the singular nature of the navigation in which they are employed, make them objects of considerable interest to the traveller. We must not expect to find, however, in that class of vessels, the same

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which were run-

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150

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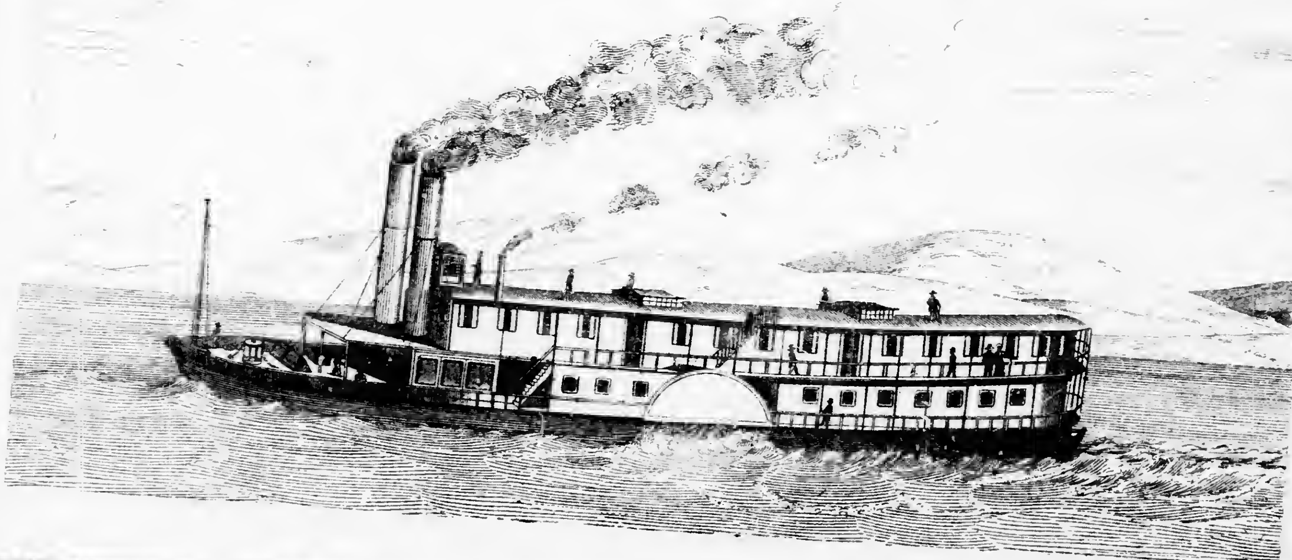
WESTERN WATER STEAM BOAT.

PLATE V.



display of good workmanship, and the attainment of the high velocities, which characterize those on the Eastern waters. Such qualifications may be very easily dispensed with, and the want of them is by no means the worst feature in the western navigation; but what is of far more importance, too many of the vessels are decidedly unsafe; and, in addition to this, their management is intrusted to men whose recklessness of human life and property is equalled only by their ignorance and want of civilization.

Economy would indeed seem to be the only object which the constructors of these boats have in view, and therefore, with the exception of the finery which the cabins generally display, little care is expended in their construction, and much of the workmanship connected with them is of a most superficial and insufficient kind. When the crews of these frail fabrics, therefore, engage in brisk competition with other vessels, and urge the machinery to the utmost extent of its power, it is not to be wondered at that their exertions are often suddenly terminated by the vessel taking fire, and going to the bottom, or by an explosion of the steam-boilers. Such accidents are frequently attended with an appalling loss of life, and are of so common occurrence, that they generally excite little or no attention. During my stay in North America, a steamer called the "Ben Sherod," as already mentioned, was burnt on the Mississippi, when 120 persons were reported to have lost their lives. I am happy in being able to add, that there is reason to believe that, in consequence of this accident, the Government of the United States have resolved to take some measures to insure the better regulation of this navigation, which has been too long neglected by them.

The vessels on the Western waters vary from 100 to 700 tons burden, and are generally of a heavy built, to enable them to carry goods. They have a most singular appearance, and are no less remarkable as regards their machinery. Plate V. is a perspective view of one of them, taken from a sketch which I made on the Ohio. They are built flat in the bottom, and generally draw from six to eight feet of water. The hull is covered with a deck at the level of about five feet above the water, and below this deck is the hold, in which the heavy part of the cargo is carried. The whole of the machinary rests on the first deck; the engines being placed near the middle of the vessel, and the boilers under the two funnels as shown in the drawings. The fire-doors open towards the bow, and the bright glare of light thrown out by the wood fires, along with the puffing of the steam from the escapement pipe, produce a most singular effect at night, and serve the useful purpose of announcing the approach of the vessel when it is still at a great distance. The chief object in placing the boilers in the manner described, is to produce a strong draught in the fire-place. The other end of the lower deck, which is covered in, and occupied by the crew of the vessel, and the deck passengers, generally presents a scene of filth and wretchedness that baffles all description. A stair-case leads from the front of the paddle-boxes on each side of the vessel, to an upper gallery about three feet in breadth. This surrounds the whole after-part of the vessel, and is the promenade of the inhabitants of the second deck. Several doors lead from the gallery into the great cabin, which extends from the funnels to within about thirty or forty feet of the stern of the vessel; the aftermost space is separated from the great cabin by a partition, and is occupied by the ladies. The large cabin contains the gentlemen's sleeping berths, and is also used as the dining-saloon. This part of the Western steamers is often fitted up in a gorgeous style; the berths are large, and the numerous windows by which the cabin is surrounded give abundance of light, and, what is of great consequence in that scorching climate, admit a plentiful supply of fresh air.

From the gallery surrounding the chief cabin, two flights of steps lead to the hurricane deck, which, in many of the steamers, is at least thirty feet above the level of the water. The wheel-house, in which the steersman is placed, is erected on the forepart of this deck, and the motion is communicated to the helm by means of ropes or iron rods, in the manner already described in speaking of the Eastern steamers.

The first cabin of a Mississippi steamboat is strangely contrasted with the scenes of wretchedness in the lower deck; and its splendour serves in some measure to distract the attention of its unthinking inmates from the dangers which lie below them. But no one who is at all acquainted with the steam-engine, can examine the machinery of one of those vessels, and the manner in which it is managed, without shuddering at the idea of the great risk to which all on board are at every moment exposed.

The Western water steamers are propelled sometimes by one and sometimes by two engines. When two engines are used, the ends of the piston-rods work in slides, and the connecting-rods are both attached to cranks on the paddle-wheel axle, placed at right angles to each other, as is the case in most of the steamers in this country. When only one engine is used, which is more generally the case, a large fly-wheel, from ten to fifteen feet in diameter, is fixed on the paddle-wheel shaft, and serves to regulate the motion of the engine, and enable it to turn its centres. The cylinders are invariably placed horizontally, and the engines are always constructed on the high-pressure principle.

The engines are generally very small in proportion to the size of the vessel which they propel, and, to make up for their deficiency in volume, they are worked by steam of great elasticity. The "Rufus Putnam," for example, a pretty large vessel, drawing six feet of water, which plies between Pittsburg on the Ohio and St Louis on the Mississippi, is propelled by a single engine, having a cylinder 16 inches diameter, and 5 feet 6 inches in length of stroke; but this engine is worked by steam of a most dangerously great elasticity. The captain of the vessel informed me that, under ordinary circumstances, the safety-valves were loaded with a pressure equal to 138 lb. on the square-inch of surface, but that the steam was occasionally raised as high as 150 lb. to enable the vessel to pass parts of the river in which there is a strong current; and he added, by way of consolation, that this amount of pressure was never exceeded except on extraordinary occasions! I made a short voyage on the Ohio in this vessel, but after receiving this information, I resolved to leave her on the first opportunity that presented itself.

The "St Louis," one of the newest boats on the Mississippi, is 230 feet in length of deck, and 28 feet in breadth of beam. She draws eight feet of water, and carries about 1000 tons. This vessel is propelled by two engines, with cylinders 30 inches in diameter, and 10 feet in length of stroke, worked by steam having a pressure of 100 lb. on the square inch of the boiler.

Explosions, as may naturally be supposed, are of very frequent occurrence; and, with a view to cure this evil, several attempts have, at different periods, been made to introduce low-pressure engines on the Western waters, but the cheapness of high-pressure engines, and the great simplicity of their parts, which require comparatively little fine finishing and good fitting, certainly afford reasons for preferring them in a part of the country where good workmen are scarce, and where the value of labour and materials is very great. It must also be recollected, that a condensing or low-pressure engine takes up a great deal more space than one constructed on the high-pressure principle. I do not apprehend, however, that the number of accidents would be diminished by the simple adoption of low-pressure boilers, without the strict enforcement of judicious regulations; and if those regulations were properly applied to high-pressure boilers, they would not fail to render them perhaps quite as safe as those boilers which are generally made for engines working on the low-pressure principle. One very obvious improvement on the present hazardous state of the Mississippi navigation, would be the enactment of a law that the pressure of the steam should in no case exceed perhaps 50 lb. on the square inch.

The boilers of these steamers are all tubular, and have circular flues in them, which permit the passage of the flame through the body of the boiler. Those of the St Louis are nine in number. They are 42 inches in diameter, and 24 feet in length. Two circular flues 16 inches in diameter pass through the interior. The whole of the flues and outer coating of the boiler are made of sheet-iron three-sixteenths of an inch in thickness, and the end plates are formed of materials of greater strength. The boiler is strengthened by numerous internal ties, and is calculated to sustain a pressure of 100 lb.

on the square inch of surface. The only protection which the boilers have from the atmosphere is a layer of clay, with which they are in all cases covered, to prevent the radiation of heat.

The steamers make many stoppages to take in goods and passengers, and also supplies of wood for fuel. The liberty which they take with their vessels on these occasions is somewhat amusing, and not a little hazardous. I had a good example of this on board of a large vessel called the "Ontario." She was sheered close inshore among stones and stumps of trees, where she lay for some hours taking in goods. The additional weight increased her draught of water, and caused her to heel a good deal, and when her engines were put in motion, she actually crawled into the deep water on her paddle-wheels. The steam had been got up to an enormous pressure to enable her to get off, and the volumes of steam discharged from the escapement pipe at every half stroke of the piston made a sharp sound almost like the discharge of firearms, while every timber in the vessel seemed to tremble, and the whole structure actually groaned under the shocks.

During these stoppages, it is necessary to keep up a proper supply of water to prevent explosion, and the manner in which this is effected on the Mississippi is very simple. The paddle-wheel axle is so constructed, that the portions of it projecting over the hull of the vessel to which the wheels are fixed can be thrown out of gear at pleasure by means of a clutch on each side of the vessel, which slides on the intermediate part of the axle, and is acted on by a lever. When the vessel is stopped, the paddle-wheels are simply thrown out of gear, and the engine continues to work. The necessary supply of water is thus pumped into the boiler during the whole time that the vessel may be at rest, and when she is required to get under weigh, the wheels are again thrown into gear, and revolve with the paddle-wheel shaft. The fly-wheel, formerly noticed, is useful in regulating the motion of the engine, which otherwise might be apt to suffer damage from the increase and diminution in the resistance offered to the motion of the pistons, by suddenly throwing the paddle-wheels into and out of gear. The water for the supply of the engine is first pumped into a heater, in which its temperature is raised, and is then injected into the boiler.

I saw several vessels on the Ohio which had only one large paddle-wheel, placed at the stern; but it is doubtful whether this arrangement is advantageous, as the action of the paddle-wheel, when placed in that situation, must be impeded by the floatboards impinging on water which has been disturbed by the passage of the vessel through it.

The Mississippi steamers carry a captain, a clerk, two engineers, and two pilots, one of whom is always at the helm. The firemen and the crew are people of colour, and generally slaves. The passage from New Orleans to Pittsburg, against the current of the river, is generally performed in from fifteen to twenty days, and from Pittsburg to New Orleans in about ten days. The distance is rather more than 2000 miles, and the cabin-passage, including all expenses, is about L.10.

The third class of vessels to which I have alluded are those which navigate the Lakes and the River St Lawrence. They differ very materially from those I have already described, being more like the steamers of this country, both in their construction and appearance. Steamboats were first used on the St Lawrence in 1812, and it is probable that they were also introduced on the Lakes about the same time. The Lake steamers are strongly-built vessels, furnished with masts and sails, and propelled by powerful engines, some of which act on the high-pressure and some on the low-pressure principle.

The largest steamer on the Lakes in 1837 was the "James Madison." She measures 181 feet in length on the deck, 30 feet in breadth of beam, and 12 feet 6 inches in depth of hold. She carries about 700 tons of goods, and draws about 10 feet of water. This vessel plies between Buffalo on Lake Erie and Chicago on Lake Michigan, a distance of 950 miles. The hulls of the vessels are built in the ports on the shores of the Lakes, and the engines are generally made at Pittsburg. It is somewhat curious to find such vessels engaged in inland navigation; but their dimensions and strength are rendered necessary by the severe storms and formidable waves encountered on the Lakes, to which I have already particularly alluded, in the chapter on Lake Navigation.

Some of the St Lawrence steamboats, all of which are owned by her Majesty's subjects resident in Canada, are fine powerful vessels. The machinery of most of them is made at Montreal. The "John Bull" is the largest of these vessels, and measures 210 feet in length of deck, 33 feet 6 inches in breadth of beam, and draws 10 feet of water. She is propelled by two condensing engines, having cylinders 60 inches in diameter, and 8 feet in length of stroke. This steamer is principally employed in towing vessels; and of her performance in this way I have already spoken at page 88. She has a small engine of about 3 horses power for pumping water into the boilers while the vessel is at rest.

The vapour contained in the boiler of a steam-engine is liable to have its volume increased or diminished to a dangerous extent by sudden variations of temperature, and the application of an apparatus capable of counteracting the tendency of such changes of temperature to produce rupture is absolutely indispensable to the safe operation of the boiler. The want of the ordinary precautions necessary for insuring safety, or the inefficient manner in which these are applied, together with the very high pressure of the steam used in many of the American steamboats, and the recklessness of the engineers employed on some navigations, have occasioned many disastrous accidents in that country from the explosion of steam-boilers. These, however, as already stated, are now happily, in a great measure, confined to the vessels employed on the Western waters. The frequent occurrence of these accidents, and the melancholy consequences attending them, induced the Government of the United States in 1832, to institute an inquiry into "the causes of steamboat explosions, and the best means of preventing them." At that period a list of the explosions which had taken place was made up by Mr Redfield of New York, which I shall give at full length, as the best means of affording an idea of their extent and serious nature.

List of Steamboat Explosions which have occurred in the United States, by W. C. Redfield.

	When exploded.	Names.	Place of Explosion.	Killed.	Wounded.
High Pressure.	1817	Constitution, .	Mississippi, .	13	0
	...	General Robinson,	Do. . .	9	0
	...	Yankee, . .	Do. . .	4	0
	...	Heriot, . .	Do. . .	1	0
	1824	Etna, . . .	New York Bay, .	13	0
	1828	Grampus, . .	Mississippi, .	unknown	0
	...	Barnet, . .	Long Island Sound,	1	0
	1830	Helen Macgregor,	Mississippi, . .	33	14
	...	Caledonia, . .	Do. . .	11	11
	...	Carr of Commerce,	Ohio River, .	28	29
	...	Huntress, . .	Mississippi, .	unknown	0
	...	Fair Star, . .	Alabama, . .	2	0
	...	Porpoise, . .	Mississippi, .	unknown	0
				115	54
Low Pressure.	Previous to 1825	Enterprise, copper boiler, .	Charleston, S. C.,	9	4
	...	Paragon, do. .	Hudson River, .	1	1
	...	Alabama, . .	Mississippi, .	4	0
	...	Feliciana, . .	Do. .	2	0
	...	Arkansas, . .	Red River, . .	4	0
	...	Fidelity, copper boiler, . .	New York Harbour,	2	0
	...	Patent, do. . .	Do. .	5	2
	...	Atalanta, do. .	Do. .	2	0
	...	Bellona, do. .	Do. .	2	0
	...	Maid of Orleans, do.	Savannah River,	6	0
	...	Raritan, unknown,	Raritan, . .	1	0
	...	Eagle, do.	Chesapeake, .	2	several
	...	Bristol, . .	Delaware River,	0	1
	...	Powhatan, copper boiler, . .	Norfolk, . .	2	0
	1824	Jersey, do. . .	Jersey City, .	2	0
	1825	Tesch, . .	Mississippi, .	several	0
	...	Constitution, .	Hudson River, .	3	0
	...	Legislator, . .	New York Harbour,	5	2
	1826	Hudson, . .	East River, .	0	1
	...	Franklin, . .	Hudson River, .	1	0
	...	Ramapo, in Jan.,	New Orleans, .	5	2
	...	Do. in March,	Do. .	1	1
	1827	Oliver Ellsworth,	Long Island Sound,	3	0
	1830	Carolina, . .	New York Harbour,	1	0
		C. J. Marshal, copper boiler,	Hudson River, .	11	2
		United States, .	Long Island Sound,	9	0
	1831	General Jackson,	Hudson River, .	12 (supposed)	13
				95	29

N.B.—Of the above low-pressure explosions, ten were copper-boilers, from which were . . . . . killed 42, wounded 7
8 iron-boilers, ... do. 35, do. 3
9 boilers, metal unknown (probably iron), do. 18, do. 19

The number of copper-boilers in use is now very small compared with those of iron.

Character of Engines not specified.

When exploded.	Names.	Place of Explosion.	Killed.	Wounded.
	Cotton Plant, .	Mobile, . .	unknown	unknown
1816	Washington (high-p.),	Ohio River, .	7	9
1826	Macon, . . .	South Carolina, .	4	0
1827	Hornet (low-pres.),	Alabama, . .	2	2
1826	Susquehannah, .	Susquehannah, .	2	0
1027	Union (high-pres.),	Ohio River, .	4	7
1830	W. Peacock, . .	Buffalo, . .	15	0
...	Tallyho (high-pres.),	Cumberland River,	0	0
...	Kenhawa (low-pres.),	Ohio River, .	8	4
...	Atlas, . . .	Mississippi, .	1	0
...	Andrew Jackson,	Savannah River,	2	0
1831	Tricolor (low-pres.),	Ohio River, .	8	8
			46[53?]	21[30?]

Recapitulation.

	Killed.	Wounded.
13 High-pressure accidents, ...	115	54
27 Low-pressure do.	95	29
12 Character of engines unknown, supposed to be chiefly high-pressure, ...	46	21
52 Total,	256	104

"In so[illegible] principal accidents comprised in the foregoing list, th[illegible]er of killed includes all who did not recover from the[illegible] wounds. In other cases, the number killed are as given in the newspapers of the day, and some of the wounded should perhaps be added. In some few instances no list has been obtained, and possibly in some no loss of life occurred. The accounts of some of the minor accidents may have been lost sight of. In making an approximate estimate of the whole number of lives which have been lost in the United States by these accidents, I should fix it at 300."

A proper uninterrupted supply of water is the only safeguard against the occurrence of such explosions, which, from their nature, are equally apt to occur to low-pressure and high-pressure boilers. Some engines have self-acting pumps for the supply of water, and in others the injection-cock is under the control of the engineer, who, by opening or shutting it, regulates the supply. The latter plan is adopted in all locomotive engines, and in most of the American steamboats. It is of the greatest consequence that the water-pump should be so arranged as to work while the engine is at rest. The steamboats on the eastern part of the United States are not so constructed; but in the steamboats on the Mississippi and the St Lawrence, as formerly noticed, I found apparatus for effecting this important object.

The exposed situation in which the boilers of all the American steamboats are placed renders them very apt to *collapse*, an accident which has been of very frequent occurrence, and has on some occasions been attended with serious consequences.

The only adaptations for reducing the chances of accident which I found in use in the American steamboats were the single safety-valve, the steam-gauge, and the water-gauge, and in a few vessels the apparatus for continuing the supply of water while the vessel is at rest.

It appears from Mr Redfield's list of accidents, that there have been nearly four explosions every year for the last fourteen years, and an annual loss of twenty-one lives from these accidents. Of the forty cases regarding which definite information had been obtained, twenty-seven were low-pressure engines, and only thirteen high-pressure. The average loss of lives by each low-pressure accident is only three and a half, but the loss by high-pressure accidents averages nine on each occasion. This may be accounted for by the great elasticity of the steam in all the high-pressure engines in America, which in its escape causes proportionally greater mischief.

The following table, containing the dimensions of several of the best steamers plying in America in 1837, was compiled partly from actual measurement of the vessels, and partly from the report of the engineers in charge of them. To Mr Alfred Stillman of New York, I am indebted for much assistance in obtaining the information contained in it:—

DIMENSIONS OF AMERICAN STEAMBOATS PLYING IN 1837

DIMENSIONS OF AMERICAN STEAMBOATS PLYING IN 1837.

NAMES.	Length of Deck.		Breadth of Beam.		Depth of Hold.		No. of Engines.	Length of Stroke.	Diam. of Piston.	Diameter of Paddle-wheels.		Breadth of Do.	Dip of Do.	Draft of Water.	At what part of Stroke cuts off the Steam.	No. of Double Strokes per minute.	REMARKS.
	Ft.	In.	Ft.	In.	Ft.	In.		Ft.	In.	Ft.	In.	Ft.	In.	Ft.			
Dewit Clinton,	235	0	28	0	9	0	1	10	66	22	0	14	28	6	$\frac{3}{4}$ from bottom of cylinder.	...	An old boat, plying between New York and Albany.
Providence,	180	0	27	0	...		1	10	65	...		...	...	9	...	...	An old boat, plying between New York and Providence.
Champlain,	180	0	28	0	9	0	2	10	42	22	0	14½	30	...	$\frac{1}{3}$	26	Two fine vessels, plying between New York & Albany, having 4 boilers placed on the guards, 2 on each side; they burn 35 or 40 cords of wood per trip.
Erie,	180	0	28	0	9	0	2	10	44	22	0	14½	30	...	$\frac{1}{3}$	26	
North America,	206	0	26	0	8	0	2	8	44	...		...	...	...	...	...	
Independence,	148	0	26	0	...		1	10	44	...		...	...	...	...	...	Plying between New York and Albany.
Albany,	212	0	26	0	9	0	1	10	65	24	4	14	30	...	...	19	Do. Do.
Lexington,	207	0	21	0	11	0	1	11	48	23	0	9	30	...	...	24	... ...
R. L. Stevens,	175	0	24	0	...		1	10	36	22	0	11	...	...	...	...	Do. New York and Providence.
Bunkerhill,	...		24	0	9	0	1	11	41	21	6	11	24	...	...	26	... ...
Highlander,	175	0	24	0	8	0	1	10	41	20	0	9	29	...	$\frac{1}{3}$	29	Do. New York and Hartford.
Narragansett,	210	0	26	0	10	7	1	11½	56	25	0	11	26	5	$\frac{1}{2}$	24	Do. New York and Newburgh.
Massachusetts,	200	0	30	0	12	0	2	9	44	21	6	...	...	...	...	...	Do. New York and Providence.
Rhode Island,	210	0	26	0	...		1	11	60	24	0	11	30	6½	...	21	Do. do.
Swallow,	224	0	22	0	8	6	1	10	46	22	6	...	...	...	...	...	Do. do.
Rochester,	209	10	24	0	8	6	1	10	43	24	0	10	30	4	$\frac{1}{2}$	27	Do. New York and Albany.
Giraffe,	175	0	26	0	7	6	1	11	44	26	0	9	...	4	...	...	Do. do.
Utica,	180	0	21	6	...		1	10	39	22	0	10	...	...	...	...	Do. New Orleans and Mobile.
Winoosky,	135	0	21	0	...		1	7	33	19	0	7	22	4½	$\frac{1}{2}$	22	Do. New York and Albany.
New York,	228	0	22	8	...		1	10	50	24	6	12	30	4	$\frac{1}{2}$	22	Plying on Lake Champlain.
																	Plying between New York & Newhaven.

CHAPTER V.

FUEL AND MATERIALS.

Fuel used in Steam-Engines and for domestic purposes—Wood—Bituminous Coal—Anthracite Coal—Pennsylvanian Coal-mines—Boilers for the combustion of Anthracite Coal—Building Materials—Brick—Marble—Marble-quarries of New England and Pennsylvania—Granite—Timber—Mode of Conducting the "Timber Trade"—"Booms"—Rafts on the St Lawrence and on the Rhine—Woods chiefly used in America—Live Oak—White Oak—Cedar—Locust—Pine—"Shingles"—Dimensions of American Forest Trees.

I need scarcely mention, that wood is very much used as fuel throughout the greater part of the United States and the British dominions in America, both for domestic purposes and for steam-engines, excepting in the neighbourhood of most of the large towns, where, the surrounding country having been cleared and brought into cultivation, it has become very scarce, and much too valuable to be made use of in that way. In such situations coal has of course been substituted in its place. Still, however, throughout a large part of the territory of the United States the forest is looked to for the chief supply of fuel. The firewood is cut into pieces about four feet long, and twelve inches in girth, and is sold in piles four feet square, and eight feet in length, containing each 128 cubic feet, a measure called by the Americans, a "cord." It varies in price in different parts of the country. In 1837, I found that in new York a cord of wood cost about 20s.; in Albany, 14s.; on Lake Champlain, the average price is 9s.; on the St Lawrence, 7s. 3d.; and on Lake Ontario, 5s.; its value gradually decreasing as the country becomes less populous. On the Mississippi and Ohio, the price of wood was from 5s. to 8s. a cord. Many experiments have been made in America to ascertain the relative values of wood and coal as fuel for steam-engines; the result of which is, that about two and three-fourth cords of wood, and one ton of coal, generate, in well-constructed boilers, an equal quantity of steam. Pine timber is considered to be the best fuel: its texture is more open, and its combustion is more perfect than hardwood, the heart or interior of which, being less affected by the heat, is often left unconsumed.

An abundant supply of fresh air, and a capacious fireplace, are the great objects to be attained in furnaces intended for the combustion of wood. To insure the first of these desiderata, the boilers of the improved steamboats, as formerly mentioned, are placed on the guards of the vessel. No ash-pit is placed below the fire-grate; and the ashes and charcoal which come from the fire fall directly into the water, while a copious stream of fresh air, constantly ascending through the fire-bars, affords a large supply of oxygen for the combustion of the fuel. The most advantageous depth of the fire-grate, or the space left between the fire-bars and the bottom of the boiler for the reception of the wood, has been found in practice to be about three feet.

Bituminous coal occurs in large quantities on the western side of the Alleghany Mountains, and has been extensively worked in the neighbourhood of Pitsburg, where it is much used in the manufacture of iron. This coal is also found in other parts of the United States, particularly in New England and in Rhode Island. In the British dominions of Nova Scotia, a vein has also been opened at the Albion coal-mines, which is said to be fifty feet in thickness. The steamboats on the Ohio, and also on the St Lawrence, occasionally burn bituminous coal; but the fire-places are all too large for coal, having been constructed for the combustion of wood.

Anthracite coal has been more extensively worked, and is much more generally used in the United States for domestic purposes, than bituminous coal. The most extensive anthracite coal-fields occur in the State of Pennsylvania, on the courses of the rivers Schuylkill and Lehigh, the navigation of which has been improved at a great expense, to facilitate the carriage of the coal from the mines to the sea for shipment. It has also been found on the banks of the Merrimac, in New England.

The Schuylkill and Lehigh coal-fields lie between a mountain called the Blue Ridge and the River Susquehanna, and are situate about 100 miles north-east of Philadelphia, the port from which the coal is shipped. The most extensive workings are at Pottsville, on the Schuylkill, and Mauch Chunk, on the Lehigh. At Pottsville, the strata of coal dip from N.E. to S.W., at an angle of about 45°, and at Mauch Chunk they are nearly horizontal. They are in general worked by level drifts, carried into the face of a long range of rising ground, which is entirely composed of one vast bed of coal. The quantity brought from the Pennsylvanian mines to Delaware Bay during the year 1836, was no less than 696,526 tons.

The anthracite of North America has a strong resemblance to that found in some parts of Wales, and also in Ireland. It is exceedingly close-grained, has a bright lustre, and, when broken, the fracture presents a great variety of fine colours, from which circumstance it has received in America the name of "peacock-tail" coal. It requires a very high temperature for its combustion, and in order to obtain this, it is necessary that the fire-places in which it is used should be lined with a good non-conducting substance. It has been several times tried in the furnaces commonly used in steam-boats, but in the fire-places of the common construction it was found that the coal was brought too closely into contact with the bottom of the boiler and flues, and the caloric being too suddenly withdrawn from it, the fire burned languidly and was occasionally extinguished. Dr Nott of New York has bestowed much labour and time in constructing a boiler and fire-place suited for anthracite coal. These have been introduced in one or two steamboats, and particularly in some of the ferry-boats plying in the bay of New York. This kind of coal is also burned in the locomotive engines on the Baltimore and Washington Railway; but its application to the purpose of generating steam cannot yet be said to have assumed a more permanent character than that of an experiment.

The principle on which the anthracite boilers are constructed is sufficiently simple. The combustion of the fuel is carried on in a chamber lined with a non-conducting substance, which is quite detached from the boiler, and the heated air only is allowed to pass through the flues, so that the disadvantages arising from the rapid extraction of caloric from the fuel, which takes place in fire-places constructed for bituminous coal or wood, are in this boiler completely obviated. The coal is also broken into small pieces about the size of a hen's egg, and in this way a great surface is exposed to the atmospheric air, and a thorough combustion of the fuel is produced.

The anthracite coal is much used for domestic purposes in New York, Philadelphia, Baltimore, and Washington. It is burned sometimes in stoves, and sometimes in an open fire-place. The heat given out by it, when burned in either way, produces great dryness of the air, to remedy which, evaporating pans are generally used to secure a healthful amount of moisture in the apartments.*

* These remarks as to the important subject of fuel, the result of observations made several years ago, seem to be still applicable to the present state of the country, as Captain Galton in his Report to the Board of Trade on the railways of the United States, says,—"Notwithstanding that the coal, fields of the United States occupy an area of 130,000 square miles, and extend into Pennsylvania, Ohio, Indiana, Illinois, Kentucky, Virginia, and Michigan; until very recently, wood was the fuel invariably used on American railways. Wood has, however, risen very much in price lately, and on the prairie lines wood is not to be had, but coal is found in their vicinity; on other lines which pass through coal-measures, coal is a cheaper fuel, hence its use is gradually being extended on railways, and it will probably soon entirely supersede wood." Captain Galton also says that several attempts have been made to burn bituminous coal in engines without coking it, but adds, that he cannot give any decided opinion as to the satisfactory results of the arrangements; he further states, that anthracite coal is used on the Pennsylvania railways, and that a form of fire-box adopted by Mr Mulholland on the Philadelphia and Reading Railway "is stated to be very successful. It is shallow, with a large grate area, the bars are of cast-iron $\frac{3}{4}$-inch broad, and with $\frac{1}{2}$-inch spaces between them, and a row of air-holes

Brick is the building material uniformly used for dwelling-houses in the large towns in the United States, in most of which wooden structures are not now permitted to be erected. The public edifices, however, are generally built of marble, which is found in great abundance in different parts of the country.*

Several marble quarries have been opened in Massachusetts and in Vermont, which produce good materials for ordinary building purposes. The City Hall at New York, and the State House at Albany, have been built of the stone produced by these quarries. This marble has a white ground with blue streaks, but its colour lies in irregular patches, and its effect in a building is not good. The finest marble is found in the neighbourhood of Philadelphia, where several quarries have been opened, and are at present extensively worked. This stone, laid down at Philadelphia (1837), costs from 4s. to 7s. per cubic foot, according to its quality. The Bank of the United States, the Philadelphia Bank, the Mint, the Exchange, and many other public edifices in Philadelphia, are built from these quarries, which afford pure white marble of very good quality. The public buildings in Philadelphia, most of which were designed by Mr Strickland, architect in that city, present by far the finest specimens of architectural design which are to be met with in the United States, and the extreme purity of the marble of which they are built adds greatly to their general effect. The new Girard College at Philadelphia, designed by Mr Walter, architect, was, when I saw it, in an advanced state of progress, and promised, when completed, to be a magnificent building. The marble of the United States is rather coarse in the grain, and not very suitable for forming the finely-wrought

4 inches deep by 1½ inch wide, which can be opened and closed at pleasure, extends along the front of the fire-box, just over the bars. There is also an arrangement to admit air to the heated gases near the tube-plate. The anthracite coal is spread evenly over the grate bars in a layer 6 inches thick. —(*Report to the Board of Trade on the Railways of the United States*, by Captain Douglas Galton, R.E., London, 1857.

* I am indebted to Mr Struthers of Philadelphia for some interesting information regarding the marbles of the United States.

capitals of columns; and the materials of those parts of all the pillars of the public buildings in Philadelphia were therefore brought from Italy.

I visited some of the quarries in the neighbourhood of Philadelphia, in which the beds of marble dipped from north to south at an inclination of 60° with the horizon. In one of them the quarriers were working a bed fourteen feet in thickness, at a depth of one hundred and twenty feet below the surface. The blocks, some of which weighed twelve tons, are raised to the surface of the ground by means of a horse-gin. A thick layer of common limestone rests on the marble; this is blasted off with gunpowder, and burned for making mortar.

Grey-coloured granite, of excellent quality, occurs at Quincy in Massachussetts, and Singsing on the Hudson. The only hydraulic works in which it has been used are the graving-docks at Boston and Norfolk, which have been already noticed; but it has also been used a good deal in New York for door-lintels and stairs, and latterly it has been introduced for public buildings. The Astor Hotel, the Gaol, and some others, are formed of it.

It is much to be regretted that there are no building materials in the neighbourhood of New York. On examining the ground laid open in some of the railway cuttings in the vicinity of the town, I found it to consist of a stratum of gravel from ten to fifteen feet in depth, with boulder-stones of granite, mica-slate, greenstone, and red sandstone; below this, mica-slate occurs, dipping from north to south at an angle of 45°; but is not fit for building purposes. This formation occurs on the island of Manhattan, on which the town of New York stands, and also on Long Island, which protects its harbour.

The fine timber which the country produces is much employed in all the American engineering works, and serves in some degree to compensate for the want of stone, while it also affords great advantages for ship-building and carpentry, which have been brought to high perfection in America. The "lumber" trade, as it is called in America,—that is to say, the trade in wood,—is carried on to a greater or less extent on almost all the American rivers; but on the Mississippi and the St Lawrence it affords employment to a vast number of persons. The chief raftsmen, under whose directions the timber expeditions are conducted, are generally persons of very great intelligence, and often of considerable wealth. Sometimes these men, for the purpose of obtaining wood, purchase a piece of land, which they sell after it has been cleared, but more frequently they purchase only the timber from the proprietors of the land on which it grows. The chief raftsman, and his detachment of workmen, repair to the forest about the month of November, and are occupied during the whole of the winter months in felling trees, dressing them into logs, and dragging them by teams of oxen to the nearest stream, over the hardened snow, with which the country is then covered. They live during this period in huts formed of logs. Throughout the whole of the newly cleared districts of America, indeed, the houses are built of rough logs, which are arranged so as to form the four sides of the hut, and their ends are half-checked into each other in such a manner as to allow of their coming into contact nearly throughout their whole length, and the small interstices which remain are filled up with clay. About the month of May, when the ice leaves the rivers, the logs of timber that have been prepared, and hauled down during winter, are launched into the numerous small streams in the neighbourhood of which they have been cut, and are floated down to the larger rivers, where their progress is stopped by what is called a "boom." The boom consists of a line of logs, extending across the whole breadth of the river. These are connected by iron links, and attached to stone piers built at suitable distances in the bed of the stream.

The boom is erected for the purpose of stopping the downward progress of the wood, which must remain within it till all the timber has left the forest. After this, every raftsman searches out his own timber, which he recognises by the mark he puts on it, and, having formed it into a raft, floats it down the river to its destination.

The boom is generally owned by private individuals, who levy a toll on all the wood collected by it. The toll on the Penobscot River is at the rate of three per cent. on the value of the timber.

The rafts into which the timber is formed, previous to being floated down the large rivers, are strongly put together. They are furnished with masts and sails, and are steered by means of long oars, which project in front as well as behind them. Wooden houses are built on them for the accommodation of the crew and their families. I have counted upwards of thirty persons working the steering oars of a raft on the St Lawrence; from this some idea may be formed of the number of their inhabitants.

The most hazardous part of the lumberer's business is that of bringing the rafts of wood down the large rivers. If not managed with great skill, they are apt to go to pieces in descending the rapids: and it not unfrequently happens, that the whole labour of one, and sometimes two years, is in this way lost in a moment. An old raftsman, with whom I had some conversation on board of one of the steamers on the St Lawrence, informed me that each of the rafts brought down that river contains from L.3000 to L.5000 worth of timber, and that he, on one occasion, lost L.2500 by one raft, which grounded in descending a rapid, and broke up. The safest size for a raft, he said, was from 40,000 to 50,000 square feet of surface; and when of that size they require about five men to manage them. Some are made, however, which have an area of no less than 300,000 square feet. These unwieldy craft are brought to Quebec in great numbers from distances varying from one to twelve hundred miles; and it often happens that six months are occupied in making the passage. They are broken up at Quebec, where the timber is cut up for exportation into planks, deals, or battens, at the numerous saw-mills with which the banks of the St Lawrence are studded for many miles, in the neighbourhood of the town. Sometimes the timber is shipped in the form of logs. The timber-rafts of the Rhine are, perhaps, the only ones in Europe that can be compared to those of the American rivers; but none of those which I have seen on the Rhine were nearly so large as those on the St Lawrence, although some of them were worked by a greater number of hands, a precaution rendered necessary perhaps by the more intricate navigation of the river.

The woods exported from the St Lawrence are white oak (*Quercus alba*), the average price of which is 15d. a cubic foot; white pine (*Pinus strobus*), 4½d.; red pine (*Pinus resinosa*), 10½d.; elm (*Ulmus Americana*), 4½d.; and white ash (*Fraxinus acuminata*), 10d. These, according to the information I received, are the average prices at which the wood sold at Quebec in 1837.

The woods used for ship-building in the United States are live-oak (*Quercus virens*), white oak (*Quercus alba*), white cedar (*Cupressus thyoides*), locust (*Robinia pseud-acacia*), yellow pine (*Pinus variabilis*), and long-leaved pine (*Pinus palustris*, or *australis* of Michaux).

The live oak, so called because it is an evergreen, grows only in the Southern States. This valuable wood is too heavy to be applied to a great extent in ship-building, its specific gravity being greater than that of water, and it is generally used along with white oak and cedar for the principal timbers only. "The climate becomes mild enough for its growth near Norfolk, in Virginia, though at that place it is less multiplied and less vigorous than in a more southern latitude. From Norfolk it spreads along the coast for a distance of fifteen or eighteen hundred miles, extending beyond the mouth of the Mississippi. The sea air seems essential to its existence, for it is rarely found in the forests upon the mainland, and never more than fifteen or twenty miles from the shore. It is most abundant, most fully developed, and of the best quality, about the bays and creeks, and on the fertile islands which in great numbers lie scattered for several hundred miles along the coast. The live oak is commonly forty or fifty feet in height, and from one to two feet in diameter, but it is sometimes much larger."*

* The Sylva Americana. By J. D. Browne, Boston, 1832.

White cedar is considered the most durable timber in use in America. It grows in the Northern States to the height of forty-five or fifty feet, and is sometimes more than ten feet in circumference. The wood is reddish, and somewhat odorous. It is much used in fences, and also for railway sleepers. It does not exist in a natural state in Canada; but the arborvitæ, which is there called white cedar, is put to all those purposes to which white cedar is applied in the United States. Locust is a hard and durable timber, and is used for treenails. It grows most abundantly in the Southern States; but it is pretty generally diffused throughout the whole country. It sometimes exceeds four feet in diameter, and seventy feet in height. The locust is one of the very few trees that are planted by the Americans. They are often seen forming hedge-rows in the cultivated parts of Pennsylvania. The yellow pine is chiefly confined to the western countries and the range of the Alleghany Mountains; and the long-leaved pine is entirely confined to the Southern States. These pines are usually employed for the masts and spars of vessels.*

Timber is employed in great quantities in the construction of quays, railways, canal locks, aqueducts, bridges, roofing of houses, and, in short, for every purpose to which it can possibly be applied. The wood used for roofing is formed into pieces called shingles, which measure eighteen inches in length, four inches in breadth, and one-third of an inch in thickness. They are nailed on the rafters of the house, and arranged in the same manner as the slates used in this country. Six inches of each single is exposed to the weather, and as each piece of wood is eighteen inches in length, every part of the roof has three thicknesses of wood, or, in other words, is one inch in thickness. The shingles are generally made of white pine, cedar, or arborvitæ. They

* I would refer such of my readers as desire information regarding the American forest-trees to an excellent paper in the "Agricultural Journal" for 1835, on the local distribution of trees in the native forests of America, by Mr James Macnab of Edinburgh, who made an extensive botanical tour in the United States and Canada.

are split with a single blow of the axe, and afterwards smoothed with an instrument resembling a spoke-shave. They cost, in 1837, 8s. per thousand.

The American forests are particularly interesting to the traveller in that country. According to Mr Browne, whose work I have already quoted, there are no less than 140 species of forest-trees indigenous to the United States, which exceed 30 feet in height. In France there are about thirty, and in Great Britain nearly the same number. One may travel a great way in America without finding a single tree of very large dimensions. But the average size of the trees is far above what is to be met with in this country. The largest which I measured was a buttonwood-tree (*Platanus occidentalis*) on the banks of Lake Erie, which I found to be 21 feet in circumference; but I measured very many varying from 15 to 20 feet. M. Michaux mentions, that on a small island in the Ohio, fifteen miles above the mouth of the Muskingum, there was a buttonwood-tree, which, at five feet from the ground, measured 40 feet 4 inches in circumference, giving a diameter of about 13 feet. He mentions another on the right bank of the Ohio, thirty-six miles above Marietta, whose base was swollen in an extraordinary manner; at four feet from the ground it was 47 feet in circumference. This tree ramified at the height of 20 feet from the ground. Another of equal size is mentioned as existing in Genesse. M. Michaux also measured two trunks of white pine on the River Kennebec, one of which was 154 feet long, and 54 inches in diameter, and the other was 142 feet long, and 44 inches in diameter at three feet from the ground. He also measured one which was 6 feet in diameter, and had reached the greatest height attained by the species, its top being about 180 feet from the ground.

CHAPTER VI.

CANALS.

Internal Improvements of North America—Great extent of the Canals and Railways—Introduction of Canals into the United States and Canada—Great length of the American Canals—Small area of their Cross Sections—North Holland Ship Canal—Difference between American and British works—Use of wood very general in America—Wooden Canal-Locks, Aqueducts, &c.—Artificial navigation of the country stopped by ice—Tolls levied, and mode of travelling on the American Canals—Means used in America for forming water-communications—Slackwater navigation on the River Schuylkill, &c.—Construction of Dams, Canals—Locks—Erie Canal—Canal Basin at Albany—Morris Canal—Inclined Planes for Canal lifts, &c.

The Americans have not rested satisfied with the natural inland navigation afforded by their rivers and lakes, nor have they made the bounty of Nature a plea for idleness or want of energy; but, on the contrary, they have been zealously engaged in the work of internal improvement; and their country now numbers, among its many wonderful artificial lines of communication, a mountain railway, which, in boldness of design and difficulty of execution, I can compare to no modern works I have ever seen, excepting, perhaps, the passes of the Simplon, and Mount Cenis in Sardinia; but even these remarkable passes, viewed as engineering works, did not strike me as being more wonderful than the Alleghany Railway in the United States.

The objects to which the Americans have chiefly directed their exertions for the advancement of their country in the scale of civilization, are the removal of obstructions in navigable rivers; the junction of different tracks of natural navigation; the connection of large towns, and the formation of lines of communication from the Atlantic Ocean to the great lakes and the valleys of the Mississippi, Missouri, and Ohio. The number and extent of canals and railways which they have executed in effecting these important objects, sufficiently prove that their exertions, during the time they have been so engaged, have been neither small nor ill-directed.

Since my visit to the country, their railway system has been, as I shall afterwards explain, vastly extended; but there is reason to suppose that the following account of the canals, although written sometime ago, will be found to convey a pretty fair description of the state of these works at the present time.

The stupendous canals which have been executed enable vessels, suited to the inland navigation of the country, to pass from the Gulf of St Lawrence to the Gulf of Mexico, and also from the city of New York to Quebec on the St Lawrence, or to New Orleans on the Mississippi, without encountering the dangers of the Atlantic Ocean. But, that the reader may be better able to understand the extent of lines of inland navigation so enormous, I shall give in detail the route from New York to New Orleans, which in 1837 was constantly made by persons travelling between those places.

		Miles
From	New York to Albany by the River Hudson, the distance is, .	150
„	Albany to Buffalo by the Erie Canal, ...	363
„	Buffalo to Cleveland by Lake Erie, ...	210
„	Cleveland to Portsmouth by the Ohio Canal, ...	309
„	Portsmouth to New Orleans by the Ohio and Mississippi Rivers,	1670
	Total distance, .	2702

This extraordinary inland journey of no less than 2702 miles, is performed entirely by means of water communication; 672 miles of the journey are performed on canals, and the remaining 2030 miles of the route is river and lake navigation.

Several short canals were made for improving the river navigation in the United States about the end of the last century; but the first work of any importance in that country was the Santee Canal, in the State of South Carolina, which was opened in the year 1802; and the first in the British dominions in America was the Lachine Canal in Lower Canada, opened in the year 1821. The great length of many of the American canals is one remarkable feature in these astonishing works. In this respect they far surpass anything of the kind hitherto constructed in Europe. The longest canal in Europe is the Languedoc, which has a course of 148 miles; and the most extensive in the United States is the Erie Canal, which is no less than 363 miles in length. But the cross-sectional area of the American canals is by no means so great as that of many in Europe. At the time when canals were introduced into America the trade of the country was small, and did not warrant the expenditure of large sums of money in their construction, the chief object being to form a communication with as little loss of time, or outlay of capital, as was consistent with a due regard to the safety and stability of the work. It is not to be expected, therefore, that the American works, although on an extensive scale, should have been originally constructed in the same spacious style as those of older and more opulent countries. The dimensions of many of the canals in the United States were consequently found to be inconveniently small for the increased traffic which they have to support; and the great Erie Canal, as well as some others, was, when I was in the country, undergoing extensive alterations, by which its breadth was to be increased from 40 to 70 feet, and its depth from 4 to 7 feet.

English and American engineers are guided by the same principles in designing their works; but the different nature of the materials employed in their construction, and the climates and circumstances of the two countries, naturally produce a considerable dissimilarity in the practice of civil-engineers in England and America. At the first view, one is struck with the temporary and apparently unfinished state of many of the American works, and is very apt, before inquiring into the subject, to impute to want of ability what turns out, on investigation, to be a judicious and ingenious arrangement to suit the circumstances of a new country, of which the climate is severe,—a country where stone is scarce and wood is plentiful, and where manual labour is very expensive. It is vain to look to the American works for the finish that characterizes those of France, or the stability for which those of Britain are famed. Undressed slopes of cuttings and embankments, roughly built rubble arches, stone parapet-walls coped with timber, and canal-locks wholly constructed of that material, everywhere offend the eye accustomed to view European workmanship. But it must not be supposed that this arises from want of knowledge of the principles of engineering, or of skill to do them justice in the execution. The use of wood, for example, which may be considered by many as inapplicable to the construction of canal-locks, where it must not only encounter the tear and wear occasioned by the lockage of vessels, but must be subject to the destructive consequences of alternate immersion in water and exposure to the atmosphere, is yet the result of deliberate judgment. The Americans have, in many cases, been induced to use the material of the country, ill adapted though it be in some respects to the purposes to which it is applied, in order to meet the wants of a rising community, by speedily and perhaps superficially completing a work of importance, which would otherwise be delayed, from a want of the means to execute it in a more substantial manner; and although the works are wanting in finish, and even in solidity, they do not fail for many years to serve the purposes for which they were constructed, as efficiently as works of a more lasting description.

When the wooden locks on any of the canals begin to show symptoms of decay, stone structures can be substituted, and materials suitable for their erection are with ease and expedition conveyed from the part of the country where they are most abundant, by means of the canal itself to which they are to be applied; and thus the less substantial work ultimately becomes the means of facilitating its own improvement, by affording a more easy, cheap, and speedy transport of those durable and expensive materials, without the use of which, perfection is unattainable.

As a farther advantage to be derived from the use of wood in such new countries as America, it may be stated that in proportion as improvement advances and greater dimensions or other changes are required, they can be introduced at little cost, and without the mortification of destroying expensive and substantial works of masonry. Some of the locks on the great Erie Canal are formed of stone, but had they all been made of wood, it would probably have been converted into a ship-canal long ago.

But the locks are not the only parts of the American canals in which wood is used. Aqueducts over ravines or rivers are generally formed of large wooden troughs resting on stone pillars, and even more temporary expedients have been chosen, the ingenuity of which can hardly fail to please those who view them as the means of carrying on improvements, which, but for such contrivances, would be stopped by the want of funds necessary to complete them.

Mr M'Taggart, the resident engineer for the Rideau Canal in Canada, gave a good example of the extraordinary expedients often resorted to, by suggesting a very novel scheme for carrying that work across a thickly wooded ravine, situate in a part of the country where materials for forming an embankment, or stone for building the piers of an aqueduct, could not be obtained but at a great expense. The plan consisted of cutting across the large trees in the line of the works, at the level of the bottom of the canal, so as to render them fit for supporting a platform on their trunks, and on this platform the trough containing the water of the canal was intended to rest. I am not aware whether this plan was carried into effect, but it is not more extraordinary than many of the schemes to which the Americans have resorted in constructing their public works; and the great traffic sustained by many of them, notwithstanding the temporary and hurried manner in which they are finished, is truly wonderful. The number of boats navigating the Erie Canal in 1836 was no less than 3167, and the average number of lockages 118 per day; facts which clearly prove the efficiency as well as the utility of the work.

With the exception of some few works in the most southern States of the Union, the artificial navigation of North America, as well as that of the northern rivers and lakes, is completely suspended during a period of from three to five months every year. During that time the water is always withdrawn from the canals and feeders. This precaution is absolutely necessary, as the intense frost with which the country is then visited very soon proves destructive to the locks and aqueducts, by the expansion of the water, which, if permitted to remain in them, is speedily converted into a mass of ice.

The rate of travelling which has been adopted on the American canals, the charges for the conveyance of passengers and goods, and the general laws for regulating canal transport, are fixed by the commissioners who have charge of the different works, and are not exactly the same in every State. The following observations, however, regarding the mode of travelling on the Pennsylvania State canals, are applicable to all others in the country.

The tolls paid to the State, by the persons who have boats on these canals, are three halfpence per mile for each boat, and three farthings per mile for each passenger conveyed in them. The passenger-boats vary from twelve to fifteen feet in breadth, and are eighty feet in length. The large-sized boats weigh about twenty tons, and cost L.250 each, and when loaded with a full complement of passengers, draw twelve inches of water. They are dragged by teams of three horses, which run ten-mile stages. The length of the tow-line generally used is about 150 feet, and the rate of travelling is from four to four and a half miles per hour.

The canal travelling in many parts of America is conducted with so little regard to the comfort of passengers as to render it a very objectionable conveyance. The Americans place themselves entirely in the power and at the command of the captains of the canal-boats, who often use little discretion or civility in giving their orders; and strangers who are unaccustomed to such usage, and would willingly rebel against their tyranny, are compelled to be guided by the majority of voices, and to submit quietly to all that takes place, however disagreeable it may be. About eight o'clock in the evening, every one is turned out of the cabin by the captain and his crew, who are occupied for some time in suspending from the ceiling two rows of cots or hammocks, arranged in three tiers, one above another. At nine, the whole company is ordered below, when the captain calls the names of the passengers from the way-bill, and at the same time assigns to each his bed, which must immediately be taken possession of by its rightful owner on pain of his being obliged to occupy a place on the floor, should the number of passengers exceed the number of beds, a circumstance of very common occurrence in that locomotive land. I have spent several successive nights in this way, in a cabin only 40 feet long by 11 feet broad, with no fewer than forty passengers; while the deafening chorus produced by the croaking of the numberless bull-frogs that frequent the American swamps was so great, as to render it often difficult to make one's-self heard in conversation, and, of course, nearly impossible to sleep. The distribution of the beds appears to be generally regulated by the size of the passengers; those that are heaviest being placed in the berths next the floor. The object of this arrangement is partly to ballast the boat properly, and partly, in the event of a breakdown, to render the consequence less disagreeable and dangerous to the unhappy beings in the lower pens. At five o'clock in the morning, all hands are turned out in the same abrupt and discourteous style, and forced to remain on deck in the cold morning air while the hammocks are removed and breakfast is in preparation. This interval is occupied in the duties of the toilette, which is not the least amusing part of the arrangement. A tin vessel is placed at the stern of the boat, which every one washes and fills for his own use from the water of the canal, with a gigantic spoon formed of the same metal; a towel, a brush, and a comb, intended for the general service, hang at the cabin door, the use of which, however, is fortunately quite optional. The breakfast is served between six and seven o'clock, dinner at eleven, and tea at five. The American canal travelling certainly forms a great contrast to that of Holland and Belgium. The boat in which I was conveyed on the canal between Ghent and Bruges, for example, was commodiously fitted up with separate state rooms, containing one berth in each, and was, in other respects, a most comfortable and agreeable conveyance. But I trust the reader will not form an estimate of American travelling from what has just been said, nor take this single specimen of it as a criterion of the whole. In the eastern and earlier settled districts of the country no such grievances have to be suffered, and there are many hundreds of persons in that part of the United States who hardly believe in their existence. So long as the traveller keeps on the east of the Alleghany Mountains, all goes on smoothly, but if he attempts to cross their summits, and to penetrate into the "far west," he must look for treatment such as I have described. There is indeed as great a difference in this respect between the seaward and interior States of North America as there is between the counties of Kent and Caithness.

But I return from these petty troubles to the consideration of a subject of more importance, namely, the works which have been employed in forming the inland lines of water communication in America. These are of two kinds, called "Slackwater" or "Stillwater" navigation and Canals. The slackwater navigation is the more simple of these operations, and can generally be executed at less expense. It consists in improving a river by the erection of dams or mounds built in the stream, by which the water is dammed back, and its depth is increased. If there be not a great fall in the bed of the river, a single dam often produces a stagnation in the run of the water, extending for many miles up the river, and forming a spacious navigable canal. The tow-path is formed along the margin of the river, and is elevated above the reach of flood-water. The dams are passed by means of locks, such as are used in canals. This method of forming water communication has been extensively and successfully introduced in America, where limited means and abundance of rivers rendered it peculiarly applicable. One of the most extensive works on this principle in the country was constructed by the Schuylkill Navigation Company, in the State of Pennsylvania, and consisted in damming up the water of the river Schuylkill. It extends from Philadelphia to Reading, and is situate in the heart of a country abounding in coal, from the transport of which the Company derives its chief revenue. It is 108 miles in length, and its construction cost about L.500,000. This line of navigation is formed by thirty-four dams thrown across the stream, with twenty-nine locks, which overcome a fall of 610 feet. It is navigated by boats from fifty to sixty tons burden. These dams are constructed somewhat on the same principle as that erected on the Schuylkill at Fairmount water-works, near Philadelphia. A detailed description of this dam is given in the chapter which treats of water-works.

One great objection to this mode of forming inland navigation, is the necessity of constructing works of great strength, sufficient to enable them to withstand the floods and ice to which they are exposed, and by which they are very apt to be damaged, or even carried away. Accidents of this kind, however, may be in a great measure guarded against by making a judicious selection of situations for the dams and locks, and placing them in such a manner in the bed of the river, that the current may act on them in the direction least detrimental to their stability, as has been done in the dam at Fairmount water-works just alluded to.*

The number of boats which passed through the locks of the Schuylkill navigation in 1836 was 24,470, the tolls on which amounted to L.14,043. The various articles taken up the river during that year weighed 61,079 tons, and

* Sir Wm. Cubitt has formed several reaches of slackwater navigation on the Severn, by erecting dams of masonry, which have been very successful. (*Stevenson's Canal and River Engineering.* A. and C. Black. Edinburgh, 1858.)

those brought towards the sea 570,094 tons, of which 432,045 tons were anthracite coal, from the State of Pennsylvania.

Slackwater navigation also occurs at intervals on many of the great lines of canal. About 78 miles of the Rideau Canal, in Canada, are, as formerly noticed, formed in this way, and in the United States it is met with on the Erie, Oswego, Pennsylvania, Frankston, Lycoming, and Lehigh Canals. The works which have been executed in forming most of the water communications in America, however, are not generally of the slackwater kind, but resemble the canals in use in Europe, being, in fact, artificial trenches or troughs, with locks to enable vessels to pass from one level to another. The locks are furnished with boom-gates, which are opened and shut by a long lever fixed to the tops of the heel and mitre posts. The sluices by which the water is admitted into the locks are placed in the lower part of the gates. They are in general common hinge-sluices, opened by means of a rod extending to the top of the gates, and worked by a crank handle.

The canals of this construction in the United States are so very numerous, and resemble each other so much, that I do not consider it necessary to give a detailed description of the various works which have been executed on all of them, but shall content myself with giving a brief sketch of the Erie Canal, which was the first in America on which the conveyance of passengers was attempted, and is the longest canal in the world regarding which we possess accurate information.

The Erie Canal was commenced in 1817, and completed in 1825. The main line leading from Albany, on the Hudson, to Buffalo, on Lake Erie, measures 363 miles in length, and cost about L.1,400,000 sterling. The Champlain, Oswego, Chemung, Cayuga and Crooked Lake Canals, and some others, join the main line, and, including these branch canals, it measures 543 miles in length, and cost upwards of L.2,300,000. This canal is forty feet in breadth at the water line, twenty-eight feet at the bottom, and four feet in depth.

Its dimensions proved too small for the extensive trade which it had to support, and, as already stated, the depth of water was, when I saw it, being increased to seven feet, and the extreme breadth of the canal to sixty feet. The country through which it passes is admirably suited for canal navigation, and there are only eighty-four locks on the main line. These locks are each ninety feet in length, and fifteen in breadth, and have an average lift of eight feet two inches. The total rise and fall is 692 feet. The tow-path is elevated four feet above the level of the water, and is ten feet in breadth. The Erie Canal begins at Buffalo, on Lake Erie, and extends for a distance of about ten miles along the banks of Lake Erie and the river Niagara, as far as Tonewanta Creek. By means of the slackwater navigation, formerly described, the channel of the Tonewanta is rendered navigable for the distance of twelve miles, and the canal is then carried through a deep cutting, extending seven and a-half miles, to Lockport. Here it descends sixty feet by means of five locks excavated in solid rock, and afterwards proceeds on a uniform level for a distance of sixty-three miles to Genessee River, over which it is carried on an aqueduct having nine arches of fifty-feet span each. Eight and a half miles from this point it passes over the Cayuga marsh, on an embankment two miles in length, and in some places, seventy feet in height. It then passes through Lakeport and Syracuse, and at this place the "long level" commences, which extends for a distance of no less than sixty-nine and a-half miles to Frankfort, without an intervening lock. After leaving Frankfort, the canal crosses the river Mohawk, first by an aqueduct of 748 feet in length, supported on sixteen piers, elevated twenty-five feet above the surface of the river, and afterwards by another aqueduct 1188 feet in length, and at last reaches the town of Albany.

Albany is the capital of the State of New York, and contains a population of about 30,000. It is situate on the west, or right bank of the Hudson, at the head of the natural navigation of the river; but some improvements have been made, which enable vessels of small burden to ascend as far as

Waterford, thirteen miles above Albany. One of these improvements has been effected by the erection of a dam across the Hudson 1100 feet in length and 9 feet in height, at a cost of upwards of L.18,000. The lock connected with this dam measures 114 feet in length and 30 feet in breadth. Albany, however, may be said to monopolize the trade of the river, and, in addition to the interest it possesses as a place of great commerce, it is important from its position at the outlet of the Erie Canal, and has a large basin or depôt for the accommodation of the boats or vessels. This basin, which has an area of thirty-two acres, is formed by an enormous mound, placed parallel to the stream of the River Hudson, and enclosing a part of its surface. The mound is composed chiefly of earth, and is 4300 feet in length and 80 feet in breadth, and being completely covered with large warehouses, it now forms a part of the town of Albany, with which it is connected by means of numerous drawbridges. The place has, in consequence, very much the same appearance as many of the Dutch towns. The lower extremity of the mound is unconnected with the shore, a large passage being left for the ingress and egress of vessels, but its upper end is separated from the bank of the river by a smaller opening, which is closed, when necessary, to prevent ice from injuring the craft lying in the basin. A stream of water is generally allowed to enter at the upper end, which, flowing through the basin, acts as a scour, and prevents it from silting up. The mound is surrounded by a wooden wharf like those of New York and Boston, at which vessels discharge and load their cargoes. This admirable basin forms a part of the Erie Canal works, and cost about L.26,000.

According to the report of the Canal Commissioners, dated March 1837, the number of boats registered in the Comptroller's office as navigating the Erie Canal and its branches, was,—

In 1834,	.	2585	
„ 1835,	.	2914	Increase, 329
„ 1836,	.	3167	„ 253

The total number of clearances or trips made during the same year was,—

In 1834,	.	64,794
„ 1835,	.	69,767
„ 1836,	.	67,270

The average number of lockages per day at each lock was,—

In 1834,	.	95½
„ 1835,	.	112
„ 1836,	.	113

The whole tonnage transported on the canal during the year 1836 was 1,310,807 tons, the value of which amounted to 67,643,343 dollars, or L.13,526,868. The proportion between the weight of freight conveyed from the Hudson to the interior of the country and that conveyed from the interior of the country to the Hudson, was in the ratio of one to five. The tolls collected in 1836, for the conveyance of goods and passengers, amounted to L.322,867. The rates of charge, according to which the tolls are collected, are annually changed, to suit the circumstances of the trade, and are not the same throughout the whole line of the canal, which renders it difficult to give a view of them. In 1836, the passage-money from Albany to Buffalo in the packet-boat was L.3, 3s., being at the rate of nearly 2d. per mile; and in a line-boat, which is an inferior conveyance, L.1, 18s., being at the rate of one-penny and two-tenths per mile. The expenditure for keeping the canal and its branches in repair during 1836 was 410,236 dollars, or about L.82,047, which, taking the whole length at 543 miles, gives an average of L.151 per mile. The average cost of repairs for the six preceding years amounted to L.136 per mile.

Before leaving the subject of canals, I must not omit to mention the Morris Canal, in the state of New Jersey, which I visited in company with Mr Douglass, the engineer for that work, to whom I am essentially indebted for the information and attention which I received from him during my stay in America. This canal leads from Jersey on the Hudson to Easton on the Delaware, and connects these two rivers. The breadth at the water-line is thirty-two, and at the bottom sixteen feet, and the depth is four feet. It is 101 miles in length, and is said to have cost about L.600,000. It is peculiar as being the only canal in America in which the boats are moved from different levels by means of inclined planes instead of locks. The whole rise and fall on the Morris Canal is 1557 feet, of which 223 feet are overcome by locks, and the remaining 1334 feet by means of twenty-three inclined planes, having an average lift of 58 feet each. The boats which navigate this canal are 8½ feet in breadth of beam, from 60 to 80 feet in length, and from twenty-five to thirty tons burden. The greatest weight ever drawn up the planes is about fifty tons. Plate VI. is a drawing of one of the boat-cars used on this canal. Fig. 1 is an elevation, in which the boat is shown in dotted lines; and fig. 2 is a plan of the car. It consists of a strongly made wooden crib or cradle, marked *a*, on which the boat rests, supported on two iron waggons running on four wheels. When the car is wholly supported on the inclined plane, or is resting on a level, the four axles of the waggons, *b*, are all in the same plane, as shown by the dotted line *x y*; but when one of the waggons rests on the inclined plane, and the other on the level surface, their axles no longer remain in the same plane, and their change of position produces a tendency to rack the cradle, and the boat which it supports; but this has been guarded against in the construction of the boat-cars on the Morris Canal by introducing two axles, shown at *c*, on which the whole weight of the crib and boat are supported, and on which the waggons turn as a centre. The cars run on plate-rails laid on the inclined planes, and are raised and lowered by means of machinery driven by water-wheels. I examined several of the planes on this canal near Newark, which appeared to operate remarkably well. The railway, on which the car runs, extends along the bottom of the canal for a short distance from the lower extremity of the plane; when a boat is to be raised, the car is lowered into the water, and the boat being floated over it,

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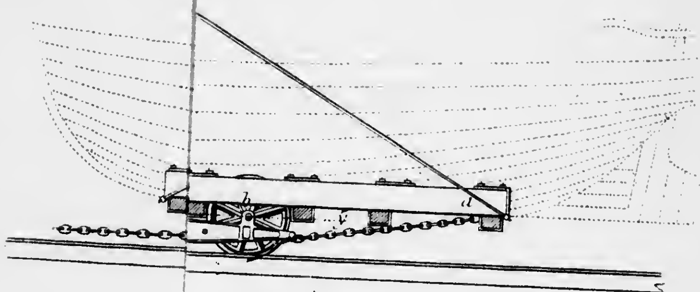

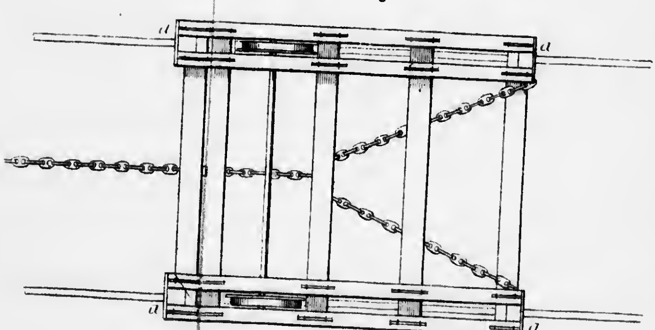

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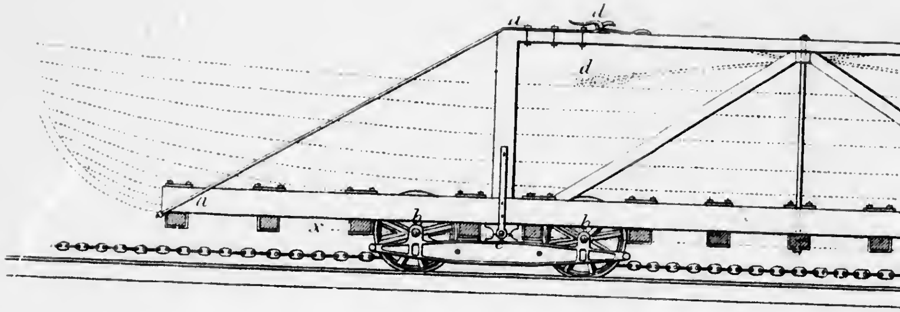

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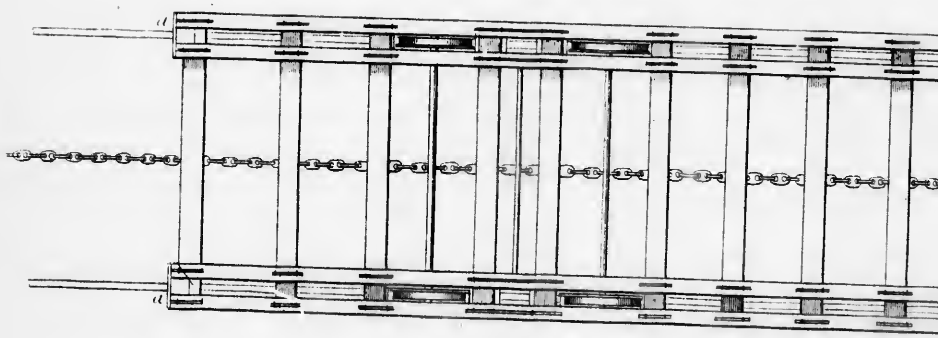
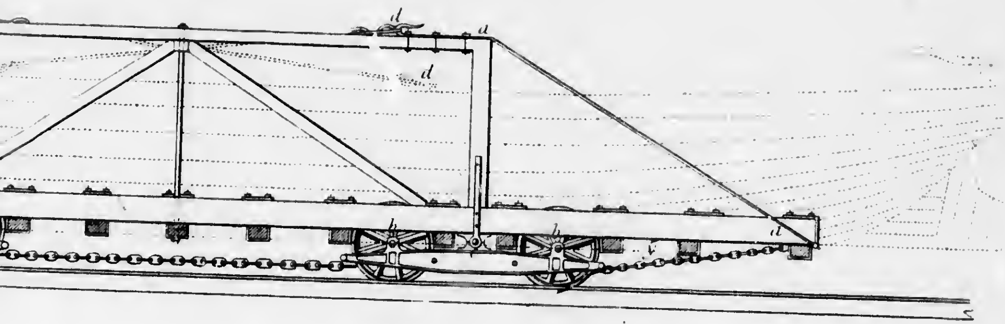


Boat car used on the inclined planes at

PLATE VI.

Fig. 1.



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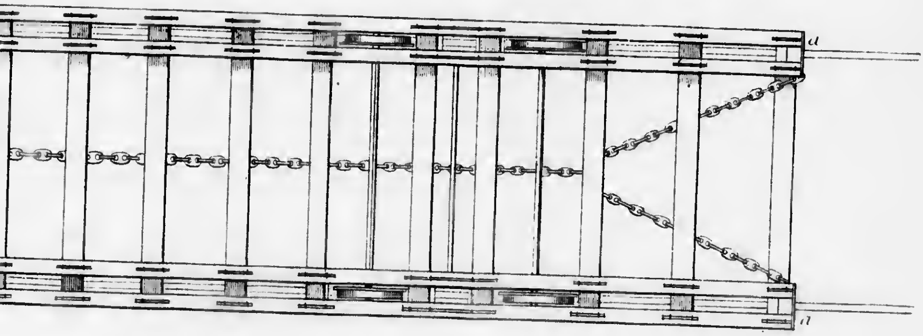


the inclined planes at the Morris Canal.

is made fast to the part of the framework which projects above the gunwale, as shown in the drawing at *d*. The machinery is then put in motion; and the car bearing the boat, is drawn by a chain to the top of the inclined plane, at which there is a lock for its reception. The lock is furnished with gates at both extremities; after the car has entered it, the gates next the top of the inclined plane are closed, and, those next the canal being opened, the water flows in and floats the boat off the car, when she proceeds on her way. Her place is supplied by a boat travelling in the opposite direction, which enters the lock, and the gates next the canal being closed, and the water run off, she grounds on the car. The gates next the plane are then opened, the car is gently lowered to the bottom when it enters the water, and the boat is again floated. The principal objection which has been urged against the use of inclined planes for moving boats from different levels is founded on the injury which they are apt to sustain in supporting great weights while resting on the cradle during its passage over the planes. It can hardly be supposed that a slimly built canal boat, measuring from sixty to eighty feet in length, and loaded with a weight of twenty or thirty tons, can be grounded, even on a smooth surface, without straining and injuring her timbers; but this has been overcome on the Monkland Canal, when Mr Leslie formed upon the carriage a caisson of boiler-plate containing two feet of water, so that the boats are water-borne.*

* Inclined planes were used on the Ketting Canal in Shropshire in 1789, and afterwards on the Duke of Bridgewater's Canal. Mr Green introduced, on the Great Western Canal, a perpendicular lift of 46 feet, and more recently (1850) Mr Leslie of Edinburgh, and Mr Bateman of Manchester, constructed an inclined plane on the Monkland Canal, wrought by two high-pressure steam-engines of 25 horse power each. The height, from surface to surface, is 96 feet, and the gradient is one in ten. The boats are not wholly grounded on the carriage, but are transported in a caisson of boiler-plate, containing two feet of water. The maximum weight raised is from 70 to 80 tons, and the whole transit is accomplished in about ten minutes. For the five years previous to the end of 1856, the average number of boats that passed over the incline each year was 7500. Sir Wm. Cubitt has also introduced three inclined planes, having gradients of one and eight, on

But notwithstanding this objection, the twenty-three inclined planes on the Morris Canal are in full operation, and act exceedingly well. No pains have been spared to render the machinery connected with them as perfect as possible, and the greatest credit is due to the engineer for the success which has attended their operation.

The Lachine, the Rideau, the Grenville, the Welland, and the St Lawrence Canals, are the only artificial water-communications in British America; but as I have already noticed these works in the chapters on River and Lake Navigation, it is unnecessary again to allude to them.

the Chard Canal, Somersetshire. One of these inclines overcomes a rise of 86 feet. (*Stevenson's Canal and River Engineering*)

CHAPTER VII.

ROADS.

Roads not suitable as a means of communication in America—Condition of the American Roads—"Corduroy Roads"—Roads from Pittsburg to Erie—New England Roads—The "National Road"—The "Macadamized Road"—City Roads—Causewaying or Pitching—Brick Pavements—Macadamizing—Tesselated wooden Pavements used in New York and in St Petersburg.

Road-making is a branch of engineering which has been very little cultivated in America, and it was not until the introduction of railways that the Americans entertained the idea of transporting heavy goods by any other means than those afforded by canals and slackwater navigation. They object to macadamized roads, in consequence of the hurtful effects of their severe and protracted winters in all such works as more particularly noticed in the chapter on railways, and also on account of the difficulty and expense of obtaining materials suitable for their construction, and for keeping them in a state of proper repair. Stone fitted for the purposes of road-making is by no means plentiful in America; and as the number of workmen is small in proportion to the quantity of work which is generally going forward in the country, manual labour is very expensive. Under these circumstances, it is evident that roads would have been a very costly means of communication, and as they are not suitable for the transport of heavy goods, the Americans, in commencing their internal improvements, directed their whole attention to the construction of canals, as being much better adapted to supply their wants.

The roads throughout the United States and Canada, are, from these causes not very numerous, and most of those by which I travelled were in so neglected and wretched a condition, as hardly to deserve the name of highways, being quite unfit for any vehicle but an American stage, and any pilot but an American driver. In many parts of the country, the operation of cutting a track through the forests of a sufficient width to allow vehicles to pass each other, is all that has been done towards the formation of a road. The roots of the felled trees are often not removed, and in marshes, where the ground is wet and soft, the trees themselves are cut in lengths of about ten or twelve feet, and laid close to each other across the road, to prevent the wheels from sinking, forming what is called in America a "Corduroy road," over which the coach advances by a series of leaps and starts, particularly trying to those accustomed to the comforts of European travelling. The following diagram represents the manner in which these roads are formed, fig. 1 being a plan, and fig. 2 a view of the ends of the logs.

Fig. 1.

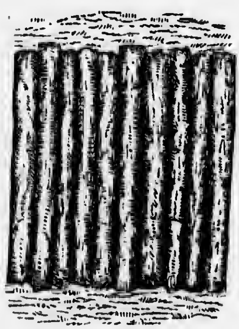
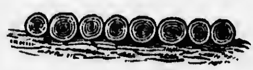


Fig. 2.



On the road leading from Pittsburg on the Ohio to the town of Erie on the lake of that name, I saw all the varieties of forest road-making in great perfection. Sometimes our way lay for miles through extensive marshes, which we crossed by corduroy roads, formed in the manner shown above; at others the coach stuck fast in mud, from which it could be extricated only by the combined efforts of the coachman and passengers; and at one place we travelled for upwards of a quarter of a mile through a forest flooded with water, which stood to the height of several feet on many of the trees, and occasionally covered the naves of the coach-wheels. The distance of the route from Pittsburg to Erie is 128 miles, which was accomplished in forty-six hours, being at the very slow rate of about two miles and three quarters an hour, although the conveyance by which I travelled carried the mail, and stopped only for breakfast, dinner, and tea, but there was considerable delay caused by the coach being once upset and several times "mired."

The best roads in the United States are those of New England, where, in the year 1796, the first American turnpike act was granted. These roads are made of gravel. The surface of the New England roads is very smooth; but as no attention has been paid to forming or draining them, it is only for a few months during summer that they possess any superiority, or are, in fact, tolerable. In Virginia and all the States lying to the south, as well as throughout the whole country to the westward of the Alleghany Mountains, the roads, I believe, are, generally speaking, of the same description as the one already mentioned between Pittsburg and Erie, affording very little comfort or facility to those who have the misfortune to be obliged to travel upon them.

But on the construction of one or two lines of road, the Americans have bestowed a little more attention. The most remarkable of them is that called the "National Road," stretching across the country from Baltimore to the State of Illinois, a distance of no less than 700 miles, an arduous and extensive work, which was constructed at the expense of the government of the United States. The narrow tract of land from which it was necessary to remove the timber and brushwood for the passage of the road measures eighty feet in breadth; but the breadth of the road itself is only thirty feet. Commencing at Baltimore, it passes through part of the State of Maryland, and entering that of Pennsylvania, crosses the range of the Alleghany Mountains after which, it passes through the States of Virginia, Ohio and Indiana, to Illinois. It is in contemplation to produce this line of road to the Mississippi at St Louis, where, the river being crossed by a ferry-boat stationed at that place, the road is ultimately to be extended into the State of Missouri, which lies to the west of the Mississippi.

The "Macadamized road," as it is called, leading from Albany to Troy, is another line which has been formed at some cost, and with some degree of care. This road, as its name implies, is constructed with stone broken, according to Macadam's principle. It is six miles in length, and has been formed of a sufficient breadth to allow three carriages to stand abreast on it at once. It belongs to an incorporated company, who are said to have expended about L.20,000 in constructing and upholding it.

Some interesting experiments have lately been set on foot at New York, for the purpose of obtaining a permanent and durable City Road, for streets over which there is a great thoroughfare. The place chosen for the trial was the Broadway, in which the traffic is constant and extensive.

The specimen of road-making first put to the test was a species of causewaying or pitching; but the materials employed are round water-worn stones, of small size; and their only recommendation for such a work appears to be their great abundance in the neighbourhood of the town. The most of the streets in New York, and indeed in all the American towns, are paved with stones of this description; but, owing to their small size and round form, they easily yield to the pressure of carriages passing over them, and produce the large ruts and holes for which American thoroughfares are famed. The footpaths in most of the towns are paved with bricks set on edge, and bedded in sand, similar to the "clinkers," or small hard-burned bricks so generally used for road-making in Holland.

The second specimen was formed with broken stones, but the materials, owing chiefly, no doubt, to the high rate of wages, are not broken sufficiently small to entitle it to the name of a "macadamized road." It is, however, a wonderful improvement on the ordinary pitched pavement of the country, and the only objections to its general introduction, as already noticed, are the prejudicial effects produced on it by the very intense frost with which the country is visited, and the expense of keeping it in repair.

The third specimen consisted of a species of tesselated pavement, formed of hexagonal billets of pine wood measuring six inches on each side, and twelve inches in depth, arranged as shown in the following cut, in which fig. 3 is a

Fig. 3.

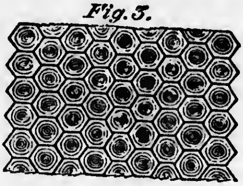
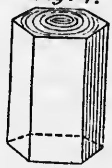


Fig. 4.



view of part of the surface of the pavement, and fig. 4 is one of the billets of wood of which it is composed, shown on a large scale. From the manner in which the timber is arranged, the pressure falls on it parallel to the direction in which its fibres lie, so that the tendency to wear is very small. The blocks are coated with pitch or tar, and are set in sand, forming a smooth surface for carriages, which pass easily and noiselessly over it. Since the date of my tour this plan has been fully tried in London and Paris, and in both places it has been found unsuccessful, and stone has again been adopted.

CHAPTER VIII.

BRIDGES.

Great Extent of many of the American Bridges—Different Constructions adopted in America—Bridges over the Delaware at Trenton, the Schuylkill at Philadelphia, the Susquehanna at Columbia, the Rapids at the Falls of Niagara, &c.—Town's "Patent Lattice Bridge"—Long's "Patent Truss Bridge."

The vast rivers, lakes, and arms of the sea in America which have been spanned by bridges, are on a scale which far surpasses the comparatively insignificant streams of this country, and, but for the facilities afforded for bridge-building by the great abundance of timber, the only communication across most of the American waters must have been by means of a ferry or a ford. The bridge over the River Susquehanna at Columbia, and that over the Potomac at Washington, for example, are each one mile and a quarter in length; and in the neighbourhood of Boston there are no less than seven bridges, varying from 1500 feet to one mile and a half in length. The bridge over Lake Cayuga is one mile, and those at Kingston on Lake Ontario, and at St John's on Lake Champlain, are each more than one-third of a mile in length.

The American bridges are in general constructed entirely of wood. Although good building materials had been plentiful in every part of the country, the consumption of time and money attending the construction of stone bridges of so great extent must, if not in all, at least in most cases, have proved too considerable to warrant their erection. Many of those recently built, however, consist of a wooden super-

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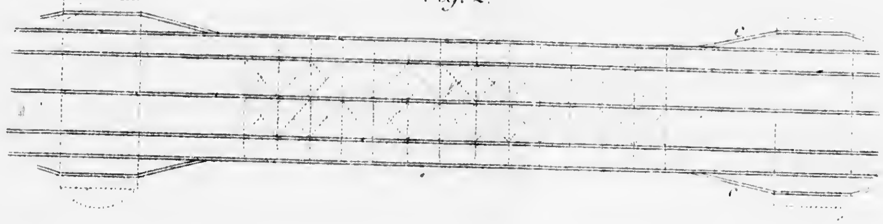

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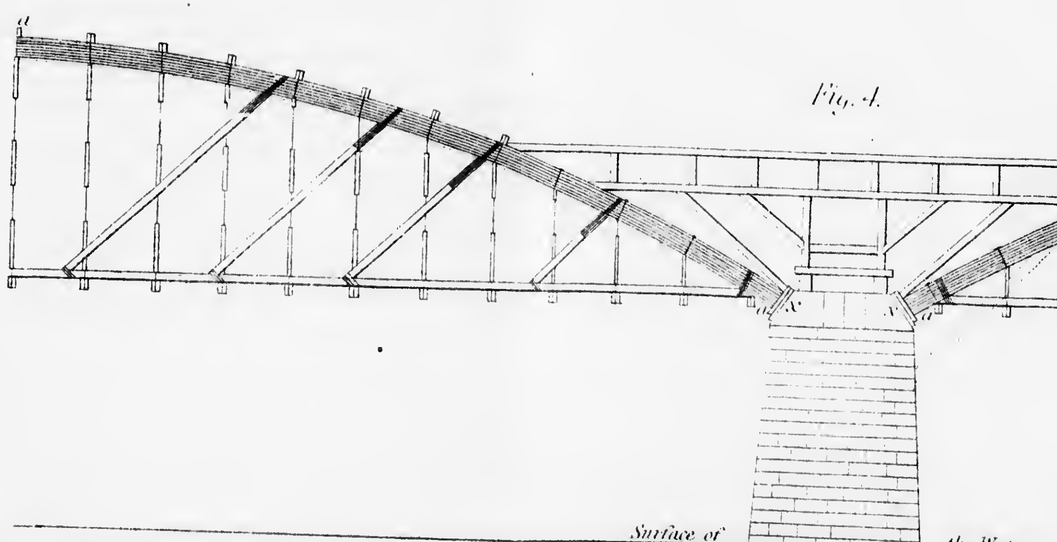
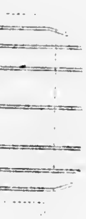


River Delaware, at Trenton.

PLATE VII.

Fig. 1.



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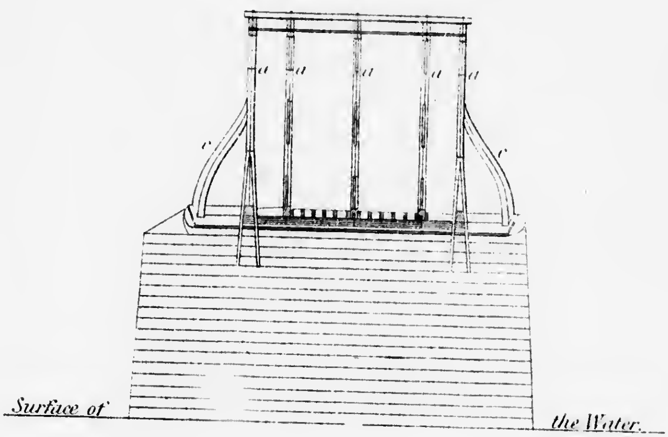

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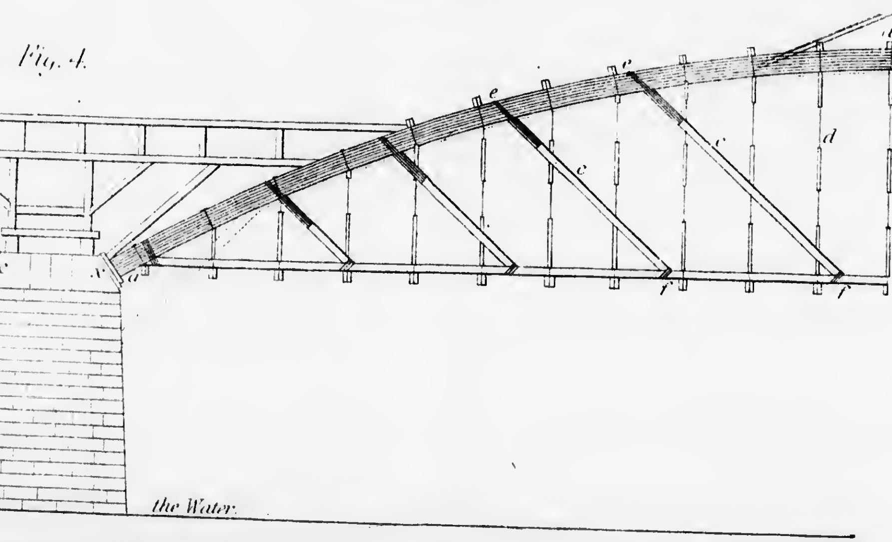

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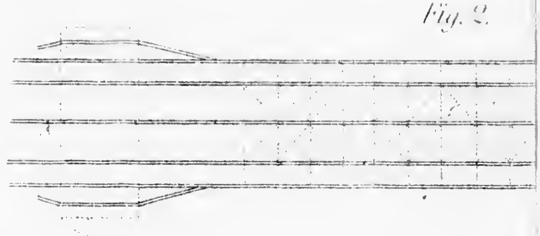

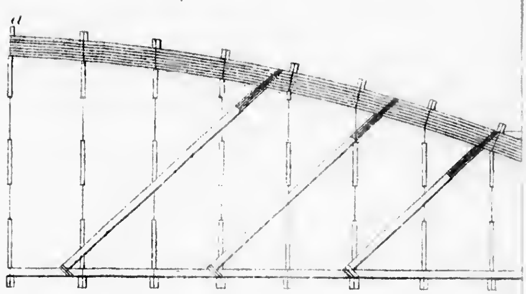

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structure resting on stone-piers, and in general exhibit specimens of good carpentry, and not unfrequently of good engineering. In those bridges which are of considerable extent and importance, the roadway, and the timbers by which it is supported, are protected by a roof or covering to preserve the wood from decay, in the manner shown in Plate VIII., in which, in order to show the timbers, one-half of the bridge is represented as covered in, and the other half as left exposed. The roadway is lighted by windows, formed at convenient distances in the roof, as shown in the drawings. The wooden bridges in Switzerland and Germany are often covered in the same manner as those in America; and by adopting this plan, the objections to wood as a building material, arising from its tendency to decay by exposure to the atmosphere, are in some degree palliated. The planking or flooring of the American bridges is never covered with any composition, as is done in this country.

The simplest method of constructing wooden bridges is to form the roadway on horizontal beams, supported on a series of piles driven into the ground, and where the nature of the situation admits of this construction, it is very generally adopted in America. But in spanning rivers, where it is of consequence to preserve a large water way for the passage of ice, or on railways, where it is often necessary that the surface of the rails should have a considerable elevation above the level of the water or ravine over which they are to pass, the use of horizontal beams supported on piles is often wholly impracticable, and in such situations other constructions have been resorted to for forming communications, some of which I shall briefly notice.

Plate VII. is the bridge over the River Delaware at Trenton, about thirty miles from Philadelphia. This bridge consists of five wooden arches, three of 200, one of 180, and one of 160 feet span, supported on four stone piers.* Fig. 1 is an elevation of the bridge, fig. 2 is a plan of one of the

* The dimensions of this bridge are not from measurements made by myself.

arches, and fig. 3 is a cross section; fig. 4 is an enlarged view, showing one of the piers, and a part of two of the arches. The roadway of each span or opening, is suspended by iron rods, from five wooden arcs, *a* in figs. 3 and 4, on the same principle as the iron bridge over the River Aire at Leeds in Yorkshire. The wooden arcs in the three largest openings are 200 feet in span, and have a versed sine of 27 feet. The arcs and suspending rods divide the roadway into four compartments, as shown in fig. 3, forming two carriage-ways in the middle of the bridge, each of which is nine feet ten inches in the clear, and a footpath at each side four feet ten inches in the clear. The entire breadth of the bridge, measured over the outer suspending arcs, is thirty-three feet eight inches. The whole is covered with a roof, in the manner shown in the drawing.

The suspending arcs, *a*, fig. 4, abutt against strong oak planks, as shown at *x*, which extend throughout the whole breadth of the stone piers. They are supported at each pier by struts *c* in figs. 2 and 3, and are connected at the top by a series of diagonal beams, represented by the dotted lines in fig. 2. These extend only about half-way down the arcs on each side of the crown, so that they do not interfere with the height of the roadway. The suspending arcs are composed of eight thicknesses of pine plank, and measure two feet eight inches in depth, and one foot one inch in breadth. The planks of which they are made measure one foot one inch in breadth, four inches in thickness, and from thirty to fifty feet in length, and are arranged so as to break joint. The wooden braces, *c*, fig. 4, are for the purpose of stiffening the roadway. They are fixed at the points, *e*, to the suspending arcs, and at *f* to the longitudinal bearing beams of the roadway by straps of iron. The suspending rods, *d*, are formed of malleable iron, and occur at every sixteen feet in the two exterior arcs, and at every eight feet in the three inner ones, which support the carriage-way.

The bridge over the Susquehanna at Columbia is constructed somewhat on the same principle as the one at Trenton which I have just described. The wooden suspending

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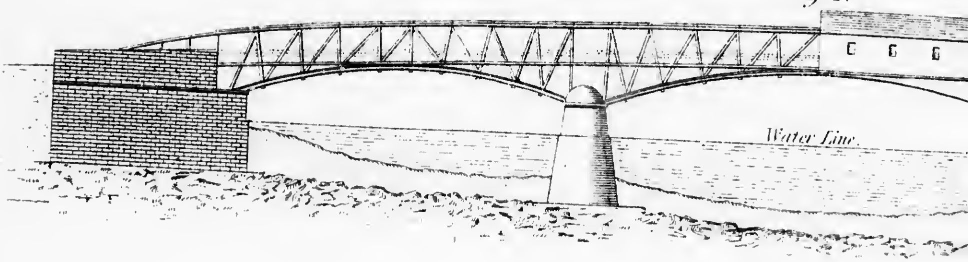
Fig. 1.



Scale of Feet

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Fig. 2.

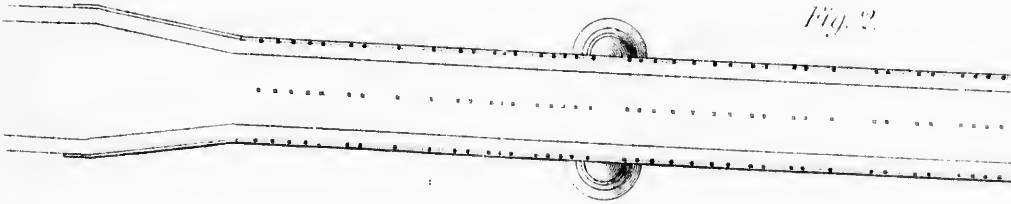
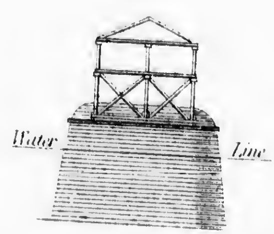


Fig. 3.



ver the Schuylkill, at Philadelphia. PLATE VIII.

Fig. 1.

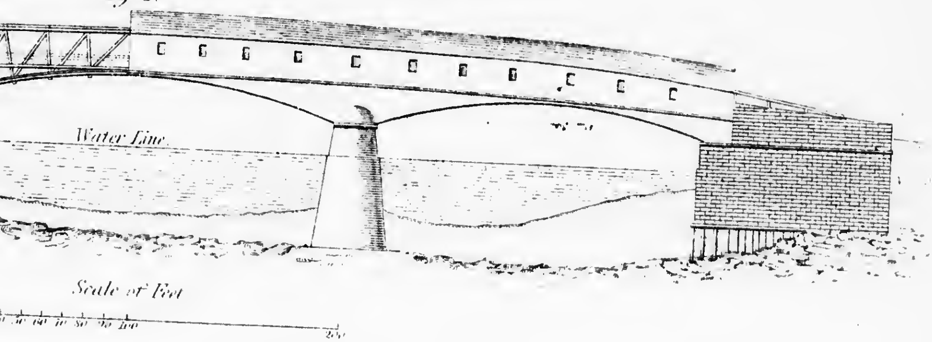


Fig. 2.

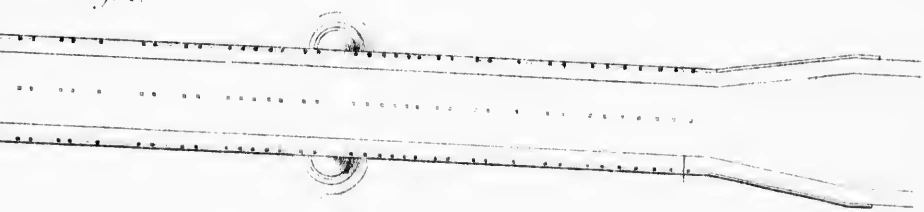


Fig. 3.

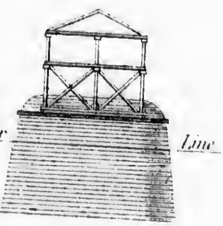
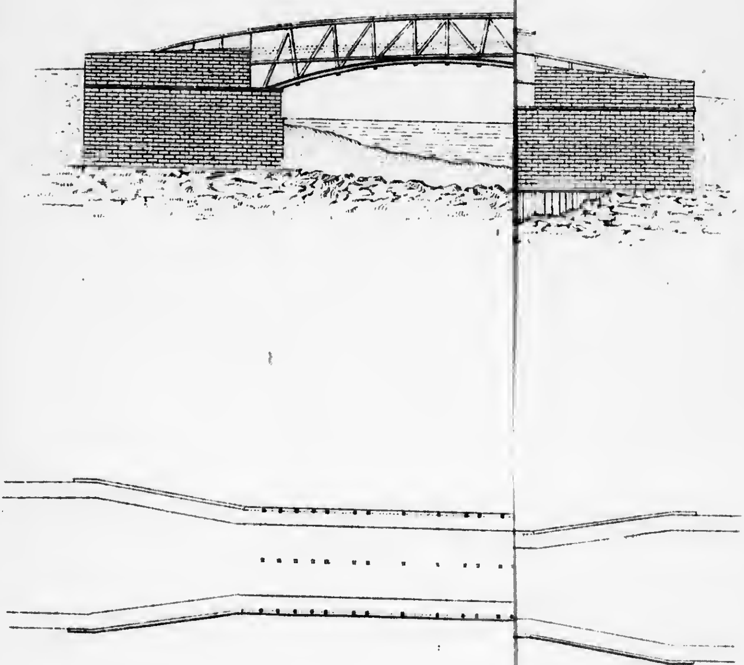


PLATE VIII.



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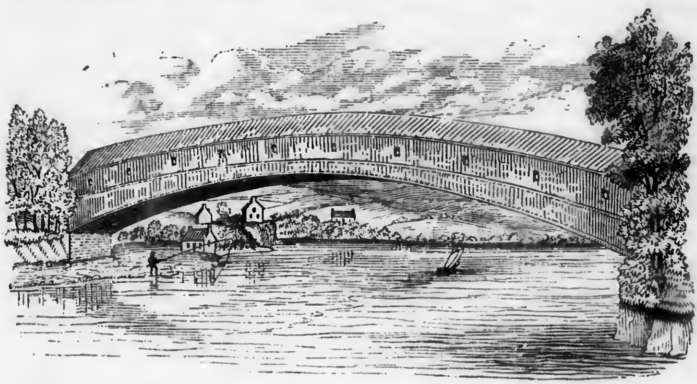
arcs, however, do not spring from the level of the roadway, but from a point about eight feet below it. In each span of the bridge, therefore, that part of the roadway which is next the springings is supported upon the arcs; and the centre part of it is suspended from them by a framing of wood. This bridge, which was begun in 1832, and completed in 1834, is perhaps the most extensive arched bridge in the world. It is certainly a magnificent work, and its architectural effect is particularly striking. It consists of no fewer than twenty-nine arches of 200 feet span, supported on two abutments, and twenty-eight piers of masonry, which are founded on rock, at an average depth of six feet below the surface of the water. The water-way of the bridge is 5800 feet; and its whole length, including piers and abutments, is about one mile and a quarter. The bridge is supported by three wooden arcs, forming a double roadway, which is adapted for the passage both of road and railway carriages. There are also two footpaths; which make the whole breadth of the bridge thirty feet. The arcs are formed in two pieces, each measuring seven inches broad by fourteen inches in depth. These are placed nine inches asunder; and the beams composing the wooden framing, by which the roadway is suspended, are placed between them, and fixed by iron bolts passing through the whole.

Plate VIII. is the "Market Street Bridge," over the Schuylkill at Philadelphia. Fig. 1 is an elevation, fig. 2 a plan, and fig. 3 a cross section. It consists of three arches. The span of the centre arch is 194 feet ten inches, and the versed sine is twelve feet. The other two arches are 150 feet in span, and have versed sines of ten feet. The breadth of the roadway is 35 feet. The piers were built with coffer-dams, one of them at the depth of 41, and the other at the depth of 21 feet below the surface of the river at high water. The work was commenced in 1801, and completed in 1805; and the expense, which amounted to L.60,000, was defrayed by a company of private individuals. There is another bridge over the Schuylkill at Philadelphia, consisting of a single arch of no less than 320 feet span, having a versed sine of about 38 feet. This bridge has a breadth of roadway of about 30 feet. It has been erected for several years, and is still in good repair and constant use. I regret, however, that I was unable to procure drawings of the wooden ribs or frames of which it is composed, sufficiently detailed and accurate to enable me to lay them before the public;* but the accompanying cut is from a sketch taken by me on the spot.



The bridge across the rapids of the River Niagara is placed only two or three hundred yards from the edge of the great falls. It extends from the American bank of the river to Goat Island, which separates what is called the "American" from the "British fall." The superstructure of the bridge is formed of timber. It is 396 feet in length, and is supported on six piers, formed partly of stone and partly of wood. When I visited the Falls of Niagara in the month of May, the ice carried down from Lake Erie by the rapids of the river, was rushing past the piers of this bridge with a degree of violence that was quite terrific, and seemed every moment to threaten their destruction.

The following very interesting account of this work is given by Captain Hall:†—

"The erection of such a bridge at such a place is a won-

* This remarkable bridge has been burnt down.

† Forty Etchings, from sketches made in North America, with the Camera Lucida, by Captain Basil Hall. Edinburgh, 1830.

derful effort of boldness and skill, and does the projector and architect, Judge Porter, the highest honour as an engineer. This is the second bridge of the kind; but the first being built in the still water at the top of the rapids, the enormous sheets of ice, drifted from Lake Erie, soon demolished the work, and carried it over the falls. Judge Porter, however, having observed that the ice in passing along the rapids was speedily broken into small pieces, fixed his second bridge much lower down, at a situation never reached by the large masses of ice.

"The essential difficulty was to establish a foundation for his piers on the bed of a river covered with huge blocks of stone, and over which a torrent was dashing at the rate of six or seven miles an hour. He first placed two long beams, extending from the shore horizontally forty or fifty feet over the rapids, at the height of six or eight feet, and counterbalanced by a load at the inner ends. These were about two yards asunder; but light planks being laid across, men were enabled to walk along them in safety. Their extremities were next supported by upright bars passed through holes in the ends, and resting on the ground. A strong open frame-work of timber, not unlike a wild beast's cage, but open at top and bottom, was then placed in the water immediately under the ends of the beams. This being loaded with stones, was gradually sunk till some one part of it—no matter which—touched the rocks lying on the bottom. As soon as it was ascertained that this had taken place, the sinking operation was arrested, and a series of strong planks, three inches in thickness, were placed, one after the other, in the river, in an upright position, and touching the inner sides of the frame-work. These planks, or upright posts, were now thrust downwards till they obtained a firm lodgment among the stones at the bottom of the river; and, being then securely bolted to the upper part of the frame-work, might be considered parts of it. As each plank reached to the ground, it acted as a leg, and gave the whole considerable stability, while the water flowed freely through openings about a foot wide, left between the planks.

"This great frame or box, being then filled with large stones tumbled in from above, served the purpose of a nucleus to a larger pier built round it, of much stronger timbers firmly bolted together, and so arranged as to form an outer case, distant from the first pier about three feet on all its four sides. The intermediate space between the two frames was then filled up by large masses of rock. This constituted the first pier.

"A second pier was easily built in the same way, by projecting beams from the first one, as had been previously done from the shore; and so on, step by step, till the bridge reached Goat Island. Such is the solidity of these structures, that none of them has ever moved since it was first erected, several years before we saw it."

Plate IX. is a drawing of "Town's Patent Lattice Bridge," which is much employed on the American railways. This construction is sometimes used for bridges of so large a span as 150 feet, and it exerts no lateral thrust tending to overturn the piers on which it rests. A small quantity of materials of very small scantling, arranged in the manner shown in the plate, possesses a great degree of strength and rigidity.

For this drawing I am indebted to Mr Robinson of Philadelphia, who is constructing many large bridges on this principle on the Philadelphia and Reading railway, several of which I examined both in their finished and unfinished state.

Fig. 1 is an elevation, and fig. 2 a cross section on an enlarged scale of the frame-work of the bridge, in which *a* is the surface of the railway; the lattice framing or ribs *b* of which the bridge is formed are composed entirely of pine planks, measuring twelve inches in breadth, and three inches in thickness. The planks are arranged at right angles to each other, so as to form a fabric resembling lattice-work, as shown in the drawing; and from this circumstance the bridge derives its name. They are fixed at the points of their intersection by oak treenails, one inch and a half in diameter, passing through them. The horizontal runners,

Fig. 3

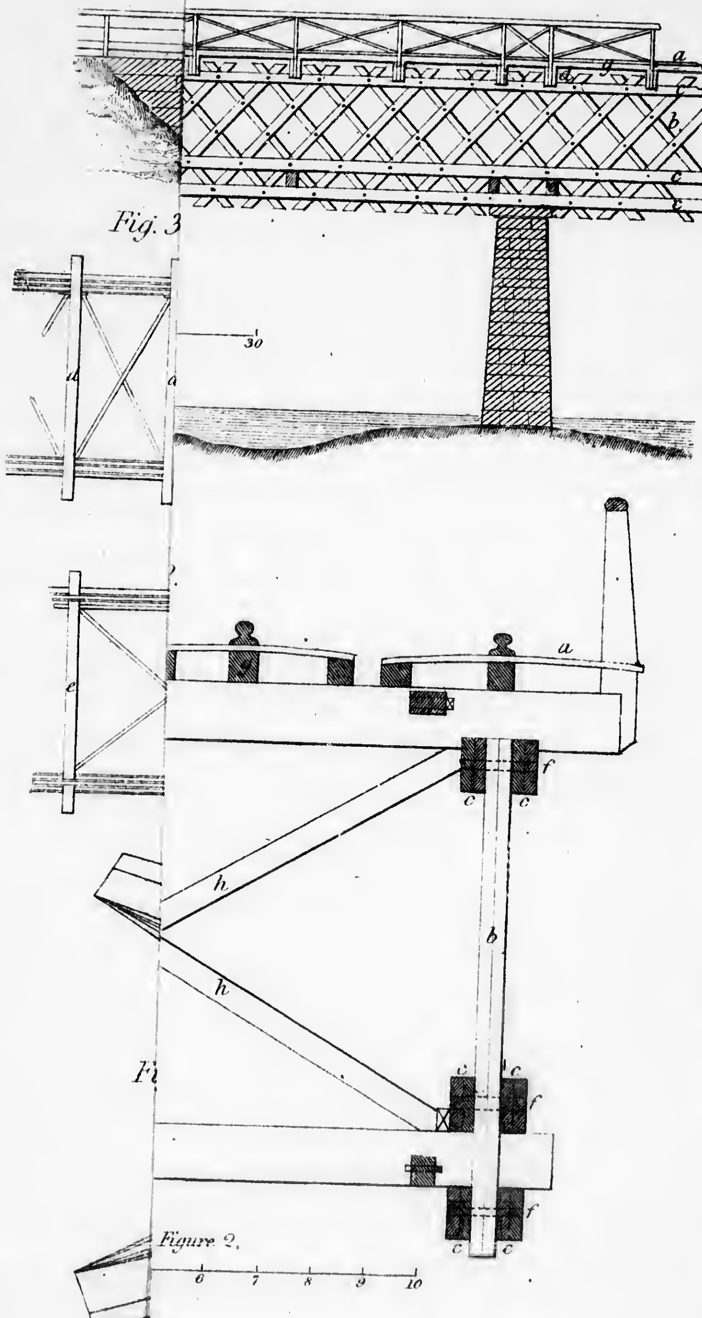


Figure 2.

Town's Patent Lattice

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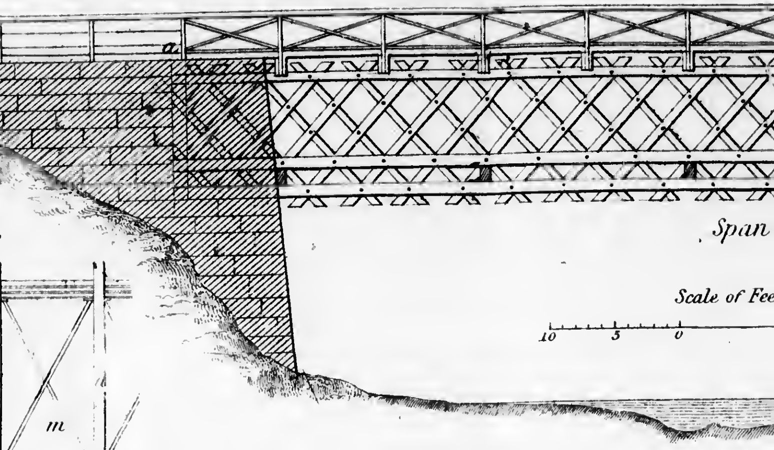

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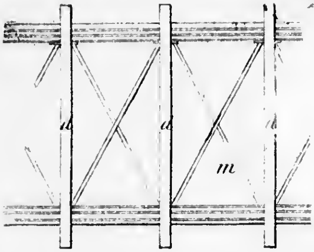

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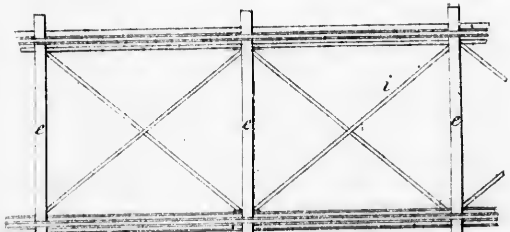

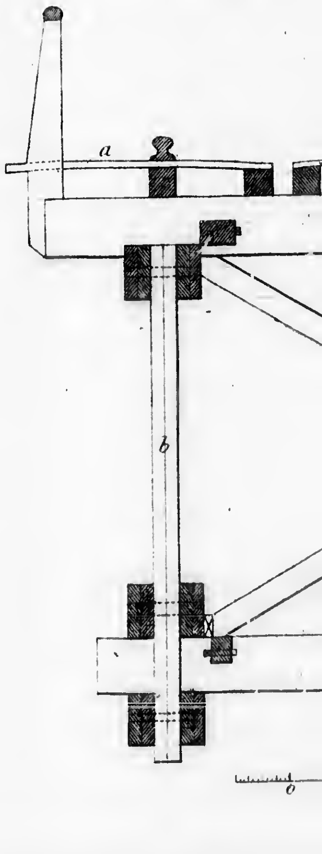

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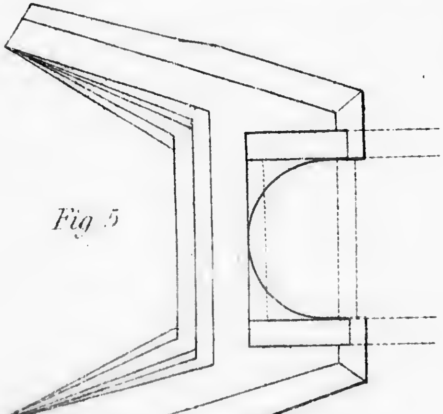

Town's Patent Lattice Bridge.

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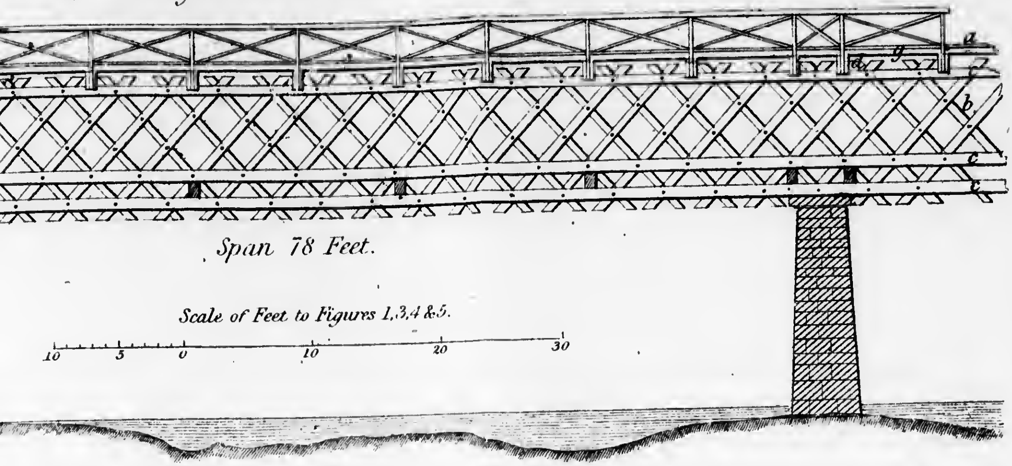

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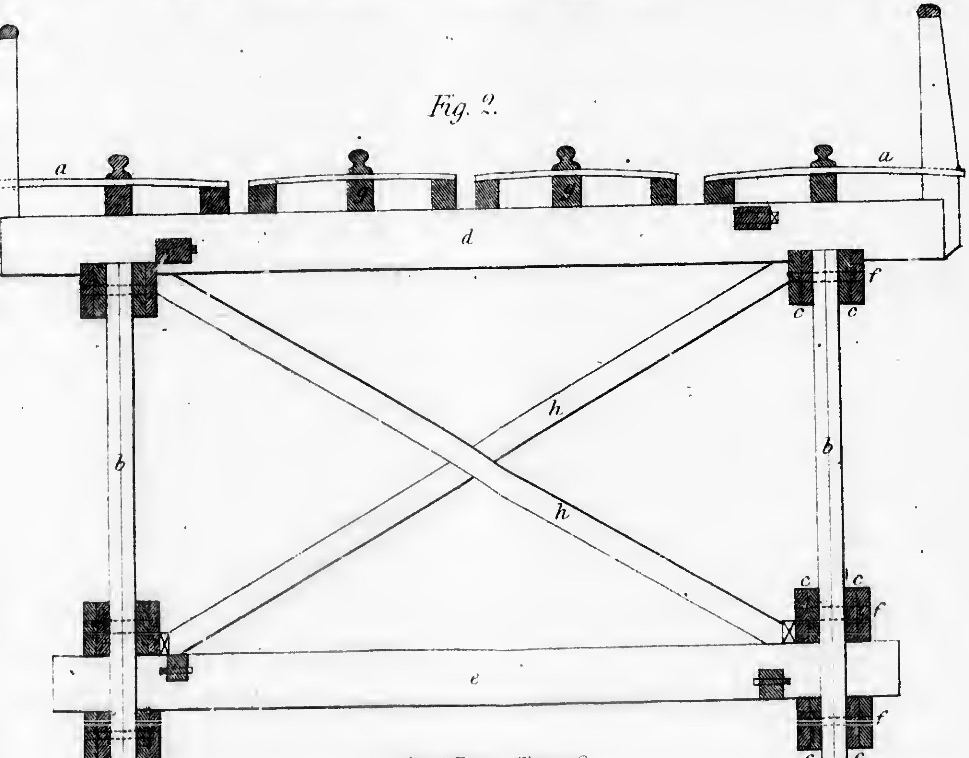

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c, are formed of planks of the same scantling, and extend throughout the whole length of the bridge. They are also fixed at the points where they intersect the planks *b*, by oak treenails passing through the whole, as shown by the dotted lines at *f*, in fig. 2. The depth of the lattice-work is proportioned to the span of the bridge. The span shown in the drawing is seventy-eight feet and the depth of the ribs is nine feet six inches. In a bridge of larger span, the planks *b* would be made of greater length, and another square or diamond added to the lattice work.

There were only two ribs or frames of lattice-work in all of the bridges constructed on this principle which I examined. One of these was placed under each side of the roadway, as shown in the cross section, fig. 2, by the letters *bb*. The ribs are connected together at the bottom by cross beams *e*, at every twelve feet. At the top they are connected in a similar manner by beams *d*, at every six feet. On these, the longitudinal beams *g* are supported, to which the planking of the roadway is spiked. To prevent the ribs from twisting or warping, they are braced at every twelve feet by diagonal beams arranged in vertical planes, as shown at *h* in fig. 2. Fig. 3 is a plan of the wood-work directly under the roadway. In this figure the beams *d*, are those on which the planking of the roadway is spiked, and the diagonal braces *m* arranged in horizontal planes are introduced to render the structure rigid. For the same reason the braces *i* are introduced, as shown in fig. 4, which is a plan of the wood-work connecting the lower part of the lattice frames. The diagonal braces are all fixed in the same manner. One of the extremities rests in a seat cut for it in the beam against which it abutts, and wedges of hard wood are inserted at the other end, by which the brace can be nicely adjusted, and afterwards tightened up, should the vibration of passing trains, or the effects of the atmosphere, cause any yielding of the timber to take place.

The lattice-frames have a rest of about five feet, in checks formed in the stone abutments for their reception, as shown in dotted lines in the elevation fig. 1 and in fig. 5, which is

a plan of one of the abutments. If the bridge is of greater extent than can be included in one span, it is simply rested on a thin pier, in the manner shown in the elevation, without any other support. A covering of light boarding, extending from the level of the roadway to the bottom of the ribs, is spiked on the outside of the lattice-work to preserve the timber.

The largest lattice-bridge which I met with, was constructed by Mr Robinson on the Philadelphia and Reading Railroad. It measures 1100 feet in length. The lattice-frames of which it is formed extend throughout the whole distance between the two abutments without a break, and are supported on ten stone piers, in the manner shown in the plate. On the New York and Haerlem Railway, there is a lattice-bridge 736 feet in length, supported in the same manner on four stone piers.

Plate X. is a drawing of "Long's patent frame bridge," which is also much employed on the different lines of railway in the United States.*

Fig. 1 is an elevation; fig. 2 a plan; and fig. 3 a cross section of this bridge, which contains a small quantity of materials, and exerts no lateral thrust. Bridges constructed on this principle, having spans of from one hundred to one hundred and fifty feet, are very commonly met with. That shown in the drawing is 110 feet in span, and the depth of the truss-frame is 15 feet. In the accompanying plate, *a* is the level of the railway; *b* the "string-pieces," as they are called in America; *c* the "posts;" *d* the "main-braces;" and *e* the "counter-braces."

The string-pieces are formed of three beams, in the manner shown in the plan and cross section. The post and main-braces are in two pieces, and the counter-braces are formed of a single beam. Figs. 4, 5, 6, and 7, illustrate the manner in which the joining is formed, at the points where the posts and braces are attached to the string-pieces. This joining is effected without the use of bolts or spikes, a construction

* A description of Long's Bridge. Concord, 1836.

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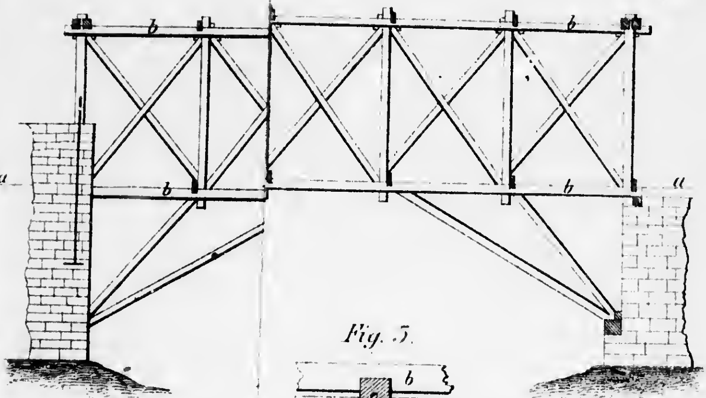
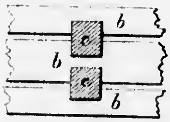


Fig. 5.



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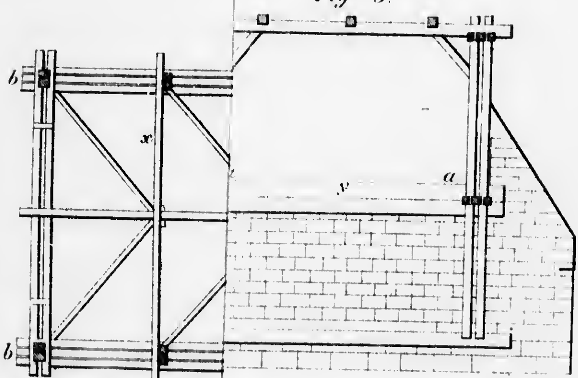


Plan

Long's Patent Frame Bridge.

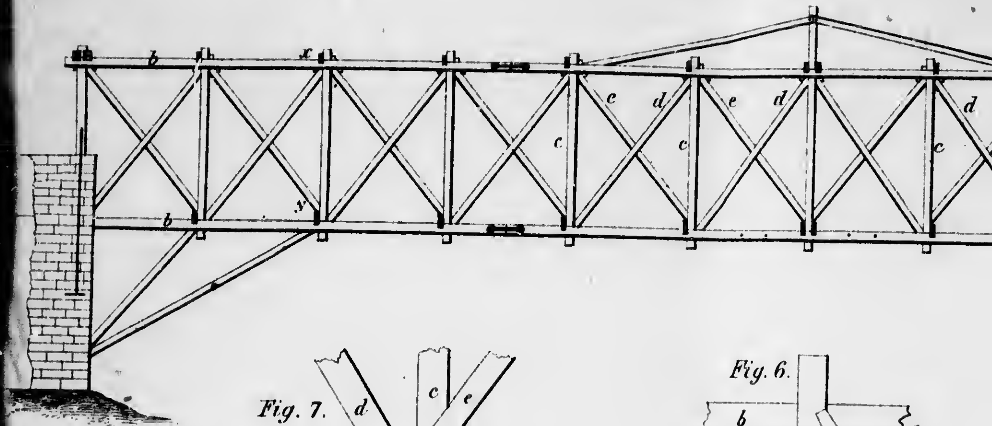


Fig. 7.

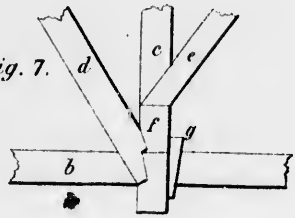


Fig. 6.

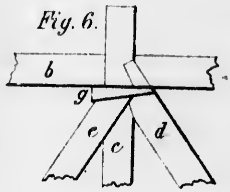
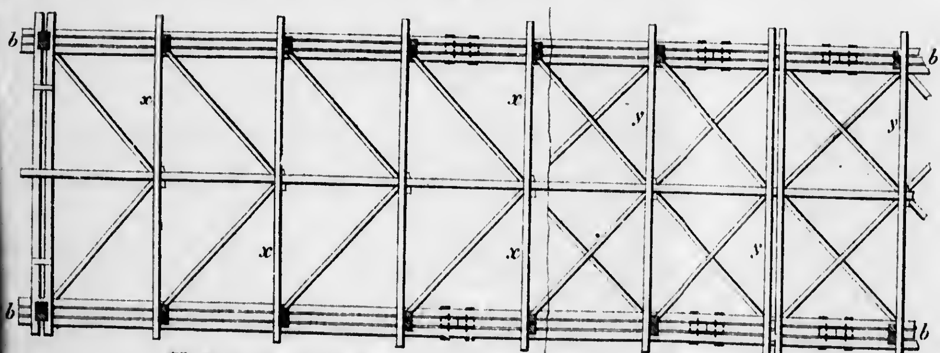


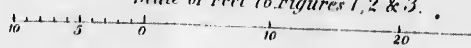
Fig. 2.



Plan of Top of Frame.

Plan of Bottom of Frame.

Scale of Feet to Figures 1, 2 & 3.



Patent Frame Bridge.

PLATE X.

Fig. 1.

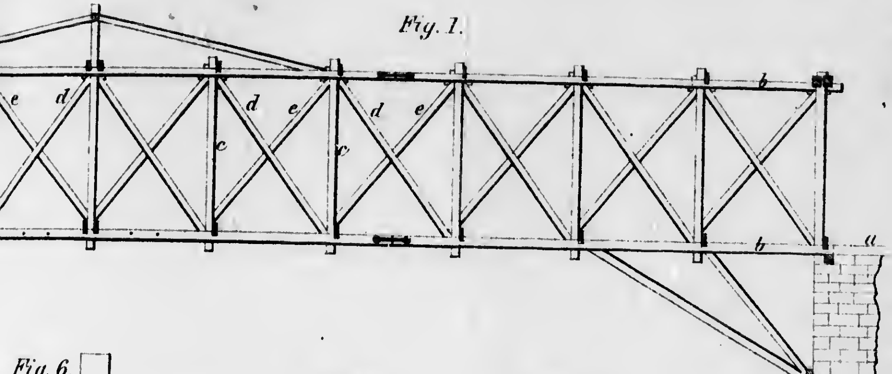


Fig. 6.

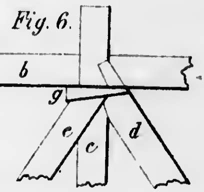


Fig. 4.

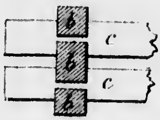
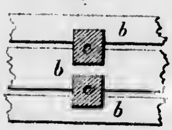
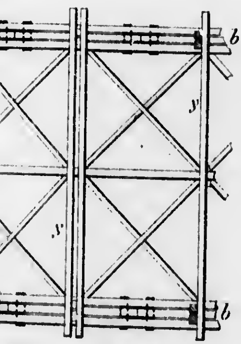


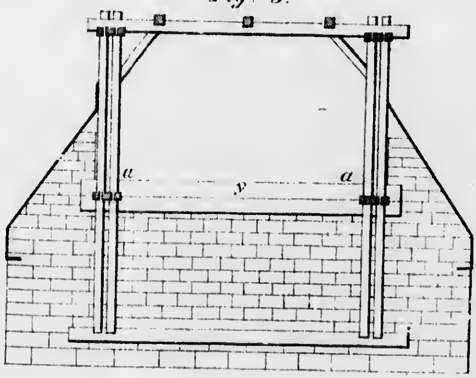
Fig. 5.





f Bottom of Frame.

Fig. 3.



f Feet to Figures 1, 2 & 3.

KELL BROS, LITHRS CASTLE ST HOLBORN.

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is effected without the use of bolts or spikes, a construction which admits of the bridge being very easily repaired, when decay of the materials or other causes renders it necessary. Figs. 4 and 5 are enlarged diagrams, showing the manner in which the posts are fixed to the strings. In fig. 4 the strings are shown in section at letter *b*, and the posts passing between them at *c*. In fig. 5 the posts are shown in section at *c*, and the strings at *b*. Fig. 6 shows the manner of fixing the main and counter braces to the upper string-piece. In this diagram *b* is the string, *c* the post, *d* the main-brace, *e* the counter-brace, and *g* is a wedge of hardwood, by which the whole wood-work is tightened up. Fig. 7 shows the manner of fixing employed at the lower string. In this diagram *b* is the string, *c* the post, *d* the main-brace, *e* the counter-brace, *g* a wedge of hard wood, and *f* a block on which the counter-brace rests. The frames are connected at the top by cross beams, *x*, and at the bottom by the beams marked letter *y*, which support the planking of the roadway.

I met with Long's Bridge in many parts of the country, but the best specimens I saw were those erected on some of the railways in the neighbourhood of Boston under the direction of Mr Fessenden the engineer.

The timbers of which Town's and Long's bridges are composed, are fitted together on the ground previous to their erection on the piers. They are again taken asunder, and each beam is put up separately in the place which it is to occupy, by means of a scaffolding or centering of timber.

Mr Galton in his report on railways, made to the Board of Trade, so recently as 1857, says :—" The bridges are ordinarily of timber. The designs of many of the bridges for large spans, and also of the roofs of stations in which timber alone, or timber in connection with iron, is used, exhibit great engineering skill, and are very instructive. The railway bridge of largest span is the suspension bridge over the Niagara River, connecting the United States with Canada. The span of the bridge is 800 feet, and the level of the rails is 250 feet above the water. The particulars of this bridge have been already published in this country. On many railways iron and stone are being adopted to replace timber structures which have decayed. I have appended a sketch of one iron, and one wooden bridge, of recent construction, which deserve consideration." The example of the wooden bridge given by Captain Galton closely resembles Long's bridge, which I have described at page 144. In the iron bridge the roadway is suspended by radiating iron rods, attached to either end of a cast-iron stretcher. It appears to me, however, that it is in timber work that the Americans excel, and that it is their timber structures which are most interesting to British engineers, who have ample opportunity of studying stone and iron bridges at home. To any engineer about to practise in a new country, the study of the American timber bridges is invaluable, as showing what gigantic and useful works may be constructed with that material, which, to a greater or less extent, every new country produces.

CHAPTER IX.

RAILWAYS.

European Railways—Introduction of Railways into the United States—The European construction of Railways unsuitable for America—Attempts of the American Engineers to construct a Railway not likely to be affected by frost—Constructions of the Boston and Lowell, New York and Paterson, Saratoga and Schenectady, Newcastle and Frenchtown, Philadelphia and Columbia, Boston and Providence, Philadelphia and Norristown, New York and Haerlem, Buffalo and Niagara, Camden and Amboy, Brooklyn and Jamaica, and the Charleston and Augusta Railroads—Rails, Chairs, Blocks, and Sleepers used in the United States—Original Cost of American Railways—Expense of upholding them—Power employed on the American Railways—Horse-power—Locomotive Engines—Locomotive Engine Works in the United States—Construction of the Engines—Guard used in America—Fuel—Engine for burning Anthracite Coal—Stationary Engines—Description of the Stationary Engines, Inclined Planes, and other works on the Alleghany Railway—Railway from Lake Champlain to the St Lawrence in Canada.

The first railway constructed in America was completed in 1827, and was intended for the conveyance of stone from the Quincy-granite quarries to a shipping port on the River Neponsett in Massachusetts, a distance of about four miles. In 1837, after a lapse of 10 years, I found that there were 57 railways completed and in full operation, whose aggregate length was 1600 miles, while the works in an unfinished state amounted to about 2800 miles. In 1857, after a lapse of 20 years, it appears from the report by Captain Galton, already quoted, that the American railway system has been greatly extended, and that about "26,000 miles of railway were in operation at that date, of which, however, not more than one sixth is double line."

Now it is a singular and significant fact, as already stated in the preface, that, notwithstanding this enormous extension of railways, and the experience which must have been gained during the course of their construction, the American railway system appears to have undergone little or no change during the last 20 years, excepting in its extent. Throughout the interesting report of Captain Galton, R.E., made to the Board of Trade in 1857, the same features which I found to be peculiar to that system in 1837, seem to be regarded as its peculiarities still; and as these peculiarities of construction, together with others due to climate, which, of course, cannot change, formed the substance of my original remarks on American railways, I have no hesitation in repeating here the chapter originally written; and at its close I shall avail myself of Captain Galton's valuable report, to give some description of the American railway legislation, and particularly of the great Prairie lines which have been constructed since my visit to the country, and which he has minutely examined.

The early American railroads consisted of iron rails and chairs resting on stone blocks, and were constructed on the same principles as those in this country. But the American engineers soon discovered that this construction of road, although it had been to a certain extent successfully applied in England, was not at all capable of withstanding the rigours of an American winter. The intense frost, with which the northern part of the country is visited, was found to split the stone blocks and to affect the ground in which they were imbedded, to such a degree, that their positions were materially altered, and the rails were in many cases so much twisted and deranged as to be quite unfit for the passage of carriages. The consequence was, that most of the railroads, constructed in the United States after the English system, had actually to be relaid at the close of every winter, and during the continuance of the frost could only be travelled on at a decreased speed. The Americans have put numerous plans to the test of actual experiment, in their endeavours to form a structure for supporting the rails, adapted to the climate and circumstances of the country. There are hardly two railways in the United States (1837) which are made exactly in the same way; but although great improvements have been effected, it is doubtful whether a structure perfectly proof against the detrimental effects of frost has yet been produced. An enumeration of the various schemes which have been proposed for the construction of railways in America, would not be very useful, even if it were possible. I shall, therefore, only mention those constructions which came under my own observation, some of which are found to be very suitable.

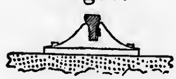
The Boston and Lowell Railway in Massachusetts is twenty-six miles in length, and is laid with a double line of rails. The breadth between the rails, which is four feet eight and a half inches, is the same in all the American railroads, and the breadth between the tracks is six feet.*

Fig. 1 is a transverse section, and fig. 2 a side view, of one of the tracks, in which *a* are granite blocks, six feet in

Fig. 1.

Fig. 2.

Fig. 3.



length, and about eighteen inches square. These are placed transversely, at distances of three feet apart from centre to centre, each block giving support to both of the rails. This construction† was first introduced in the Dublin and Kingstown Railway, in Ireland, but was found to produce so rigid a road, that great difficulty was experienced in securing the fixtures of the chairs. From the difficulty, also, of procuring a solid bed for stones of so great dimensions, most of

* Captain Galton (in 1856), says, that "the general gauge in the United States is four feet eight and a-half inches; that the New York and Erie, and one or two lines in connection with it, have a six feet gauge; and that the gauge of the Canadian lines is five feet three inches."

† Transactions of the Society of Arts for Scotland; Edinburgh New Philosophical Journal for April 1835 and April 1836.

them, after being subjected for a short time to the traffic of the railway, were found to have split. The blocks on the Boston and Lowell Railway were affected in the same manner, and are besides found to be very troublesome during frost.

Fig. 3 is an enlarged view of the rail and chair used on this line. The rails are fish-bellied, weigh 40 lb. per lineal yard, and rest in cast-iron chairs, weighing 16 lb. each. The form of the rails and chairs resembles that at first used on the Liverpool and Manchester Railway.

Figs. 4 and 5 represent another construction which has been tried on this line. In these views *a* are longitudinal trenches, two feet six inches square, and four feet eight and

Fig. 4.

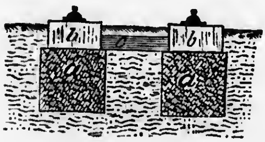
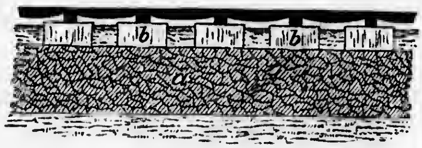


Fig. 5.



a half inches apart from centre to centre, formed in the ground, and filled with broken stone, hard punned down with a wooden beater, as a foundation for the stone blocks *b* on which the rails rest. These blocks measure two feet square, and a foot in thickness, and *c* is a transverse sleeper of wood, two feet eight inches and a half in length, one foot in breadth, and eight inches in thickness, which is placed between the blocks to prevent them from moving.

The plan of resting the railway on a foundation of broken stone, shown in the last and some of the following figures, was adopted in the expectation that it might be sunk to a sufficient depth below the surface of the ground, to prevent the frost from affecting it; but it has failed to produce the desired effect, as subsequent experience has shown that many of those railways whose construction was more superficial have resisted the effects of frost much better.

The New York and Paterson Railway is sixteen and a half miles in length, and extends along a marshy tract of ground. Its construction is shown in figs. 6 and 7. The foundation of the road consists of a line of pits under each rail, eighteen inches square, and three feet in depth. They

Fig. 6.

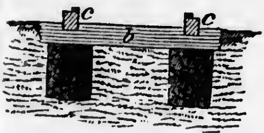
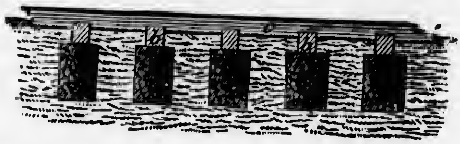


Fig. 7.



are placed three feet apart from centre to centre, and filled with broken stones. On this foundation transverse wooden sleepers, *b*, measuring eight inches square, and seven feet in length, are fairly bedded, on which rest the longitudinal sleepers marked *c*, measuring eight inches by six. To these, plate-rails of malleable iron, two and a half inches wide, and half an inch thick, weighing about 13 lb. per lineal yard, are fixed by iron spikes.

Figs. 8 and 9 are a cross section and side view of the

Fig. 8.

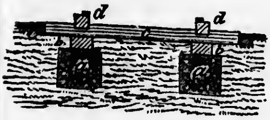


Fig. 9.

Saratoga and Schenectady Railway. The parallel trenches marked *a*, are eighteen inches square, and four feet eight and a half inches apart from centre to centre. They extend throughout the whole line of the railway, and are firmly punned full of broken stones. Longitudinal sleepers of wood, marked *b*, measuring eight by five inches, are placed on these trenches, which support the transverse wooden sleepers, marked *c*, measuring six inches square, and placed three feet apart from centre to centre. Longitudinal runners, marked *d*, measuring six inches square, are firmly spiked to the transverse sleepers, and the whole is surmounted by a plate-rail half an inch thick, and two and a half inches wide, weighing about 13 lb. per lineal yard.

The Newcastle and Frenchtown Railway, which is sixteen miles in length, and forms part of the route from Philadelphia to Baltimore, is constructed in the same way as that between Schenectady and Saratoga, excepting that the plate-rail is two and a half inches broad, and five-eighths of an inch thick, and weighs nearly 16 lb. per lineal yard. The Baltimore and Washington Railway is also constructed in the same way as regards the foundation and arrangement of the timbers, but edge-rails are employed on that line three and a half inches in breadth at the base, and two inches in height.

Several experiments have been made on the Columbia Railroad, in Pennsylvania, which is eighty-two miles in length, and is under the management of the State. Part of the road is constructed in accordance with figs. 10 and 11,

Fig. 10.

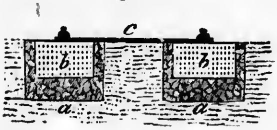
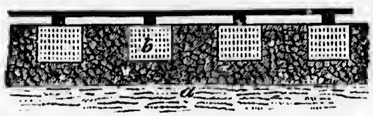


Fig. 11.



which are a transverse section and side view of one of the tracks. The trenches marked *a*, measuring two feet six inches in breadth, and two feet in depth, are excavated in the ground, and filled with broken metal; in these, the stone-blocks, *b*, two feet square, and a foot in thickness, are imbedded at distances of three feet apart, to which the chairs and rails are spiked in the ordinary manner. The rails on each side of the track are connected together by an iron bar, marked *c* in fig. 10. This attachment is rendered absolutely necessary on many parts of the Columbia Railroad, by the sharpness of the curves, which, at the time when the work was laid out, were not considered so prejudicial on a railway as experience has shown them to be.

Another plan tried on this line is shown in figs. 12 and 13, which are a transverse section and side view. In this arrangement a continuous line of stone curb, one foot square, marked *a*, resting on a stratum of broken stone, is substituted for the isolated stone blocks shown in figs. 10 and 11. A plate-rail, half an inch thick, and two and a half inches broad, is spiked down to treenails of oak, or locust wood, driven into jumper-holes bored in the stone curb.

Fig. 12.

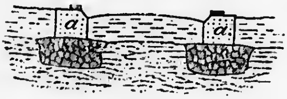
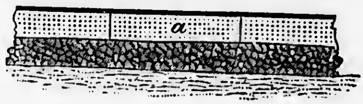


Fig. 13.



Figs. 14 and 15 represent the construction of the Boston and Providence Railway, which is forty-one miles in length.

Fig. 14.

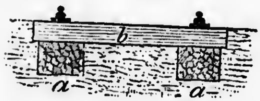
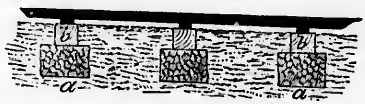


Fig. 15.



Pits, measuring eighteen inches square, and one foot in depth, marked *a*, are excavated under each line of rail, at intervals of four feet. They are filled with broken stone, and form a foundation for the transverse sleepers, marked *b*, measuring eight inches square, on which the chairs and rails are fixed in the usual manner.

The construction shown in figs. 16 and 17, which are

Fig. 16.

Fig. 17.

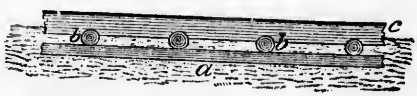
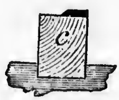


Fig. 18.



a cross section and side view of one of the tracks, is in very general use in America. I met with it on the Philadelphia and Norristown, the New York and Haerlem, and the Buffalo and Niagara railroads; and I believe it has been introduced on many others. It consists of two lines of longitudinal wooden runners, marked *a*, measuring one foot in breadth, and from three to four inches in thickness, bedded on broken stone or gravel. On these runners, transverse sleepers, *b*, are placed, formed of round timber with the bark left on, measuring about six inches in diameter, and squared at the ends, to give them a proper rest. Longitudinal sleepers, *c*, for supporting the rails, are notched into the transverse sleepers, as shown in the diagram. Fig. 18 is an enlarged view of the plate-rail and longitudinal sleeper used for railways of this construction. The rail is made of wrought-iron, and varies in weight from 10 to 15 lb. per lineal yard. It is fixed down to the sleepers at every fifteen or eighteen inches, by spikes four or five inches in length, the heads of which are countersunk in the rail.

Figs. 19 and 20 are the rails used on the Camden and

Fig. 19.

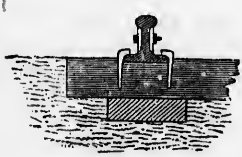
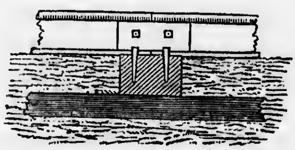


Fig. 20.



Amboy Railway, which is sixty-one miles in length. They are parallel edge-rails, and are spiked to transverse sleepers of wood, and, in some places, to wood treenails driven into stone blocks. Their breadth is three and a half inches at the base, and two and a half at the top, and their height four inches. They are formed in lengths of fifteen feet, and secured at the joints by an iron plate on each side, with two screw-bolts passing through the plates and rails, as shown in the diagram. On the Philadelphia and Reading Railroad, rails of the same form have been adopted.

Figs. 21 and 22 show another construction, which I observed on several of the railroads. It was proposed with a view to counteract the effects of frost. Round piles of timber, marked *a*, about twelve inches in diameter, are driven into the ground as far as they will go, at the distance of three feet apart from centre to centre. The tops are cross-cut, and the rails are spiked to them in the same way as in the

Camden and Amboy Railway, which is shown in figs. 19 and 20. The heads of the piles are furnished with an iron strap,

Fig.21.

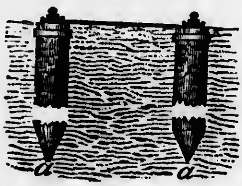
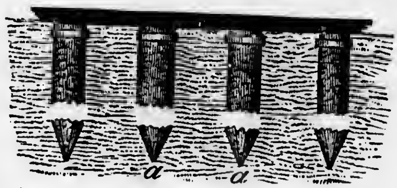


Fig.22.



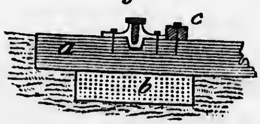
to prevent them from splitting; and the rails are connected together at every five feet by an iron bar.

Figs. 23 and 24 are a transverse section and side view of

Fig.23.

Fig.24.

Fig.25.



the present structure of the Brooklyn and Jamaica Railroad, on which Mr Douglass, the engineer for that work, has made several experiments. The road, represented in the cut, is exceedingly smooth, and is said to resist the effects of frost very successfully. It consists of transverse sleepers, measuring eight by six inches, marked *a*, supported on slabs of pavement, two feet square, and six inches thick, marked *b*. The wooden runner, marked *c*, is spiked on the inside of the chairs to render them firm. An enlarged view of the rail is shown at fig. 25.

The railroad between Charleston and Augusta, and many others in the southern States, where there is a scarcity of materials for forming embankments, are carried over low lying tracts of marshy ground, elevated on structures of wooden truss-work, such as is shown in figs. 26 and 27. The framing in fig. 27 is used in situations where the level of the rails does not require to be raised more than ten or twelve feet above the surface of the ground. Piles from ten

Fig. 26.

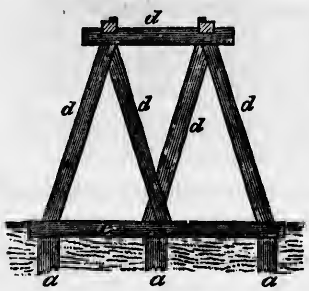
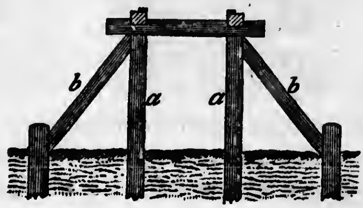


Fig. 27.



to fifteen inches in diameter, marked *a*, are driven into the ground by a piling engine, and, in places where the soil is soft, their extremities are not pointed but are left square, which makes them less liable to sink under the pressure of the carriages. The struts marked *b* are attached to the tops of the piles, and are also fixed to dwarf piles driven into the ground. Their effect is to prevent lateral motion. Fig. 26 is a truss-work which is used for greater elevations, and is sometimes carried even to the height of fifteen or twenty feet. Piles marked *a* are driven into the ground, and connected by the transverse beam *c*. Above these the superstructure formed of the beams *d* is raised, and upon it, the rails are placed. It is evident, however, that these structures are by no means suitable or safe for bearing the weight of locomotive engines or carriages, and, as may naturally be expected, very serious accidents have occasionally occurred on them. They are besides generally left quite exposed, and in some situations, where they are even so much as twenty feet high, no provision is made for pedestrians, who, if overtaken by the engine, can save themselves only by scrambling to the ground.

These varieties of construction were all in use when I visited the United States in 1837, but the American engineers had not at that time come to any definite conclusion as to which of them constituted the best railway. It seemed to be generally admitted, however, that the wooden structures were in most situations more economical than those formed of stone, and were also less liable to be affected by the frost. Structures of wood also possess a great advantage over those of stone, from the much greater ease with which the rails supported by them are kept in repair. Wooden railroads are more elastic, and bend under great weights, while the rigid and unyielding nature of the railroads laid on stone blocks causes the impulses produced by the rapid motion of locomotive carriages, or heavily loaded waggons, over the surface, to be much more severely felt both by the machinery of the engine and by the rails themselves. Experience, both in this country and in America, has shown the truth of these remarks.*

The rails used in the United States, when I visited the country, were of British manufacture. The Government of the United States, in order to encourage railways, removed the duty from iron imported for that purpose, and the rails which were often taken out as ballast were laid down on the quays of New York nearly at the same cost as in any of the ports of Great Britain. Those of the Brooklyn and Jamaica road, in lengths of fifteen feet, and weighing 39 lb. per lineal yard, were of British manufacture, and cost at New York when they were landed, in 1836, L.8 per ton; the cast-iron chairs, also of British manufacture, and weighing about 15 lb. each, cost L.9 per ton. There is a great abundance of iron-ore in America, and some of the veins in the neighbourhood of Pittsburg I found to be pretty extensively worked; but the Americans knew that it would be bad economy to attempt to manufacture rails, so long as those made at Merthyr Tydvil Iron-works, in Wales, could be laid down at their seaports at so small a cost. In some of the iron-works which I visited, the workmen were rolling plate-rails, which was the only kind they ever attempted to make. It appears however, from Captain Galton's report, that foreign iron is now taxed to the amount of 30 per cent.

* Sleepers have in this country been invariably substituted for stone-blocks, since the remarks in the text were written.

The Railway Companies are obliged to economize iron to the utmost; and the rails used, which are made in America, are still as light as possible, the usual weight being from 50 to 65 lb.? per lineal yard.

The stone blocks in use on the railways were made of granite, which, as already noticed, is found in several parts of the United States. Yellow pine is generally employed for the longitudinal sleepers, and cedar, locust, or white-oak, for the transverse sleepers on which the rails rest; cedar, however, if it can be obtained, is generally preferred for the transverse sleepers, because it is not liable to be split by the heat of the sun, and is less affected than perhaps any other timber, by dampness and exposure to the atmosphere. The cedar sleepers used on the Brooklyn and Jamaica Railway, measuring six inches by five, and seven feet in length, notched, and in readiness to receive the rails, cost 2s. 3½d. each, laid down at Brooklyn. It is a costly timber, and is not very plentiful in the United States; it has also risen greatly in value since the introduction of railways, for the construction of which it is peculiarly applicable. For all treenails, locust-wood is universally employed.

The American railroads are much more cheaply constructed than those in this country, which is owing chiefly to three causes; *first*, they are exempted from the heavy expenses often incurred in the construction of English railways, by the purchase of land and compensation for damages; *second*, the works are not executed in so substantial and costly a style; and, *third*, wood, which is the principal material used in their construction, is got at a very small cost. The first six miles of the Baltimore and Ohio Railroad, which is formed "in an expensive manner, on a very difficult route," has cost, on an average, about L.12,000 per mile. The railroads in Pennsylvania cost about L.5000 per mile; the Albany and Schenectady Railroad upwards of L.6000 per mile; the Schenectady and Saratoga Railway L.1800 per mile*; and the Charleston and Augusta Railroad

* Facts and suggestions relative to the New York and Albany Railway. New York, 1833.

about the same. Mr Moncure Robinson, in a report relative to the Philipsburg and Juniata Railroad, states, that the first ten miles of the Danville and Pottsville Railroad, formed for a double track, but on which a single track only was laid, cost on an average L.4400 per mile, and that the Honesdale and Carbondale Railroad, 16⅓ miles in length, laid with a single track, and executed for a considerable portion of its length on truss-work, is understood, with machinery, to have averaged L.3600 per mile. The average cost of these railways, constructed in different parts of the United States, is L.4942 per mile* which contrasts strongly with the cost of the railways constructed in this country, which perhaps may be taken on an average at L.35,000 per mile.

The following extract, embodying an estimate from Mr Robinson's Report, will give some idea of the cheapness with which many of the American works are constructed:—

"The following plan," says Mr Robinson, "is proposed for the superstructure of the Philipsburg and Juniata Railroad:—

"Sills of white or post oak, seven feet ten inches long, and twelve inches in diameter, flattened to a width of nine inches, are to be laid across the road at a distance of five feet apart from centre to centre. In notches formed in these sills, rails of white oak or heart pine, five inches wide by nine inches in depth, are to be secured, four feet seven inches apart, measured within the rails. On the inner edges of these rails, plates of rolled iron, two inches wide by half an inch thick, resting at their points of junction on plates of sheet iron, one-twelfth of an inch thick, and four and a half inches long, are to be spiked with five-inch wrought iron spikes. The inner edges of the wooden rails to be trimmed slightly bevelling, but flush at the point of contact with the iron rail, and to be adzed down outside the iron to pass off rain-water.

* The average cost of the Railways throughout the whole of United States at the end of 1851, was stated to be about £7000 per mile.—*Report to the Lords of the Committee of Privy Council for Trade on the Railways of the United States*, by Captain Douglas Galton, R.E.

"Such a superstructure as that above described would be entirely adequate to the use of locomotive engines of from fifteen to twenty horses power, constructed without surplus weight, or similar to those now in use on the little Schuylkill Railroad in this state (Pennsylvania), or the Petersburg Railroad in Virginia; and it will be observed that only the sills, which constitute but a very slight item in its cost, are much exposed to the action of those causes which induce decay in timber. It is particularly recommended for the Philipsburg and Juniata Railroad, by the great abundance of good materials along the line of the improvement, for its construction, and the consequent economy with which it may be made.

"The following may be deemed an average estimate of the cost of a mile of superstructure as above described. :—

	Dollars.
1056 trenches, 8 feet long, 12 inches wide, and 14 inches deep, filled with broken stone, at 25 cents each,	264
Same number of sills, hewn, notched, and imbedded, at 50 cents each,	528
10,912 lineal feet of rails (allowing $33\frac{1}{3}$ per cent. for waste), at 4 cents per lineal foot, delivered,	436·48
2112 keys, at $2\frac{1}{2}$ cents each,	52·80
10,560 lineal feet of plate rails, 2 inches by $\frac{1}{2}$ inch, weight $3\frac{1}{3}$ lb. per foot, $15\frac{7}{100}$ tons, delivered at 50 dollars (L.10) per ton,	785·50
1509 lb. of 5-inch spikes, at 9 cents per pound,	135·81
Sheet iron under ends of rails,	30·21
Placing and dressing wood, and spiking down iron rails,	280
Filling between sills with stone, or horse-path,	180
2692 dollars, or about L.540."	2692·80

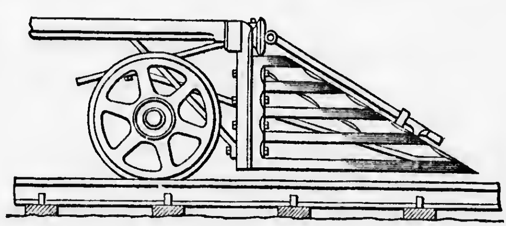
On some of the American Railways, where the line is short or the traffic small, horse power is employed, but locomotive engines for transporting goods and passengers are in much more general use. In New York, Brooklyn, Philadelphia, Baltimore, and other places which have lines of railway leading from them, the depôt or station for the locomotive engines is generally placed at the outskirts, but the rails are continued through the streets to the heart of the town, and the carriages are dragged over this part of the line by horses, to avoid the inconvenience and danger attending the passage of locomotive engines through crowded thoroughfares. I travelled by horse power on the Mohawk and Hudson Railway, from Schenectady to Albany, a distance of sixteen miles, and the journey was performed in sixty-five minutes, being at the astonishing rate of fifteen miles an hour. The car by which I was conveyed carried twelve passengers, and was drawn by two horses, which ran stages of five miles. The fencing, even of the locomotive lines, is often very defective, and a large bell on the engine, which is rung at the numerous level crossings, is the chief warning which road passengers receive of the approach of trains. Captain Galton says that level crossings are scarcely ever provided with gates or gate-keepers, except in special cases, near towns, but a large board is placed over the crossing with the words printed—*Railroad Crossing, look out for the Cars when the Engine Bell rings.* Trenches 4 feet deep and 4 feet 6 inches wide, called cattle guards, are cut across the railway on either side of the level crossings to prevent cattle from straying on the line, and the rails are carried past these trenches on narrow beams stretching across the excavated space.

The first locomotive engines used in America were of British manufacture, but several very large workshops have lately been established in the country for the construction of these machines, which are now manufactured in great numbers. The largest locomotive engine-works are those of Mr Baldwin, Mr Norris, Mr Long, and Messrs Grant and Eastrick, all in Philadelphia, and the Lowell Engine-work at Lowell. When I visited the work of Mr Baldwin, to whom I am indebted for much attention and information, I found no less than twelve locomotive carriages in different stages of progress, and ali of substantial and good workmanship. Those parts of the engine, such as the cylinder, piston, valves, journals, and slides, in which good fitting and fine workmanship are indispensable to the efficient action of the machine, were very highly finished, but the external parts, such as the connecting rods, cranks, framing, and wheels, were left in a much coarser state than in engines of British manufacture. The American engines, with their boilers filled, weigh from twelve to fifteen tons, and cost about L.1400 or L.1500, including the tender. This is not much more than the cost of an engine of the same weight in this country. They have six wheels. These are arranged in the following manner, so as to allow the engine to travel on rails having a great curvature; the driving wheels, which are five feet in diameter, are placed in the posterior part of the engine close to the fire-box, and the fore part of the engine rests on a truck running on four wheels of about two feet six inches in diameter: a series of friction-rollers, arranged in a circular form, is placed on the top of the truck, and in the centre stands a vertical pivot, which works in a socket in the framing of the engine. The whole weight of the cylinders and the fore part of the boiler rests on the friction-rollers, and the truck turning on the pivot as a centre, has freedom to describe a small arc of a circle; so that when the engine is not running upon a perfectly straight road, its wheels adapt themselves to the curvature of the rails, while the relative positions which the body of the engine, the connecting rods, and other parts of the machinery bear to each other, remain unaltered.* The object of this arrangement will be apparent when it is stated that some of the curves on the American Railways have so small a radius as 350 feet.

From the unprotected state of most of the railways, which are seldom effectually fenced, cattle often stray upon the line,

*I believe an attempt was made to apply Avery's Rotatory Engine to propel a locomotive carriage, on one of the American railways, but I could not obtain satisfactory information either as to the particulars of the experiment, or the part of the country in which it was made. Avery's engines, are, I believe, a good deal used in the northern parts of the United States, for driving small mills. They are generally of from 6 to 12 horses power. In New York I saw three of them at work, one in the Astor Hotel, which was employed to pump water, grind coffee, &c., one in a saw-mill in Attorney Street, and the third working a printing press; these were the only engines constructed on the rotatory principle, which I saw in actual use in the country.

and are run down by the engines, which are in some cases thrown off the rails by the concussion, producing very serious consequences. To obviate this, and render railway travelling more safe, an apparatus called a "guard" is employed; those I saw consisted of a strong framework of wood, fixed to the fore-axle of the locomotive carriage, and supported on two small wheels, about two feet in diameter, which run on the rails about three feet in advance of the engine. The outer extremity of the framework is shod with iron slightly bent up, and comes to within an inch of the top of the rails. The upper part of the surface of the guard is covered with wood, and the lower part with an iron grating. The apparatus affords a complete protection to the wheels of the engine. I experienced the good effects of it upon one occasion on the Camden and Amboy Railway. The train in which I travelled, while moving with considerable rapidity, came in contact with a large waggon loaded with firewood, which was literally shivered to atoms by the concussion. The fragments of the broken waggon, and the wood with which it was loaded, were distributed on each side of the railway, but the guard prevented any part of them from falling before the engine-wheels, and thus obviated what might in that case have proved a very serious accident. The guards now in use are of the form shown in the cut, which is taken from the drawing given by Captain Galton in his Report.



The fuel used on most of the railways is wood, but the sparks vomited out by the chimney when it is not covered with a cap or grating, are a source of constant annoyance to the passengers, and occasionally set fire to the wooden bridges on the line, and the houses in the neighbourhood. Anthracite and bituminous coal, as formerly noticed in the chapter on fuel and materials, are now coming to be more generally used.

In situations where the summit level of a railway cannot be attained by an ascent sufficiently gentle for the employment of locomotive engines, or where the formation of such inclinations, though perfectly practicable, would be attended with an unreasonably large outlay, transit is generally effected by means of inclined planes, worked by stationary engines. This system has been introduced on the Portage Railway, over the Alleghany Mountains, on a more extensive scale than in any other part of the world. The Portage, or Alleghany Railway, forms one of the links of the great Pennsylvania Canal and railroad communication from Philadelphia to Pittsburg,—a work of so difficult and vast a nature, and so peculiar, both as regards its situation and details, that it cannot fail to be interesting to every engineer, and I shall, therefore, state at some length the facts which I have been able to collect regarding it.*

This communication consists of four great divisions, the Columbia Railroad, the Eastern Division of the Pennsylvania Canal, the Portage or Alleghany Railroad, and the Western Division of the Pennsylvania Canal. These works form a continuous line of communication from Philadelphia on the Schuylkill to Pittsburg on the Ohio, a distance of no less than 395 miles.

Commencing at Philadelphia, the first Division of this stupendous work is the Philadelphia and Columbia Railroad, which was opened in the year 1834. It is eighty-two miles in length, and was executed at a cost of about L.666,025, being at the rate of L.8122 per mile. There are several viaducts of considerable extent on this railway, and two in-

* I understand that a tunnel has now been made to avoid the steep inclines on this line, but its original construction is a lasting monument to American enterprize, and a proof of what may be overcome by boldness of design and perseverance, and the details of its construction must ever be worthy of a place in the records of Engineering, so that I offer no apology for repeating the sketch of the work as originally executed.

clined planes worked by stationary engines. One of these inclined planes is at the Philadelphia end of the line. It rises at the rate of one in 14·6 for 2714 feet, overcoming an elevation of 185 feet. The other plane, which is at Columbia, rises at the rate of one in 21·2 for a distance of 1914 feet, and overcomes an elevation of 90 feet. A very large sum is incurred in upholding the inclined planes, and surveys have lately been made with a view to avoid them. The cost of maintaining the stationary power, and superintendance of the Philadelphia incline, is said to be about L.8000 per annum, and that of the Columbia incline about L.3498 per annum. Locomotive engines are used between the tops of the inclined planes. The steepest gradient on that part of the line is at the rate of one in 117; but the curves are numerous, and many of them very sharp, the minimum radius being so small as 350 feet. This line of railway was surveyed, and laid out before the application of locomotive power to railway conveyance had attained its present advanced state,—at a period when sharp curves and steep gradients were not considered so detrimental to the success of railways as experience has since shown them to be.

The passenger carriages on the Columbia Railroad, and, indeed, on all the American lines, are extremely large and commodious. They are seated for sixty passengers, and are made so high in the roof, that the tallest person may stand upright in them without inconvenience. There is a passage between the seats, extending from end to end, with a door at both extremities; and the coupling of the carriages is so arranged, that the passengers may walk from end to end of a whole train without obstruction. In winter they are heated by stoves. The body of each of these carriages measures from fifty to sixty feet in length, and is supported on two four-wheeled trucks, furnished with friction-rollers, and moving on a vertical pivot, in the manner formerly alluded to in describing the construction of the locomotive engines. The flooring of the carriages is laid on longitudinal beams of wood, strengthened either with suspension rods of iron below, or with cross framing above in the sides of the carriage.

At the termination of the railway at Columbia, is the commencement of the Eastern Division of the Pennsylvania Canal, which extends to Hollidaysburg, a town situate at the foot of the Alleghany Mountains. This canal is rather more than 172 miles in length, and was executed at an expense of L.918,829, being at the rate of L.5342 per mile. There are 33 aqueducts, and 111 locks on the line, and the whole height of lockage is 585·8 feet. A considerable part of this canal is slackwater navigation, formed by damming the streams of the Juniata and Susquehanna. The canal crosses the Susquehanna at its junction with the Juniata, at which point it attains a considerable breadth. A dam has been erected in the Susquehanna at this place, and the boats are dragged across the river by horses, which walk on a tow path attached to the outside of a wooden bridge, at a level of about thirty feet above the surface of the water. I regret that I passed through this part of the canal after sunset, and had only a very superficial view of the works at this place, which are of an extensive and curious nature.

Hollidaysburg is the western termination of the Eastern Division of the Pennsylvania Canal. The town stands at the base of the Alleghany Mountains, which extend in a south-westerly direction, from New Brunswick, to the State of Alabama, a distance of upwards of 1100 miles, presenting a formidable barrier to communication between the eastern and western parts of the United States. The breadth of the Alleghany range varies from a hundred to a hundred and fifty miles, but the peaks of the mountains do not attain a greater height than 4000 feet above the level of the sea. They rise with a gentle slope, and are thickly wooded to their summits. "The Alleghany Mountains present what must be considered their scarp or steepest side to the east, where granite, gneiss, and other primitive rocks are seen. Upon these repose first, a thin formation of transition rocks dipping to the westward, and next a series of secondary rocks, including a very extensive coal formation."* The National

* Encyclopædia Britannica, article America.

Road, which has already been noticed, was the first line of communication formed by the Americans over this range; and in the year 1831, an Act was passed for connecting the Eastern and Western Divisions of the Pennsylvania Canal by means of a railroad. This important and arduous work, which cost about L.526,871, was commenced within the same year in which the Act for its construction was granted, and the first train passed over it on the 26th day of November 1833, but it was not till the year 1835, that both the tracks were completed, and the railway came into full operation.

The railway crosses the mountains by a pass called "Blair's Gap," where it attains its summit level, which is elevated 2326 feet above the level of the Atlantic Ocean. Mr Robinson surveyed a line of railway from Philipsburg to the River Juniata, which is intended to cross the Alleghany Mountains by the pass called "Emigh's Gap." The summit level of this line is stated, in a report by the directors, to be 292 feet lower than that of the Portage Railway.

The preliminary operation of clearing a track for the passage of the railway from a hundred to a hundred and fifty feet in breadth, through the thick pine forests with which the mountains are clad, was one in which no small difficulties were encountered. This operation, which is called *grubbing*, is little known in the practice of engineering in this country, and is estimated by the American engineers, in their various railway and canal reports, at from L.40 to L.80 per mile, according to the size and quantity of the timber to be removed; an estimate which, from the appearance of American forests, I should think must, in many instances, be much too low. The timber removed from the line of the Alleghany Railway was chiefly spruce and hemlock pine, of very large growth. I passed over the Alleghany Mountains on the 11th of May, at which time the trees were thickly covered with foliage, and formed a wall on each side of the railway, which completely intercepted the view of the surrounding country during the greater part of the journey. An extensive view was occasionally obtained from the tops of the inclined planes, when nothing but a dense black forest was visible, stretching in all directions as far as the eye could reach.

The line is laid with a double track, or four single lines of rails, and is twenty-five feet in breadth. For a considerable distance the railway is formed by side-cutting along steep sloping ground, composed of clay-slate, bituminous coal and clay, part of the breadth of the road being obtained by cutting into the hill, and part by raising embankments protected by retaining walls of masonry. The railway is consequently liable to be deluged, or even entirely swept away, by mountain torrents, and the thorough drainage of its surface has been attended with great expense and difficulty. The retaining walls by which the embankments are supported, are in some places not less than a hundred feet in height; they are built of dry-stone masonry, and have a batter of about one-half to one, or six inches horizontal to twelve inches perpendicular. There are no parapet or fence walls on the railway, and on many parts of the line, especially at the tops of several of the inclined planes, the trains pass within three feet of precipitous rocky faces, several hundred feet high, from which the large trees growing in the ravines below, almost resemble brushwood. One hundred and fifty-three drains and culverts, and four viaducts, have been built on the railway. One of the viaducts crosses the River Conemaugh at an elevation of seventy feet above the surface of the water. There is also a tunnel on the line 900 feet in length, twenty feet in breadth, and nineteen feet in height.

The inclined planes are, however, the most remarkable works which occur on this line. The railway extends from Hollidaysburg on the eastern base, to Johnstown on the western base of the Alleghany Mountains, a distance of thirty-six miles; and the total rise and fall on the whole length of the line is 2571·19 feet. Of this height, 2007·02 feet are overcome by means of ten inclined planes, and 564·17 feet by the slight inclinations given to the parts of the railway which extend between these planes. The distance from Hollidaysburg to the summit-level is about ten miles, and the height is 1398·31 feet. The distance from Johnstown to the same point is about twenty-six miles, and the height 1172·88 feet. The height of the summit-level of the railway above the mean level of the Atlantic is 2326 feet.

The following are the lengths, gradients, and elevations overcome by the several inclined planes, five of which are placed on each side of the summit-level :—

No. of Plane.	Length in Feet.	Gradient.	Height overcome.
Plane No. 1.	1607·74	One in 10·71	150 feet.
... 2.	1760·43	... 13·29	132·40 ...
... 3.	1480·25	... 11·34	130 50 ...
... 4.	2195·94	... 11·68	187·86 ...
... 5.	2628·60	... 13·03	201·64 ...
... 6.	2713·85	... 10·18	266 50 ...
... 7.	2655·01	... 10·19	260·50 ...
... 8.	3116·92	... 10·13	307·60 ...
... 9.	2720 80	... 14·35	189·50 ...
... 10.	2295·61	... 12·71	180·52 ...

The following table shows the length of each section of the railway between the inclined planes, and the elevation overcome on it :—

	Length in miles.	Gradient.	Height overcome.
From Johnstown to foot of plane No. 1, ...	4·13	1 in 214·92	101·46
— head of plane No. 1 to foot of plane No. 2,	13·06	— 363·73	189·58
— do. No. 2 to do. No. 3,	1·43	— 477·87	15·80
— do. No. 3 to do. No. 4,	1·90	— 533·61	18·80
— do. No. 4 to do. No. 5,	2·56	— 523·90	25·80
— foot of plane No. 5 to head of plane No. 6,	1·62	— 449·24	19·04
— do. No. 6 to do. No. 7,	0·15	level	...
— do. No. 7 to do. No. 8,	0·61	— 596·44	5·40
— do. No. 8 to do. No. 9,	1·18	— 519·20	12·00
— do. No. 9 to do. No. 10,	1·70	— 303·44	29·58
— do. No. 10 to Hollidaysburg, . .	3·72	— 133·88	146 71

The machinery by which the inclined planes are worked, consists of an endless rope passing round horizontal grooved wheels placed at the head and foot of the planes, which are furnished with a powerful break for retarding the descent of the trains. The ropes were originally made $7\frac{1}{2}$ inches circumference, but they have lately (1837) been increased to 8 inches, to prevent a tendency which they formerly had to slip in the grooved wheels, occasioned by their circumference being too small for the size of the groove or hollow in the wheel. Two stationary engines of twenty-five horse power each are placed at the head of the inclined planes, one of which is in constant use in giving motion to the horizontal wheels round which the rope moves while the trains are passing the inclined planes. Two engines have been placed at each station, that the traffic of the railway may not be stopped should any accident occur to the machinery of the one which is in operation; and they are used alternately for a week at a time. Water for supplying the boilers has been conveyed to many of the stations at a great expense.

The planes are laid with a double track of rails, and an ascending and a descending train are always attached to the rope at the same time. Many experiments have been made to procure an efficient safety-car to prevent the trains from running to the foot of the inclined plane, in the event of the fixtures by which they are attached to the endless rope giving way. Several of these safety-cars are in use, and are found to be a great security. The trains are attached to the endless rope simply by two ropes of smaller size made fast to the couplings of the first and last waggons of the train, and to the endless rope by a hitch or knot, formed so as to prevent it from slipping.

Locomotive engines are used on the parts of the road between the inclined planes.

The following extract, from the Report of the Pennsylvania Canal Commissioners for 1836, affords the best proof of the traffic which the road is capable of carrying on:—

"The Portage Railway, however complicated in its operations, and limited in capacity by inclined planes, as canals are by locks, is nevertheless adequate to the transaction of a vast amount of business. Occupying, as it does, a nearly central position on the main line between Columbia and Pittsburg, the capacity of the planes ought to be equal to that of the canal locks on those Divisions. Many suppose the planes fall very far short of that limit, and that their full capacity is nearly reached.

"It is, however, due to our commercial interest and the public at large, to state that the maximum of that limit is very far from being attained. The length of the longest plane is about 3000 feet; the time occupied in moving up or down it is five minutes; the time occupied in attaching is two and a-half minutes, making seven and a-half minutes, or eight drafts per hour of three loaded cars, carrying three tons each, making twenty-four cars, or seventy-two tons per hour.

"It will be observed by the Report of the Superintendent, that the number of cars weighed at Hollidaysburg, and transported from east to west, from April 1st to October 31st, is 14,300, making a transit of a number not exceeding a hundred per day; but, instead of this number, when the trade demands it, twenty-four cars can be passed up, and the same number down, the longest plane in each hour, making two hundred and eighty-eight cars in the day of twelve hours, or five hundred and seventy-six in one direction in twenty-four hours; this can be accomplished by using the road day and night, by means of a double set of hands. This is the true limit of the capacity of the road."

From the same report it appears, that from the 1st of April to the 31st of October, the time during which the railway was open in the year 1836, 19,171 passengers were conveyed along the line; and the following is a statement in pounds weight of the merchandise weighed at the weigh-scales at Hollidaysburg during the same period, amounting to 37,081 tons, conveyed in 14,300 waggons.

Months.	Merchandise.	Iron.	Coal.	Lumber.	Number of Cars.
April,	7,192,310	1,863,170	673,060	315,435	1,323
May,	13,262,218	1,654,495	2,335,390	258,940	3,208
June,	5,146,415	3,389,160	2,384,735	367,045	1,947
July,	4,724,830	1,843,760	1,019,070	63,310	1,335
August,	8,124,370	2,076,820	2,094,300	347,950	2,183
Sept.,	7,132,345	2,063,645	3,645,660	86,620	2,324
October,	5,899,050	1,938,710	2,899,730	260,140	1,980
	51,481,538	14,829,760	15,051,945	1,699,440	14,300

The travelling on this railway is very slow. The train by which I was conveyed left Hollidaysburg at nine in the morning, reached the summit at twelve, and arrived at Johnstown at five in the evening, seven hours having been occupied in travelling thirty-six miles, being only at the rate of about five miles an hour. Much time is lost in ascending and descending the inclined planes, and an hour is generally spent for dinner at an inn on the summit, which is the only house unconnected with the works which is met with on the whole journey.

The fourth division of this grand work is the Western Division of the Pennsylvania Canal, which extends from the termination of the Portage Railway at Johnstown to Pittsburg. It has 64 locks, 16 aqueducts, 64 culverts, 152 bridges, and a tunnel upwards of 1000 feet in length. This canal traverses the valleys of the Conemaugh, Kiskiminetas, and Alleghany Rivers; measures 105 miles in length, and cost L.560,000, being at the rate of L.5333 per mile.

The whole distance of the Pennsylvania canal and railroad communication, extending from Philadelphia to Pittsburg, is 395 miles. I travelled this distance in ninety-one hours, exclusively of the time lost in stopping at Columbia, Harrisburg, and other places of interest on the route. The average rate of travelling was therefore 4.34 miles per hour. One hundred and eighteen miles of this extraordinary journey were performed on railroads, and the remaining 277 miles on canals. The charge made for each passenger conveyed the whole distance was L.3, being at the rate of nearly 2d. per mile.

Since these remarks were written the American railways have, as already noticed, been greatly extended; and I gladly avail myself of the valuable Report of Captain Galton, made to the Board of Trade in 1857, from which the following extracts as to the routes of the great prairie and other lines are taken; which, together with the observations I have laid before the reader, will, it is believed, afford a pretty accurate idea of the American railway system at the present date:—

" The railways of the United States," says Captain Galton, "appear to have been designed principally with the view of connecting the sea coast with the fertile lands in the west; but the range of the Alleghany Mountains rising in the north near Lake Ontario, and running nearly parallel to the coast, intersects every line of travel between the important commercial sea-board cities and the western districts.

"The direct eastern and western traffic which traverses this range passes over four principal railway routes, viz.:—

"*1st*, The New York Central Railway, which is a link in the communication from Boston to the West; this is connected with New York by the Hudson River Railroad, and is connected with western lines at Niagara and Buffalo. This line passes up the valley of the Mohawk, and has favourable gradients along its whole length.

"*2d*, The New York and Erie Railway, which, crossing the Alleghany Mountains near the head waters of the Susquehanna and Delaware, forms a connection with western lines at Niagara and along the south shore of Lake Erie.

"*3d*, The Pennsylvania Central Railway, which runs from Philadelphia to Pittsburg, and there forms a connection with the railways crossing the centre of Ohio.

"*4th*, The Baltimore and Ohio Railway, from Baltimore to Wheeling, and thence to Columbus and Cincinnati.

"It is not probable that, for the present, any other line will be carried across the Alleghany Mountains, at least to the north of Baltimore. Hence the development of the Western States; and the projected railroads to the Pacific will add to the important traffic which these several roads already possess.

"To the south, roads are projected to run from Virginia, from Charleston, and from Savannah to the Mississippi.

"In addition to these eastern and western routes of the United States must be mentioned the communication by water along the lakes, a communication which is continued by the Erie Canal to New York, and by the St Lawrence through Canada to the Atlantic; and the line of Canadian railways, which, since the opening of the Grand Trunk Railway, has assumed considerable importance. This line commences with the Great Western of Canada at Detroit, and, passing through Toronto, is continued by the Grand Trunk Railway, which, when the Victoria Bridge shall have been completed, will afford an uninterrupted line of railway communication through Montreal to Quebec, and to Portland in the State of Maine. But it cannot be considered that this line of communication is completed, or that a proper outlet has been afforded to the trade of the British North American possessions, until the line of railway through Canada shall have been continued on to Halifax.

"The great question, however, of railway extension from east to west, which now occupies the attention of the American public, is the construction of a railway to connect the Eastern States with the Pacific Ocean. Five routes have been proposed, but the most practicable are limited to the three following lines, viz. :—

1*st*, From St Paul's to Vancouver, near the parallel of 48°.

2*d*, From Council Bluffs to Benicia, which is near to San Francisco, *viâ* the south-west pass, near the parallel of 42°.

3*d*, From Fulton to San Pedro, near the parallel of 32°.

The following comparison of the routes is obtained from the Secretary of State's report to Congress on the subject, viz. :—

	Length.	Height of Summit-Level or Passes.	Estimated Cost.	Proportion of Arable Land through which they pass.
	Miles.	Feet.		
1*st*,	1864	6044	£25,000,000	30 per cent.
2*d*,	2032	8733	23,000,000	35 "
3*d*,	1618	5717	17,000,000	45 "

"The question of a means of communication across this continent is one which Great Britain should not leave to be solved by the United States alone."

"The principal north and south route, not including the railways along the eastern coast, is the Illinois Central Railway. This railway runs from Cairo at the confluence of the Mississippi and Ohio rivers to Chicago and Dubuque; and from its termini lines are projected to run northwards to

Superior City, and southwards to Mobile, on the Gulf of Mexico.

"Chicago is the chief focus of railway communication in the west, and may be called the offspring of the railway system.

"It is situated in one of the most fertile regions of the world, at the southern extremity of Lake Michigan, on a perfectly flat plain, at the edge of the prairies. At no great distance from it are rich mines of lead, iron, copper, and coal. It possesses communication by water with the Atlantic by means of the lakes, the St Lawrence, and the Erie Canal, and with the Gulf of Mexico by the Bridgeport Canal, and the Mississippi. It forms the mart for the interchange of the produce of the prairies with the lumber and other articles which require to be imported; and hence it is to the railways by which that produce is developed, that its great progress has been due.* In 1832 the site of the present town was occupied by a small fort and a few log cabins. The first railway was completed in 1850, and the following figures will give some idea of the rapid increase of Chicago since that period.

"* The progress of Chicago is due to the cultivation of the rich prairie land by which it is surrounded; but it has been much favoured by the reciprocity treaty between the United States and Canada. At the present time the land of the prairies is only cultivated at intervals along the lines of railway, but the area of the State of Illinois is 55,000 square miles, and it is stated upon good authority that 80 per cent. of the whole area—equal to 44,000 square miles, or 28,260,000 acres—consists of first-class arable land, very similar to what is already in cultivation. It is stated that an average crop of wheat in Illinois is from 25 to 30 bushels per acre, and that frequently it reaches 40 bushels per acre. If one-fourth of the above-mentioned area were devoted to the culture of wheat, and if the annual average produce per acre be taken at 25 bushels, the yield would amount to nearly 180,000,000 of bushels annually. As the prairies are bare of timber, no clearing is necessary, and the land need only be ploughed and sown to obtain a crop. The absence of timber, however, gives rise to an enormous demand for lumber, as the houses are almost invariably at first built of wood. The President of one of the principal railways told me that it is curious to observe how, in the first year or two after a railway is opened, the necessaries of life alone are transported along it, but how, as time progresses, luxuries, such as New York carriages and harness, handsome furniture, &c., are sent for by the settlers.

"In 1849 the population was 23,047; in 1855 it was 83,509. In 1851 the number of miles of railway centering in Chicago were 40, and the annual receipts from traffic about L.8000; in 1855 the miles of railway centering in Chicago amounted to 2933, and the receipts from traffic to L.2,659,640. In 1849 the amount of lumber received at Chicago amounted to 73,259,553 feet; in 1855 to 326,553,467 feet. Twenty years ago Chicago and the surrounding district imported grain for food; in 1853 the amount of grain exported was 6,500,000 bushels, and in 1855 the export of grain amounted to 16,633,813 bushels,—the total amount received into the city in 1855 being 20,487,953 bushels. The value of beef packed in Chicago in 1851 was about L.130,000; in 1855 about L.230,000. The value of real estate in Chicago, which is stated to have been L.360,000 in 1840, and L.1,600,000 in 1850, was estimated at L.8,200,000 at the end of 1855."

"Railways in the United States appear to have been constructed under four different arrangements:—

1*st*, By the State.

2*d*, By a company to whose share capital, or mortgage debt, the State has contributed, retaining an interest in the line and some power of interference.

3*d*, By a company to whom lands have been granted, but which otherwise has not been interfered with.

4*th*, By a company unassisted, and therefore not interfered with.

"1*st*, The railways made by the State do not appear to have been successful. State railways have consequently not proved remunerative, and they have generally been transferred to private companies."

"2*d*, The States and municipal corporations have in several instances given assistance to railway companies. In most cases the State or the corporation of the town has reserved to itself the right of appointing directors in proportion to the amount contributed; but as these directors are generally elected by universal suffrage for short periods, they often desire to regulate the management of the railway more with reference to local political objects, than to its interests as a commercial speculation.

"This arrangement is therefore false in principle, and combines two conflicting elements. If the railway is a commercial speculation, the management should be left to the company; if, on the contrary, it is to be worked with a political object, the commercial element should be left out of view, and the line be wholly managed by the State."

"*3d*, The mode by which the State induces a company to construct a railway by grants of land, is one which deserves attention, as being especially applicable in many of our colonial possessions.

"This system is resorted to in the Western States with a remarkable degree of success. In these states the fertility of the soil cannot be made available without means of communication, and any amount of land is well applied which will induce a company to construct a railway. In all new territories the land is surveyed in lots, each containing a square mile. The railway company to whom land is granted is allowed to take, in addition to the actual land required for the line, a specified quantity in alternate lots on each side within a certain distance from the line. In case any of those lots which would naturally fall to the company, should have been previously bought by individuals, the railway company selects other lots.

"This system gives security to capitalists for their investment. It makes it the interest and the business of the company to publish the merits of the district, and by offering facilities to the travelling public, to induce the settlement of the country; hence the value of the alternate lots of land which are retained by the State is increased.

"The State, in granting the land, generally reserves a per-centage on the gross receipts of the company. On the Illinois Central Railway this amount is 7 per cent.

"As the progress of this railway affords a striking illustration of the advantages of this method, it appears desirable to give a brief account of it.

"The company was formed for the purpose of making a railway through Illinois from Cairo, at the confluence of the Ohio and Mississippi, to Dubuque on the Mississippi, with a branch line to Chicago. Its course lay chiefly through prairie land, only inhabited at a few points. On the 20th September 1850, Congress granted to the State of Illinois 2,595,000 acres of land to aid in the construction of the Illinois Central Railroad. The vacant lands, in alternate sections within 6 miles of the road, were conveyed by direct terms in the grant, and, in lieu of such portions as had been previously sold, selections were authorized to be made between 6 and 15 miles on each side of the road. The company was incorporated by the Legislature of the State of Illinois in 1851, and the grant conferred upon it. The company created a capital stock of 17,000,000 dollars, on which 25 per cent. has been paid; and for the additional money required for the construction of the railway, they have raised 20,000,000 dollars by mortgage on the security of 2,345,000 acres of the land granted to them, and they have reserved 250,000 acres, the proceeds from which are to assist in paying the interest on this mortgage.

"The ordinary price of new land in the States is one dollar per acre; the company are selling the land at prices varying from 5 to 25 dollars per acre, which is paid for in five annual instalments, with 3 per cent. interest. When the last instalment has been paid, commissioners appointed by the State grant a title to the purchasers of the land upon the railway company producing to them such a number of mortgage bonds cancelled as amount to the price they have received for the land.

"This line runs for the greater part of its course through prairie land without trees—land which, with a small expenditure of labour, produces most luxuriant crops.

"When the line was first opened the country was nearly uninhabited; stations were placed at every 8 or 10 miles, round which villages, and in some cases towns, have sprung up, and fields of corn and herds of cattle are now to be seen on every side. If well managed, this railway should prove most lucrative to the shareholders. It has already largely developed the resources of the State, and the per-centage which it pays to the Government will eventually relieve the State from taxation to a considerable extent.

"*4th*, A large number of railways have been constructed without State assistance."

"In a majority of States, general railroad laws have been passed, enabling corporations to be formed for making railways, the course of which is to be approved of by Railroad Commissioners or by some executive authority, due notice of the intended route being given in order that all persons affected may have an opportunity to object. Very large discretionary powers are left with the commissioners as regards crossing roads, streets, rivers, &c. But as a general rule, the companies prefer special charters, which confer greater privileges. A projected railroad is sometimes opposed on grounds of public inconvenience; but I was informed that opposition by individuals on private grounds is unknown, and would not be tolerated.

"The company receives powers by its charter to take all necessary land, the mode of compensation varying in the different States. In some States the Courts appoint juries of twelve or of seven persons to determine the value. In other States a jury of twelve persons is named in the usual manner, from which each party alternately strikes off one until six are left. In other States the Court of the county names commissioners to make awards.

The decisions are not in all cases final; an appeal may sometimes be carried into some Court of the State."

CONSTITUTION OF RAILWAY COMPANIES.

"A railway company is governed by a president and a board of directors.

"The president is paid highly, and is selected for his knowledge of business and practical acquaintance with the management of railways. He devotes his whole time to the affairs of the company. In him is vested the whole executive power, and he is responsible for the efficient and economical working of the line. The directors are generally good men of business, but unpaid, excepting when they are required to attend continuously on occasional committees; they would appear generally to have the position of a consultative body, to assist and watch over the president, and to be responsible for the financial position of the company, and for the proper management of the accounts.

"These officers are elected annually by a majority of votes, present, or represented by proxy, at a general meeting."

Captain Galton gives the following view of the financial position of the American Railways:—

"The cost per mile of railway open averages from L.10,000 to L.12,000 on the New York and Massachusetts railways as compared with L.35,000 on British railways.

"The earnings per mile run by the trains average 77·28 dol. for Massachusetts railways, 88 dol. for New York railways, and 91 dol. for the other railways mentioned, as against 68·45 dol. for England; the expenditure per train per mile being 47·52 dol., 50 dol., and 52 dol., compared with 38·22 dol. for England. The receipts per mile of railway are L.1397 in Massachusetts, and L.1576 in New York, compared with L.3013 in English railways; the working expenses per mile of railway in those States being L.857·65., and L.892·66., compared with L.1504·39 for English railways.

"It appears, from the figures I have obtained, that the number of trains are fewer in proportion to the traffic; and that those trains are better filled than ours.

"The charge for maintenance of way is high as compared with that on English railways, and the proportion which the working expenses bear to the receipts from traffic is higher than in England, being fifty-six and sixty per cent. of the receipts as compared with forty-eight per cent. on English railways. The high cost of maintenance of way is probably in part due to the necessity for removing snow in winter; but the generally large proportion which the working expenses bear to the receipts, as compared with English railways, is due, partly to the less perfect condition of the lines, and partly to the higher value of labour." Captain Galton gives a table which shows the average wages paid to the different classes of railway servants on one of the principal railways in the United States—viz., the New York and Erie Railway. From this it appears, that an engine-driver receives on an average between 11s. and 12s. per day; the wages of a fireman and a porter average between 4s. and 5s. per day; and a platelayer earns about 4s. per day.

Captain Galton remarks that "these results show that the number of trains is better adapted to the requirements of the traffic than is the case with us; that the original cost of the railways has been much smaller than that of English railways; that the cost of working in proportion to the receipts, is on an average larger than in this country; and that the proportion which the profits bear to the capital invested is between five and six per cent. in New York and Massachusetts, and more in the Western States, as compared with three or three and a-half per cent. on British railways. But it must be borne in mind that the ordinary rate of interest in the United States, on the best securities, is as much as six, seven, or eight per cent., and that, consequently, the profits on railways in the eastern States, do not bear a very different ratio to the ordinary rate of interest than is the case in this country."

With reference to the construction of the Great Western Prairie lines, Captain Galton says—

"The ballasting is generally very deficient at first. On the prairie lines it is impossible to procure ballast, except from very considerable distances. In constructing these lines, a ditch is dug on each side of the road, and the soil banked up, so as to cover the centre of the sleepers, but sloped off on each side, leaving the ends of the sleepers exposed, in order to allow rain to drain off rapidly.

"The elasticity of the soil makes these roads far from disagreeable to travel over when dry; but in wet weather and frost, the absence of ballast is a source of great inconvenience and danger. This may be remedied, to some extent, by placing a good drain under the centre, as well as the sides of the roads; but nothing can compensate for the absence of ballast, which, in a severe climate like that of America, should be of broken stone, not less than two feet in depth under the sleepers, with good drainage; it is sometimes customary to slope the top of the ballast on each side, so as to cause the snow melted on the surface to drain off.

"The dust caused by the friable nature of the soil is the great inconvenience of summer travelling in the United States.

"Several plans have been tried to avoid it. On some railways windows have been constructed, so that the sides should slant outwards and throw it off.

"On the Michigan Central Railway a screen of tarred canvas is fixed, so as to reach from the lower framing of the cars to within about 2 inches of the rails outside the wheels. The screen terminates in a framework, which is arranged to abut against a similar framework on the next car, so that from one end of the train to the other a tunnel is formed under the cars, in which the dust is confined, and can only escape at the end of the train. This plan prevents dust in the cars, but is said to cause heated axles.

"On the New York and Erie Railway, the following plan secures freedom from dust, and good ventilation:—A funnel, placed at the top of the car, faces the direction in which the train is proceeding, and the movement of the train causes the air to pass down this funnel into a chamber, where it is purified. A cistern of water is fixed under the car, and a pump, worked by the rotation of the axles of the car, forces the water into the chamber through jets arranged to fill the chamber with spray. The air, in passing through this spray, is freed from dust. In cold weather a stove is placed so as to warm the water. The air then passes through flues under the floor into the interior of the car. The windows must be kept closed. As this arrangement is in practical use on several cars on the New York and Erie Railway, it would be well worthy of a trial upon English railways; especially in large saloon carriages." *

* The dust and high temperature will, in all probability, be found to occasion considerable difficulty on the great Indian lines now in course of construction.

For many very valuable and interesting details as to the management of the American railways, I have to refer the reader to Captain Galton's Report, and shall close this chapter by giving at length his concluding remarks, which contain a recapitulation of his observations and inferences:—

"There are two distinguishing features of the American system in its relations to the public, which contrast strongly with the system in operation in this country, viz:—

"*First*, That the public are left almost entirely to take care of themselves in trains, at stations, and at level crossings, the only warning of danger being a placarded notice, or the sound of the engine bell.

"*Second*, That the conveniences and comfort in the cars are extended equally to all ranks of passengers at a low rate of fare; by which the tendency to travelling is promoted.

"These two features are no doubt in some measure due to the habits of the people. Indeed, it is to be borne in mind, that the American railway system must not be judged by the standard that we have established in England.

"In this country, where the space is limited, and where good roads and canals already existed, railways were sought as a means of annihilating distance by high speeds, and of centralizing business into one focus; and were at first scarcely considered as a means of conveyance for the lower classes.

"In a new country, where time is not so valuable, high speeds are not required, but a cheap and certain means of locomotion for all classes, and of transporting the produce of the country to a market, is a first necessity. A railway is the best instrument for satisfying this want. Any saving in the cost per mile of a railway adds to the means available for extension; and, in a rapidly developing new country, capital is dear. Hence a rough-and-ready cheap railway, although it entails increased cost for maintenance, is preferable to a more finished and expensive line. These considerations have influenced the construction of American railways, and the system which has grown up under them is well adapted to the wants of the country.

"But this system has not yet attained a fixed position.

"As the population, and the consequent traffic, increases, new capital must be expended in stations, sidings, and additional lines of rails, by which the cost per mile, which now averages from L.7000 to L.9000, will be increased; the several railways will become more interlaced; a freer interchange of working stock will probably be necessary, possibly involving a resort to an establishment similar to the railway clearing-house.

"Independently of the conveniences afforded equally to all ranks of passengers already mentioned, there are many points in the system which are worthy of consideration.

"*1st*, The general system upon which the railway companies are organized is one which appears to afford a good guarantee for efficient management. A railway is managed by a well-paid president, in whom the whole executive power is vested; he is responsible for the efficient and economical working of the line. A body of directors, generally good men of business, unpaid, excepting on peculiar occasions, are appointed to watch over the interests of the shareholders, and to see that the president does *his* duty; and also to take care that the accounts are kept in such a form, and with such checks, that malversation cannot take place. The shareholders have the privilege of electing the president and the directors annually, instead of being compelled to elect them for three years, as is the case in England. They therefore possess a direct control over the management of their affairs.

"*2d*, There are several matters connected with the construction of railways which are worthy of notice, viz.:—

"The encouragement of the use of rails on roads and streets, to facilitate the distribution of goods traffic, as well as to accommodate local passenger traffic, would prove very useful in many towns where the streets are broad, instead of throwing every impediment in the way of thus extending the advantages of railways.

"The practice of attaching a signal to the lever by which the switches or points are moved, and of habitually locking facing points in position, might be advantageously followed.

"The plan of carrying a railway over a hill by zig-zags (inclined planes) would afford a comparatively inexpensive means of crossing a steep mountain pass. Each zig-zag terminates in a level space, and the train having been moved forward along one zig-gag on to the level space, is backed up the next, and so on.

"The principle of supporting engines and carriages on two independent trucks deserves attention;* the small diameter of the wheels may possibly increase the friction, but the cars run safely, and the double springs secure easy motion; it enables very long bodied cars to be used, which accommodate more passengers with less dead weight than is usually the case in England, especially on narrow guage lines. The absence of doors renders the amount of attendance on passengers more easy. The conveniences before described, which are afforded in American cars, are a great comfort on long journeys.

"The invariable establishment of a means of communication between the different servants in charge of a train, and the use of breaks to each carriage, might be adopted with advantage. The mode of coupling carriages together by means of a central connection deserves notice, as being less dangerous for the *employés* than the plan in use on English railways.†

"The protection afforded to the engine-driver and fireman against the inclemency of the weather, is well worthy of imitation, and would promote safety by enabling the men to keep a better look-out. And the use of a bell on the engine, in lieu of the continual use of the steam whistle, to give notice of the approach of a train to stations and at level crossings, presents many advantages, especially in towns.

* "Carriages on this principle were in use for a short time on the Waterford and Limerick Railway."

† "A central connection between carriages has been in use on the Dublin and Kingstown Railway."

"3*d*, Economy and increased efficiency results from the use of the electric telegraph to transmit information of the movements of all the trains on a railway, and to enable a responsible officer, placed in a central position, to control them when they become irregular, as well as to learn each day the positions of all cars on the railway, and the quantity of goods, &c., at each station which requires to be accommodated, and to give orders for the cars to be moved to meet the wants of the [illegible].

"4*th*, The detailed organization on the New York and Erie Railway deserves attentive consideration; its main features being a high degree of centralization, and the systematic arrangement of the duties of the officers and servants, so as to enforce a rigid system of personal accountability through every grade of the service.

"5*th*, Those general legislative provisions for securing the public interests, which appear principally to deserve notice, are, that railway companies shall keep their lines in repair, and open for public use, and that they shall supply sufficient accommodation, and transport merchandise and property without partiality, favour, or affection, and with all practicable dispatch. That a railway company is prohibited from exercising the calling of a banker, broker, or dealer in any article whatever. That in some States a government department is empowered to inquire minutely into the causes of railway accidents, to examine witnesses on oath, and to call for all necessary books, papers, &c., and to publish their reports.

"6*th*, But it is with reference to the construction of railways in our own colonies that the American system deserves especial notice. The considerations which led to the adoption of, and the necessities which fostered that system, apply with equal force to railways in the colonies. It appears therefore desirable to call attention to some of the deductions which may be drawn from the consideration of this system.

"*a*. A railway would appear to be the best road for arterial lines of communication in a new country.

"*b.* In making railways in a new country, bearing in mind the high rate of interest which money commands, the outlay for construction should be as small as possible, consistent with safety and economy of working; the object being to devote the money to be spent to extending the mileage and opening out the country, rather than to making very solid works or to obtaining high speeds.

"*c.* Railways made by the States in America have not proved successful, in consequence of the persons selected to manage them being chosen from political considerations.

"*d.* The encouragement given to private companies for the construction of railways in new states, by means of grants of land, has proved very successful. It has facilitated the rapid settlement of the country and the development of its resources. It has directly benefited the State by enhancing the price of the land retained by the State, as well as by the permanent reduction of the general taxation occasioned by the contribution of seven per cent. on the gross receipts of the railway reserved to the State in consideration of the grant of land. But the successful instances of this system are limited to localities where land is of a superior quality, and the climate favourable."

CHAPTER X.

WATER-WORKS.

Fairmount Water-works at Philadelphia—Construction of the Dam over the River Schuylkill—Pumps and Water-wheels—Reservoirs, &c.—The Water-works of Richmond in Virginia—Pittsburg—Montreal—Cincinnatti—Albany—Troy—Wells for supplying New York and Boston—Plans for improving the supply of Water for New York and Washington.

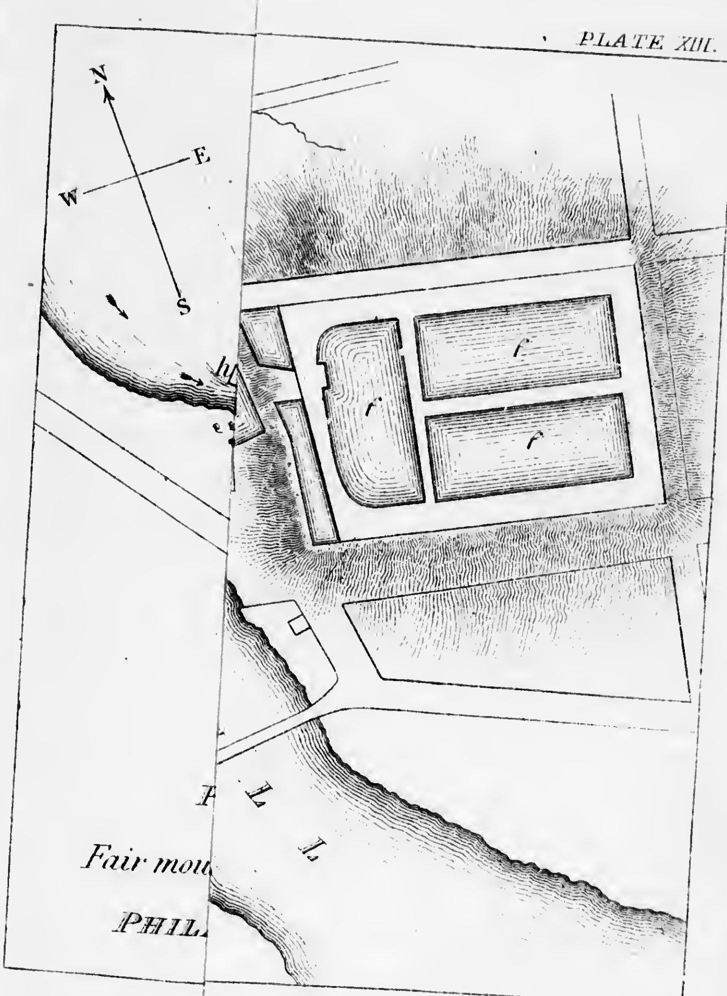
The Fairmount Water-works are situate on the east bank of the River Schuylkill, about one mile and a-half from the town of Philadelphia. They are remarkable for their efficiency and simplicity, as well as their great extent. They were commenced in 1819, and were in a working state in 1822. According to the Water Company's Report for the year 1836, the whole sum expended in their execution, up to that date, was L.276,206.*

The water of the River Schuylkill, with which the town of Philadelphia is supplied, is raised by water power into four large reservoirs, placed on a rocky eminence near the bank of the river; and after passing through gravel filter-beds, it is conveyed in two large mains to the outskirts of the town, and thence led into the various streets by smaller mains and branch-pipes.

Plate XIII. is a ground plan of the water-works, including part of the River Schuylkill and the adjoining country. Letters *a*, *b*, *c* represent a dam which has been thrown across the river in order to obtain a fall of water for driving the water-wheels. Letter *d* is the mill-race, *e*, *e* the buildings in which the water-wheels and force-pumps are placed, and

* Annual Reports of the Watering Committee to the Select and Common Councils of the City of Philadelphia.

PLATE XIII.



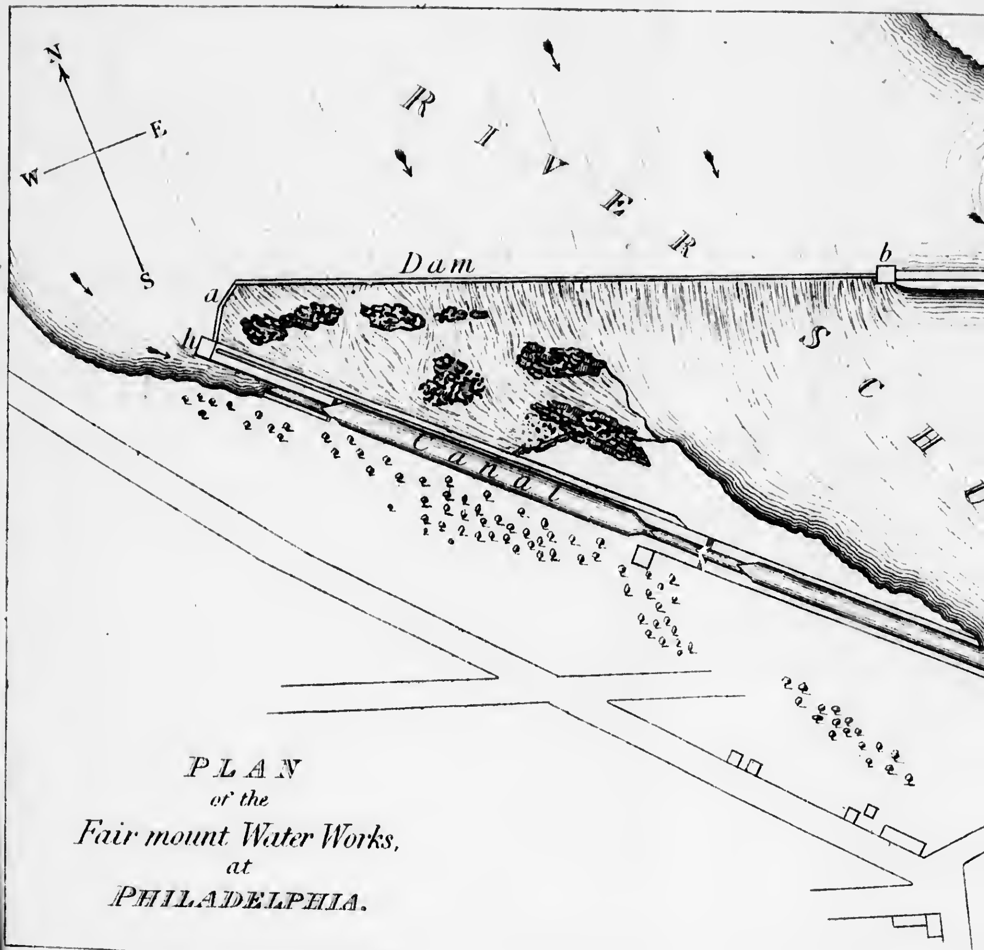

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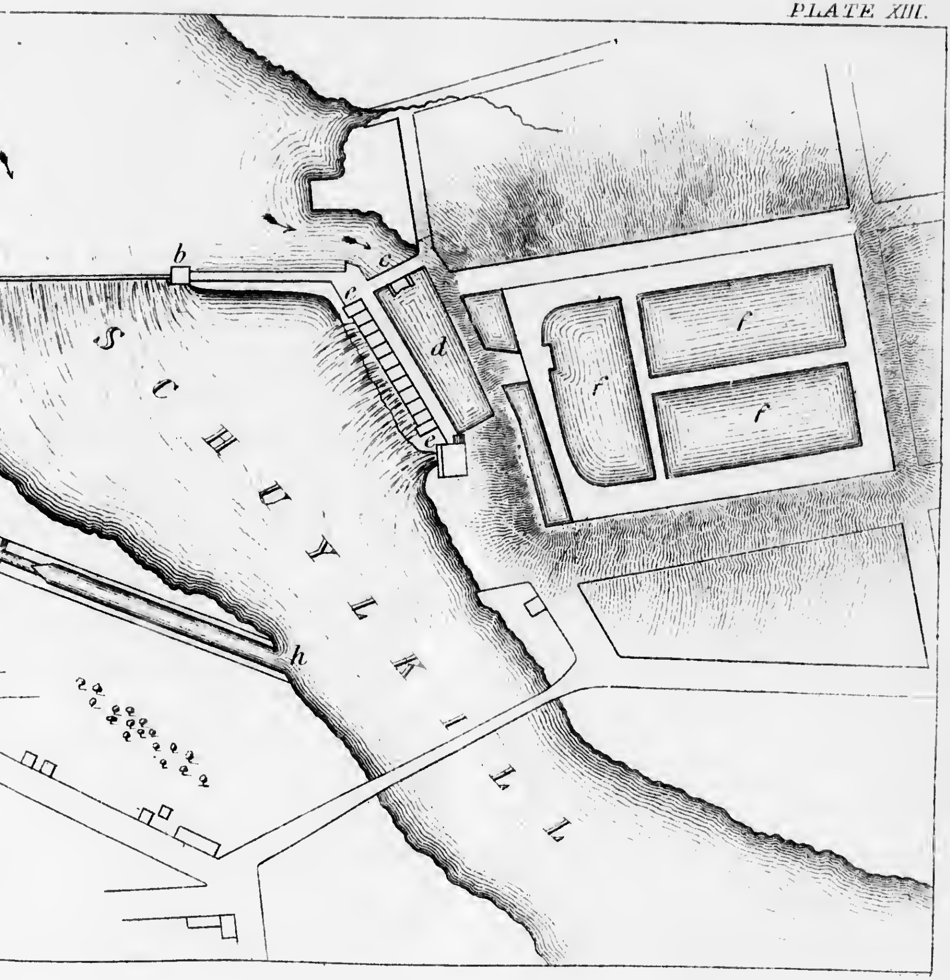
PLATE XIII.



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f, *f*, *f* are the filters and reservoirs for the reception of the water.

The erection of the dam across the river was the first and most arduous part of this work. It measures about sixteen hundred feet in length from bank to bank, and creates a stagnation in the flow of the stream, which extends about six miles up the river. The greatest depth of water in the line of the dam at low water of spring tides is twenty-four feet, and the rise of tide is six feet. From *c* to *b* the bottom of the river consists of rock covered with a deposit of mud about 11 feet in depth, and from *b* to *a* the bottom is entirely composed of bare rock, part of which, at the western side of the river, is exposed during low water, as shown in the plate. The line of the dam forms an angle of about 45 degrees with the direction of the stream. In this way a large overfall is formed for the water, and its perpendicular rise above the top of the dam, when the river is in a flooded state, is not so great as it would have been had the dam been placed at right angles to the stream. By adopting this direction the strength of the structure is also considerably increased, for the mass of the dam opposed to any given section of the stream is greater directly as the cosine, or inversely, as the sine of the angle formed by the line of the dam and the direction of the stream impinging on it.

The part of the dam which was first formed is that which is founded on the mud bottom extending from *c* to *b*. It consists of a large mound composed of rubble stones and earth thrown into the river. It measures 270 feet in length, 150 feet in breadth at the base, and 12 feet at the top, and its upper slope or face, which is exposed to the wash of the river, is cased with rough pitching formed of large stones. The termination of the dam at the point *b* is protected by a cut-stone pier, measuring twenty-eight feet by twenty-three feet, which is founded on rock, and built in water twenty-eight feet in depth.

The part extending from *b* to *a* is the overfall dam. It measures 1204 feet in length, and is founded on a rocky bottom, which rises pretty regularly from *b*, where there is a depth of twenty-four feet during the lowest tides, towards *a*, where the rock is uncovered at low water.

The current of the river being strong, it was found impossible to form this part of the dam by constructing a mound of rubble on the rocky bottom, according to the plan followed in founding the first part of the structure, on a bottom composed of mud. The expedient resorted to for retaining the stones on the shelving rock was extremely ingenious, and has proved very effective.

The overfall dam consists of a strong wooden framework or crib, which was formed in separate compartments, and sunk in small portions in the line of the dam, by filling it with stones. Plate XIV. is a drawing of the dam, in which fig. 1 is an elevation of a part of its lower front or face, and fig. 2 is a cross section. These views show the wooden frames or cribs of which the dam is composed, and also the rubble-stone hearting which prevents them from floating. The cribs are formed of logs of wood, measuring eighteen by twenty inches, connected together by strong dove-tailing, notched three inches deep, in the manner shown in the drawing. The size of the wooden frame-work, measured in the direction of the stream, is seventy-two feet, and the separate compartments of which it was formed measured twenty feet in breadth. The part of the dam over which the water flows, marked *aa*, and also the posterior part of it, *ab*, are covered with planking six inches in thickness. In forming the dam, the cribs were floated one after another to the site which they were to occupy, and large stones being thrown into them, they gradually sank, until at last they rested on the bottom of the river. The upper parts of the several cribs, or those portions of them which stood above the level of low water, were then firmly connected together, so as to form one continuous framework, behind which a large mass of rubble hearting and earth was placed, in the manner shown in the drawing, to give the whole structure weight and stability, and to prevent leakage.

This mode of forming dams is very generally practised in America in forming lines of slackwater navigation, and has tcwards

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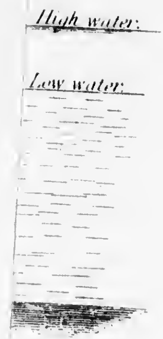
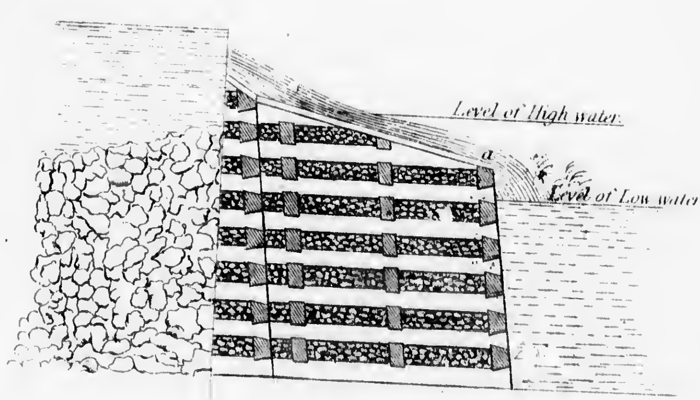
PLATE XIV.





ir mount Water works

Fig. 1.

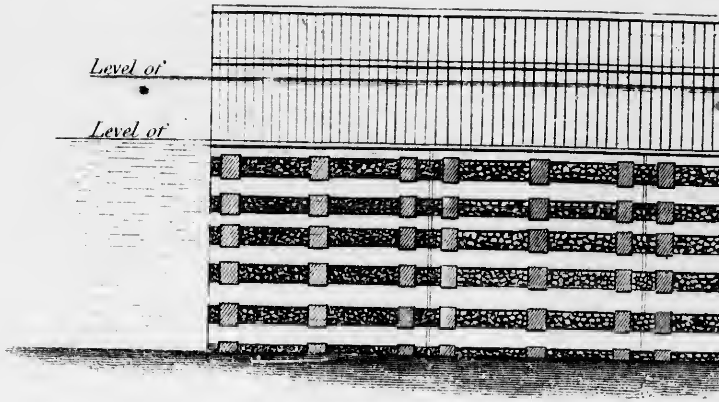
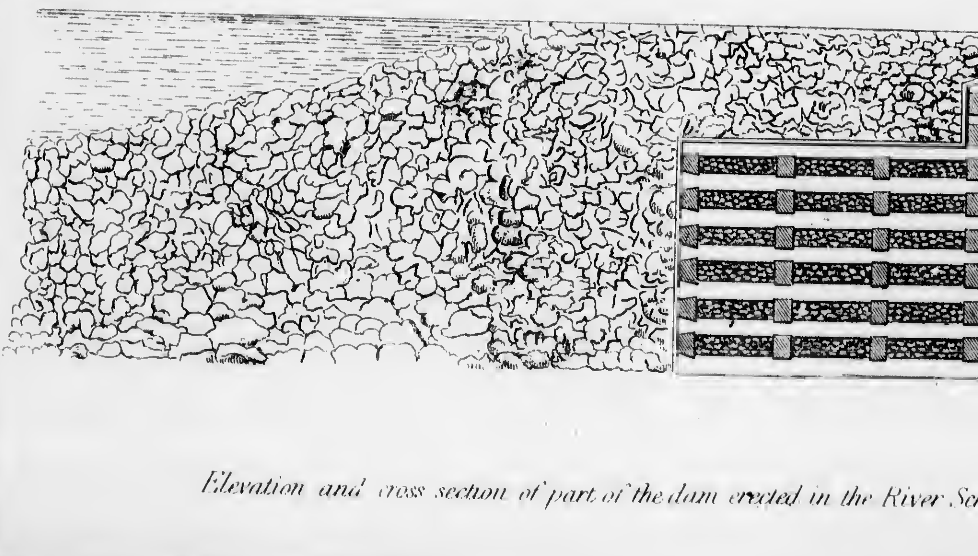


Fig. 2.



Elevation and cross section of part of the dam erected in the River Sc

Fig. 1.

PLATE XIV.

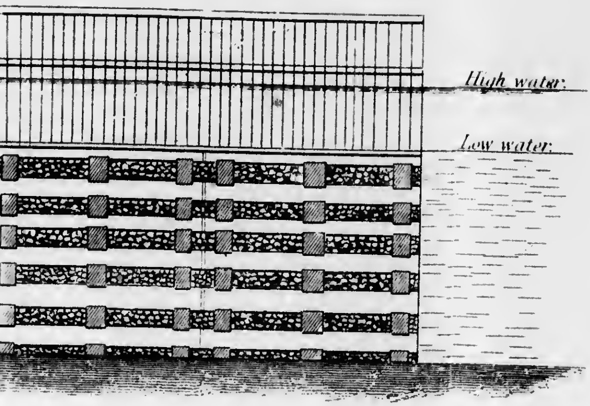
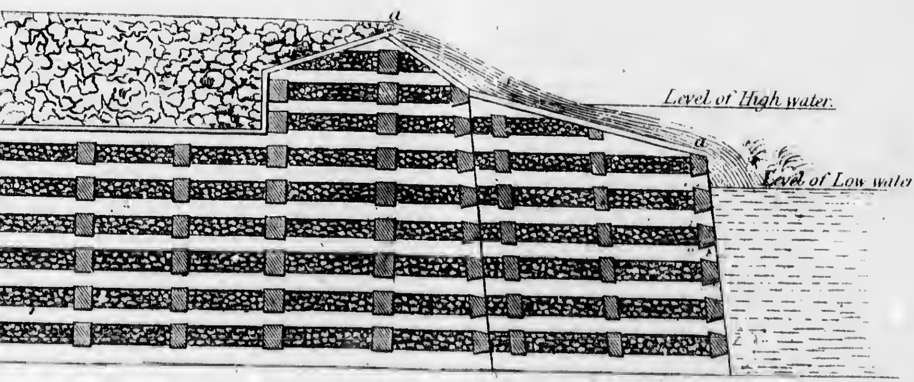


Fig. 2.



...m erected in the River Schuylkill, at Fair mount Water works

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been found to stand remarkably well. The dam just alluded to, at the Fairmount Water-works, withstood a great flood which occurred at the breaking up of the ice, on the 21st February 1832, without sustaining the smallest injury. On that occasion the water of the Schuylkill flowed over the top of the dam in a solid body no less than eight feet eleven inches in depth. As the erection of the dam impeded the navigation of the river, the Water Company had to compensate the Schuylkill Navigation Company by forming a canal, marked *hh* in Plate XIII., for the passage of their coal barges. This canal is about 900 feet in length. It has two locks of six feet lift each, and one guard-lock at the upper extremity.

The water is admitted into the mill-race *d*, by three archways at *c*, which have a water-way sixty-eight feet in breadth, and, when the river is in its ordinary state, admit a body of water six feet in depth. These archways can be shut by means of gates, and the whole of the water can be drawn off from the mill-race, if required, by opening a sluice communicating with the part of the river below the dam. The mill-race, which is excavated in solid rock, was a most laborious and expensive work. It is 419 feet in length, and 140 feet in breadth; its depth varies from sixteen to sixty feet.

From *d*, the water flows to the wheel-houses *e*, which have been built of a sufficient size to admit of eight wheels and eight force-pumps being employed to raise the water. In 1837 only six of the wheels and six force-pumps had been put up. The average daily quantity of water raised by each pump during the last year was 530,000 gallons, and the whole quantity of water distributed from the reservoirs per day, to 19,678 householders, was 3,122,664 gallons. It has been calculated that thirty gallons of water, acting on the wheel, raised one gallon into the reservoir.

The water-wheels vary from fifteen to sixteen feet in diameter. They are fifteen feet in breadth, and make thirteen revolutions per minute. The spokes, rims, and buckets are formed of wood, but they revolve on cast-iron axles, weighing five tons each. The working of the wheels is impeded during spring tides, by the water rising upon them; but it has been found that their motion is not materially affected until the back-water rises about sixteen inches on the wheel. They are stopped, however, on an average, about sixty-four hours every month from this cause.

The pumps are common double-acting force-pumps, having a stroke of six feet, worked by cranks attached to the axles of the paddle-wheels. The height to which the water is forced is ninety-two feet, and the most substantial work is necessary to insure the stability of the pumping apparatus, under the pressure of a column of water of so great a height.

A cast-iron main, sixteen inches in diameter, leads from each of the force-pumps to the reservoirs. The communication between the force-pumps and the reservoirs, can be cut off by a stop-cock, placed on the main, so that, when the pumps are not in motion, they can be relieved from the pressure of the column of water. The shortest main is 284 feet in length.

The reservoirs for containing the water are placed at an elevation of 102 feet above the level of low water, and fifty-six feet above the highest part of the streets of Philadelphia. There are four reservoirs, the aggregate area of which is about six acres. The reservoirs are founded on an elevated rock, but the water is retained by means of artificial walls and embankments. The side walls of the reservoirs are built with stone, behind which there is a backing of clay puddle, two feet in thickness, and the whole is surrounded towards the outside, by an embankment of earth, sloping at the rate of one perpendicular to one horizontal, and covered with grass sods. The reservoirs are paved with bricks, laid with lime-mortar, on a layer of clay-puddle, and well grouted, to prevent leakage. The depth of water in the reservoirs is twelve feet three inches, and, when filled, they contain upwards of twenty-two millions of gallons of water. There is a considerable advantage in having four reservoirs. The water, after being discharged from the force-pumps into one of them, passes through all the other reservoirs, between each of which there is a filter, so that any impurities in the water are extracted during its passage from one cistern to another, and prevented from entering the pipes, which distribute it to the town.

The water is conveyed from the reservoirs, and distributed through the town, in cast-iron pipes 98¾ miles long. About one-half of these pipes was cast in America, and the remainder were imported from England. The two mains leading from the reservoirs to the town measure twenty-two inches in diameter. The small mains and pipes which have been laid in the streets measure from three to twelve inches in diameter. The pipes are formed in the usual manner, and the different lengths are connected by spigot and faucet joints. The average cost of the whole of the pipes and mains laid down was 7s. 1½d. per lineal foot.

The very small cost at which the town is now supplied is an ample ground for having substituted, even at considerable outlay in the first instance, the system of raising by means of water instead of steam power; steam having been used at the Fairmount works previous to the year 1822. The expenditure, including repairs and salaries connected with the works, for distributing a daily supply of 3,122,664 gallons of water was, in 1836, L.2800. The following information regarding the details of this most interesting and efficient work are drawn up by Mr Graffe, the superintendent, and printed in the Water Company's annual report for the year 1836:—

	Gallons.	Gallons.
The Reservoir No. 1 was finished in 1815, and contains,	3,917,659	
The Reservoir No. 2 was finished in 1821, and contains,	3,296,434	
The Reservoir No. 3 was finished in 1827, and contains,	2,707,295	
Containing, . .		9,921,388
The first section of Reservoir No. 4 was finished in 1835, and contains, ...	3,658,016	
The second section of Reservoir No. 4 was finished in 1836, and contains, ...	4,381,322	
The third section of Reservoir No. 4 was finished in 1836, and contains, ...	4,071,250	
		12,110,588
The Reservoirs contain together, . .		22,031,976

	Dollars.
Reservoir No. 1 cost, ...	32,508.52
Reservoir No. 2 cost, ...	9,579.47
Reservoir No. 3 cost, ...	24,521.75
First, second, and third sections of Reservoir No. 4 cost, .	67,214.68
Total, .	133,824.42

The whole expense of the reservoirs amounted to 133,824 dollars, which is equal to about L.26,765.

"The water of the reservoirs covers a surface exceeding six acres. The reservoirs are each twelve feet three inches deep, and are elevated above the water in the dam ninety-six feet perpendicular.

"The water flowing from the reservoirs for the supply of the city and districts, per day, at different periods of the year 1836 was as follows:—

	Gallons.
From February 1st to 21st, in very cold weather, .	1,769,800
... February 21st to March 20th, ...	2,113,257
... March 20th to June 3d, ...	3,046,120
... June 3d to July 22d, ...	3,942,643
... July 22d to September 9th, ...	4,152,917
... September 9th to October 28th, ...	3,679,800
... October 28th to December 31st, ...	3,154,114

"The average daily supply, in 1836, was 3,122,664 gallons. The above supply of water is distributed to 16,678 tenants by private pipes, and to 3000 families by public pumps, making the number of families supplied 19,678.

"The quantity of iron pipes laid for the distribution of the water is as follows:—

	Miles.
In the city, ...	58
In the district of Spring Gardens, . . .	$11\frac{3}{8}$
In Southwark, ...	$10\frac{1}{4}$
In the Northern Liberties, ...	$12\frac{7}{8}$
In Moyamensing, ...	$2\frac{5}{8}$
In Kensington, ...	3
Together .	$98\frac{1}{8}$

"The water rents collected for the year 1837 are as follows:—

	Dollars.
In the city,	57,080.50
Including rents on the Girard estate, and rent due by H. J. Williams and others at Fairmount,	1,048.50
In Spring Gardens,	13,674.25
In Southwark,	10,517.50
In the Northern Liberties,	20,009.37
In Moyamensing,	1,956.00
In Kensington,	2,146.25
Total,	106,432·37

Amounting in all to about 106,432 dollars, which is equal to about L.21,286.

	Dollars.
The expenses for the water-power works connected with the applicable parts of the former steam-works were, December 31, 1831,	1,138,323.54
Add the expenses for reservoirs, iron pipes, &c., in 1832,	65,195.58
Do. Do. in 1833,	37,354.06
Do. Do. in 1834,	65,163.36
Do. Do. in 1835,	73,288.38
Do. Do. in 1836,	71,706.51
	1,451,031.43
From which deduct, for the support of working machinery, materials, salaries, &c., 14,000.00 dollars per annum for the last five years,	70,000.00
Leaves the expenditure for the permanent works, up to 31st December 1836,	1,381,031.43

The expenditure for permanent works, therefore, amounts to 1,381,031 dollars, which is equal to about L.276,206.

The supply of water for the town of Richmond in Virginia, is procured from the James River, in the same manner as at Philadelphia; but the works are on a much smaller scale. The water is raised 160 feet by two water-wheels into two reservoirs, measuring 194 feet in length, 104 feet in breadth, and ten feet eight inches in depth, which are capable of containing upwards of two millions of gallons of water. Before leaving the reservoirs, the water is purified by passing through two gravel filters. The water-wheels are eighteen feet in diameter, and ten feet in breadth, and the fall is ten feet. The barrels of the two force-pumps are nine inches in diameter, and six feet in length of stroke, and, in the ordinary state of working, when only one wheel is in operation, raise about 400,000 gallons of water in twenty-four hours.

The cast-iron main which leads from the pumps to the reservoir is eight inches in diameter, and about 2400 feet in length. Mr Stein was engineer for the work, which is said to have cost about L.20,000.

Pittsburg, on the Ohio, in the State of Pennsylvania, is supplied with water from the River Alleghany. It is raised by a steam-engine of eighty-four horse power into a reservoir capable of containing 1,000,000 gallons of water, and elevated 116 feet above the level of the river. The main leading from the pumps to the reservoir is fifteen inches in diameter, and the pump raises 1,500,000 gallons in twenty-four hours.

Montreal also is supplied in the same manner from the water of the St Lawrence, which is raised by steam power to an elevated reservoir, and then distributed through the town.

The following account of the water-works, which have lately been established at Cincinnati, on the Ohio, in the State of Ohio, is given by Mr Davies the superintendent:—

"The Cincinnati Water-works were constructed in 1820. The water was taken from the Ohio River by a common force-pump, worked by horse-power, placed upon the bank of the river, sufficiently near low-water mark to be within the usual atmospheric pressure, and thrown from that point to the reservoir, 160 feet above low water-mark, from which it was conveyed to the town in wooden pipes. The town at that time afforded no inducement for a larger supply of water than could be brought through wooden pipes of three inches and a-half in diameter, consequently the works at the river were only calculated to supply a pipe of that size. Only a short time, however, was necessary, to prove the necessity of an increase, and a change from horse-power to steam.

"The works now consist of two engines, one propelling a double force-pump of ten inches in diameter, and four feet stroke, throwing into the reservoir about 1000 gallons in a minute; the other propelling a pump of twenty inches in diameter, eight feet stroke, and discharging about 1200 gallons per minute. The reservoirs are built of common limestone; the walls are from three to six feet thick, and grouted. The water is conveyed immediately to the town, without being permitted to stand or filter. Iron pipes of eight inches in diameter convey it through the heart of the town, from which it branches in wooden pipes of from one and a half to three and a half inches in diameter. From these it is conveyed into private dwellings in leaden pipes at the expense of the inhabitants, who pay from eight to twelve dollars* per annum, according to the purposes for which it is used. Each family, of course, use any quantity they choose, their hydrants communicating freely with the main pipes. The iron pipes are made in lengths of nine feet each, and connected together by the spigot and faucet joint run with lead, which occupies a space round the pipe of three-eighths or half an inch in thickness."

Albany, on the Hudson, is principally supplied with water procured in the high ground in the neighbourhood, and conveyed in a six-inch pipe for a distance of about three miles to a reservoir near the town.

Troy, on the eastern or left bank of the Hudson, about fourteen miles above Albany, is also abundantly supplied with good water collected in the high ground in the neighbourhood. The reservoir stands about one-third of a mile from the town, and is seventy feet above the level of the streets. It is capable of containing 1,900,000 gallons, and the water is conveyed from it to the town in a main twelve inches in diameter. The works are said to have cost L.23,000. The nnual expense of conducting them is L.160.

The situation of Boston is somewhat like that of New York. It is surrounded by the sea, and the supply of good water is far from being sufficient for the inhabitants. Mr Baldwin, civil engineer, has made a survey and plan for the supply of the town, in which he contemplates bringing water from some springs in the neighbourhood.†

At present the town is supplied chiefly from wells. Ac-

* From about L.1, 12s. to L.2, 8s.

† *Report on introducing pure Water into the city of Boston.* By Loammi Baldwin, C.E. Boston. 1835.

cording to Mr Baldwin's report, there are no less than 2767 wells in Boston, thirty-three of which are Artesian. Only seven, however, out of the whole number, produce soft water; and of these, two are Artesian.

Great difficulty has been experienced in forming many of the wells on the peninsula of Boston, in some of which, on tapping the lower strata, the water is said to have risen to seventy-five, or eighty feet above the level of the sea.*

The following very interesting remarks regarding two of these wells, are quoted by Mr Storrow in his Treatise on Water-works:—

"Dr Lathrop gives the following history of a well dug near Boston Neck.† 'Where the ground was opened, the elevation is not more than one foot, or one foot and a half above the sea at high water. The well was made very large. After digging about 22 feet in a body of clay, the workmen prepared for boring. At the depth of 108 or 110 feet the augur was impeded by a hard substance; this was no sooner broken through and the augur taken out, than the water was forced up with a loud noise, and rose to the top of the well. After the first effort of the long confined elastic air was expended, the water subsided about six feet from the surface, and there remains at all seasons, ebbing and flowing a little with the tides.'

"Dr Lathrop observes, that the proprietors of this well were led to exercise great caution in carrying on the work, by an accident which had happened in their immediate neighbourhood. 'A few years before, an attempt was made to dig a well a few rods (16½ feet) to the east near the sea. Having dug about 60 feet in a body of clay without finding water, preparation was made in the usual way for boring; and after passing about 40 feet in the same body of clay, the augur was impeded by stone. A few strokes with a drill broke through the slate covering, and the water gushed out with such rapidity and force, that the workmen with diffi-

* *A Treatise on Water-works.* By Charles S. Storrow. Boston. 1835.

† *Memoirs of the American Academy of Arts and Sciences.* Vol. 3.

culty were saved from death. The water rose to the top of the well and ran over for some time. The force was such as to bring up a large quantity of fine sand, by which the well was filled up many feet. The workmen left behind all their tools, which were buried in the sand, and all their labour was lost. The body of water which is constantly passing under the immense body of clay, which is found in all the low parts of the peninsula, and which forms the basin of the harbour, must have its source in the interior, and is pushed on with great force from ponds and lakes in the elevated parts of the country. Whenever vent is given to any of those subterranean currents, the water will rise, if it have opportunity, to the level of its source.'"

The only supply of water which the inhabitants of New York enjoyed in 1837 was obtained from wells sunk in different parts of the town. The water was raised from these wells by steam-power to elevated reservoirs, and thence distributed in pipes to different parts of the town. Some of the wells in New York belong to the Manhatten Water Company, and some to the corporation. One well, belonging to the corporation, is 113 feet in depth. For the purpose of collecting water, there are three horizontal passages leading from the bottom of the well, which measure four feet in width, and six feet in height; two of them are seventy-five, and the third is one hundred feet in length. This well cost about L.11,500, and yields 21,000 gallons in twenty-four hours. There are many other wells in the town, some of which are said to produce 120,000 gallons in twenty-four hours. The supply at New York is far from being adequate to the wants of the inhabitants; and the water in most of the wells being hard and brackish, is not suitable for domestic purposes.

New York is built on a flat island, which is nearly surrounded by salt water, so that the method that has been resorted to for the supply of Philadelphia, and most other towns in the United States, by pumping from the river, is altogether impracticable in that situation. Many plans have been proposed, and, among others, that of throwing a dam across the Hudson, so as to exclude the salt water; but as a free passage, by means of locks, must be preserved for the numerous vessels which navigate the river, the success of such a plan seems very doubtful.

Many engineers in the United States of great reputation have made surveys of the country in the neighbourhood of New York, in order to devise a plan for the supply of the city with water; but the scheme which had been ultimately adopted at the time of my visit was that of conveying the water of the River Croton in a tunnel, for a distance of about forty miles, to New York. I had the good fortune to meet with Mr Douglass, an engineer, who, I believe, may be said to have had the merit of originating this gigantic work, with whom I went over part of the ground to be traversed by it, and from whom I received much information relative to the water supply of New York, and other matters of engineering. The works have, since my visit, been completed under the direction of Mr John B. Jervis as chief engineer, and the following short notice of them may prove interesting. Most of the details are from the works by Mr Tower and Mr Schrampe who were engaged in carrying out the work.*

The Croton River flows into the Hudson, about forty miles above New York. It is supplied mainly by several springs and small lakes situated about twenty-five miles from its mouth. Its mean discharge was ascertained to be about fifty millions of gallons in twenty-four hours, equal to 5787 cubic feet per minute. Its minimum flow was found to be twenty-seven millions of gallons in twenty-four hours, or 3121 cubic feet per minute. The following are the works by which this water has been made available for the supply of New York:—

A dam has been thrown across the Croton River at a point about five miles above its junction with the Hudson. The construction of this dam was attended first with failure, and afterwards with difficulty, but it was ultimately completed

* *Illustrations of the Croton Aqueduct.* By F. B. Tower. New York and London. 1843.

Description of the New York Croton Aqueduct. By T. Schrampe. In English, German, and French. New York and Berlin.

satisfactorily. It consists of timber cribs filled with stones, which form the nucleus of the dam. These are covered on the upper side by an earthen embankment, and on the lower side by a facing of masonry. By means of this dam the water of the Croton is raised about thirty-eight feet, and dammed back six miles, forming a store reservoir of about 400 acres, and having a capacity of 600 millions of gallons above the level of the discharge sluices. The whole of the works connected with this dam and its off-lets appear to be executed in a very substantial manner. The water is conveyed from the Store Reservoir to New York in an aqueduct of masonry, excepting at the crossing of Harlem River and Manhatten Valley, where two iron pipes, three feet in diameter, are used; but provision has been made for laying two additional pipes if necessary. These pipes are carried across Harlem River on a bridge of sixteen arches, at a height of 100 feet above the level of the river, to admit of a free navigation. In crossing Manhatten Valley they are laid on the bottom, and are depressed about 102 feet from the level of the aqueduct. On reaching New York the aqueduct discharges into a Receiving Reservoir at the outskirts of the city, which has an area of thirty-one acres, and contains 150 millions of gallons. From thence the water is led in iron pipes to the Distributing Reservoir, which is situated in the heart of the city. It has an area of four acres, and contains 20 millions of gallons. From this point the water is conveyed in service pipes to the different parts of the town.

The construction of these works seems to be very similar to works of a kindred nature in this country. The aqueduct varies in size and design according to the rate of inclination and the soil through which it passes. In order to counteract the effects of frost and the contraction of impurities, it is covered throughout its whole extent of thirty-eight miles. The curves which occur in its course are nowhere less than 500 feet radius. To admit of repair, it is provided with six let-offs and stop-gates. There are also ventillators for air at every mile, and intermediate manholes at every quarter of a mile to allow access to the tunnel, the general size of which is about eight feet high and seven feet broad. The following particulars as to the levels are given by Mr Tower :—

"The bottom of the water-way of the aqueduct, where it leaves the gate chamber at the Croton Dam, is 11·4 feet below the surface of the Store Reservoir, and 154·77 feet above the level of mean tide at the city of New York. The following table shows the length of the different planes of descent from the Store to the Receiving Reservoir :—

	Miles.		Feet.	Inches per Mile.
The 1st plane extends . .	49·43	and the descent is	2·94	$7\frac{1}{8}$
The 2d do. . . .	28·053	do.	30·69	$13\frac{1}{4}$
Length of pipes across Harlem River,	0·261	...	...	...
Diff. of level between extremes of pipes,	...	do.	2·29	
The 3d plane extends . .	2·033	do.	2·25	$13\frac{1}{4}$
Length of pipes across Manhatten Valley, ...	0·77	...	...	...
Diff. of level between extremes of pipes,		do.	3·86	...
The 4th plane extends . .	2·023	do.	1·60	$9\frac{1}{2}$
	38·090		43·63	

"In crossing the Harlem River there is a fall of two feet, and at Manhatten Valley a fall of three feet; more than that would have been had the aqueduct continued across these places with its regular inclination. This extra fall was allowed, to adjust the number and capacity of the pipes (which descend below the level of the aqueduct and rise again), to discharge the full quantity of water as freely as the aqueduct of masonry would have done had it been continued across the valleys. There is therefore a loss of this extra head of water for the city reservoirs, but this small loss of head was not considered of such importance as to induce the building of structures across these valleys up to the plane of the aqueduct grade.

"The surface of the Store Reservoir is 166 feet above the mean level of high water at New York; the difference of level between that and the surface of the Receiving Reservoir is forty-seven feet, leaving the surface of this reservoir 119 feet above high water. The fall from the Receiving Reservoir to the Distributing Reservoir is four feet, its surface being 115 feet above high water. This last is the height to which the water may generally be made available in the city. The surface velocity of the water in the aqueduct when the water is two feet deep has been ascertained to be about 1½ mile per hour, which, taking the width at seven feet, gives a discharge of 1848 cubic feet per minute; which, at 30 gallons to each person, would afford a supply to 532,226 persons. But the works are calculated to convey a quantity sufficient to fill the aqueduct to the depth of four feet, so that this will provide for an enormous population."

The work was commenced in 1837, and opened in 1842. It is stated to have cost L.1,713,000; the service-pipes for the city are stated at L.362,000; making in all L.2,075,000 as the total expenditure. Mr Schrampe says, "that the interest payable on this sum, which ranges from five to seven per cent., is collected by a direct water tax, and some indirect taxes. By means of a sinking fund the capital will be redeemed by degrees. The water tax amounts to L.2 for a house of middle size (the city has over 33,500 such houses); manufacturers, hotels, &c., pay according to their extent."

For farther details regarding this truly useful and magnificent work, I must refer the reader to the interesting books from which I have quoted.

The citizens of Washington have followed the example of their neighbours of New York, and are constructing an aqueduct to supply that city with water from the River Potomac. Its length (as stated in the Report of the Council of Civil Engineers in 1858) is about twelve miles, and the height of the source about 150 feet above high water mark. The aqueduct is circular, nine feet in diameter, and is built chiefly of rubble masonry, fourteen inches in thickness, laid in hydraulic cement. The fall is nine inches in 5000 feet; a bridge, of 200 feet span of iron, crosses the creek between Washington and Georgetown. The iron pipes, forty-eight inches diameter, do duty as arched ribs to support the bridge, and also as mains to convey the water under pressure; and they are lined with staves of wood as a protection against frost. It is expected that the work will be completed in August 1859. The estimated cost was L.510,000.

CHAPTER XII.

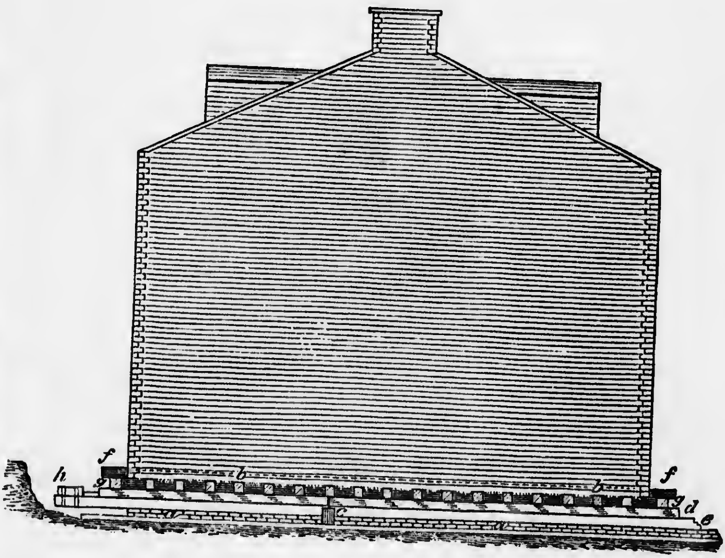
HOUSE-MOVING.

In consequence of the great value of labour, the Americans adopt, with a view to economy, many mechanical expedients which, in the eyes of British engineers, seem very extraordinary.

Perhaps the most curious of these is the operation of moving houses, which is often practised in New York. Most of the old streets in that town are very narrow and tortuous, and in the course of improving them, many of the old houses were found to interfere with the new lines of street, but instead of taking down and rebuilding those tenements, the ingenious inhabitants have recourse to the more simple method of moving the whole *en masse*, to a new site. This was, at first, only attempted with houses formed of wooden framework, but now the same liberty is taken with those built of brick. I saw the operation put in practice on a brick house, at No. 130 Chatham Street, New York, and was so much interested in the success of this hazardous process, that I delayed my departure from New York for three days, in order to see it completed. The house measured fifty feet in depth by twenty-five feet in breadth of front, and consisted of four storeys, two above the ground-floor, and a garret-storey at the top, the whole being surmounted by large chimney-stacks. This house, in order to make room for a new line of street, was moved back fourteen feet six inches from the line which the front wall of the house originally occupied, and as the operation was curious and exceedingly interesting in an engineering point of view, I shall endeavour, by referring to the accompanying diagrams, to describe the manner in which it was accomplished. Fig. 1 is an elevation of the gable, and fig. 2 an elevation of the front of the house.

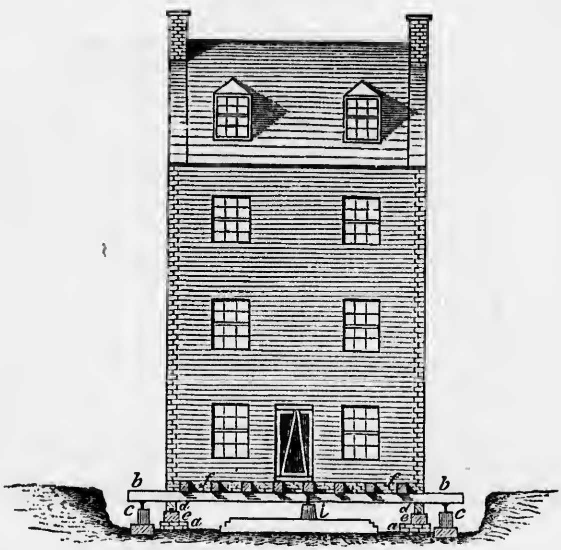
The first step in the process is to prepare a foundation for

Fig. 1.



the walls on the new site which the house is intended to occupy. A trench is next cut round the outside of the house, and the lower floor being removed, the earth is excavated from the interior, so as to expose the foundations of the side walls and gables, which are represented in the cuts by *a*. Horizontal beams of wood, marked *b*, measuring about twelve inches square, are then arranged at distances of three feet apart from centre to centre, at right angles to the direction in which the house is to be moved, their ends being allowed to project about three feet each beyond the building, through holes drifted in the gables for their reception, as shown at *b*, *b*, in fig. 2. A series of powerful screw-jacks, marked *c*, amounting perhaps to fifty in number, are then placed under the projecting ends of the horizontal beams *b*. The screw-jacks, as shown in the diagrams, generally rest on a beam of wood bedded in the ground, but in some cases they are placed on a foundation of stone. They are carefully *ranced* or fixed, so as to prevent them from kanting or twisting on the application of pressure.

Fig. 2.



When the process has reached this stage, the screw-jacks are worked so as to bring the upper sides of the horizontal beams *b*, into close contact with the gables, through which they pass, and the intermediate portions of the walls, between the several points of support, being carefully removed, the whole pressure of the gables is brought to bear on the horizontal beams *b*, which rest on the screw-jacks *c*. Two strong beams *d*, *e* are placed, one resting above the other, under each gable (a part of which is removed for their reception), at right angles to the horizontal beams *b*; the lower beam *e* rests on the old foundation of the house, which is levelled for its reception, and the upper beam *d* is firmly fixed, by means of cleats of wood and spikes, to the horizontal beams *b*, passing through the house. The lower beams form the road, as it were, on which the upper ones, supporting the house, slide. The lower beams are accordingly extended, as shown at *e*, fig. 1, by means of similar beams, resting on a firm foundation, to the new site of the house. After the beams *d*, *e* have been securely placed close under the horizontal beams *b*, the screw-jacks are unscrewed, and the whole weight of the gables is again made to bear on the foundations. Holes, at distances of about three feet apart from centre to centre, are next drifted in the front and back walls of the house, through which logs, marked *f*, are inserted, in the same way as formerly described in the gables. The ends of these logs project about three feet beyond the faces of the walls, and are supported by cross-beams, shown at *g*, *g*, fig. 1, the ends of which rest upon the beams *d*, under the gables. The intermediate portions of the front and back walls, between the supporting beams, being removed in the same manner as the gables, the whole weight of the building rests on the lower beams, *d* and *e*, on which the motion is to take place. A very powerful screw-jack, shown at *h*, fig. 1, is fixed, in a horizontal position, to each of the beams *e*, on which the house is to move. The end of the screw-jacks butt against the upper beams *d*; and when they are worked, the upper beams, bearing the whole weight of the house, slide smoothly along on the lower beams *e*. The two beams are well greased; and a groove in the upper, and a corresponding feather on the surface of the lower one, insure a motion in the direction of their length. The length of the screws in the screw-jacks *h*, is about two feet; so that if the house has to be removed to a greater distance than that included in their range, they are unfastened, and again fixed to the beam *e*, when the house is then propelled other two feet. In this way, by prolonging the beams *e*, and removing the screw-jacks, the house may be moved to an indefinite distance.

When the house has been brought directly over the foundation which was prepared for it, and which we shall now suppose to be represented by *a* in the cuts, the spaces between the beams *f* and the foundation *a*, in the front and back walls of the house, are built up, and also the intermediate spaces between the several beams *f*. Screw-jacks, as shown at *c* and *i*, are then ranged all round the house under the ends of the projecting beams; they are now, as formerly, placed on firm foundations, and properly braced, to prevent them from twisting or kanting. These screw-jacks are then all worked, and the weight of the house is transferred to them from the beams *d*, *e*, *g*, which are carefully removed. The space between *a a*, fig. 1, and the horizontal beams *b*, which was occupied by the beams *d*, *e*, is now built up, and also the intermediate spaces between the beams *b*. The screw-jacks *c* are then slackened one after another, and the beams *b* withdrawn, the space which each occupied being carefully built up before another screw-jack is removed. The same process is performed with the beams *f*, and the house then rests on its new foundation *a*, which, in the case I saw in New York, was fourteen feet six inches from the spot on which the house was built.

The operation I have attempted to describe is attended with very great risk, and much caution is necessary to prevent accidents. Its success depends chiefly upon getting a solid and unyielding base for supporting the screw-jacks *c*, *i*, and for the prolongation of the beam *e* to the new site which the house is to occupy. It is further of the utmost importance that in working the screws their motion should be simultaneous, which, in a range of 40 or 50 screw-jacks, is not very easily attained. The operation of drifting the holes through the walls also requires caution, as well as that of removing the intermediate pieces between the beams *b* and *f*, which pass through both walls. The space between the beams is only two feet, and the place of the materials removed, is, if necessary, supplied while the house is in the act of moving, by a block of wood which rests on the beams *d*. The screw-jacks *h*, by which the motion is produced, require also to be worked with the greatest caution, as the cracking of the walls would be the inevitable consequence of their advancing unequally.

Notwithstanding the great difficulty attending the successful performance of this operation, it is practised in New York without creating the least alarm in the inhabitants of the houses, who, in some cases, do not even remove their furniture while the process is going forward. The lower part of the house which I saw moved was occupied as a carver and gilder's shop; and on Mr Brown, under whose directions the operation was proceeding, conducting me to the upper storey, that he might convince me that there were no rents in the walls or ceilings of the rooms, I was astonished to find one of them filled with picture frames and plates of mirror glass, which had never been removed from the house. The value of the mirror glass, according to Mr Brown, was not less than 1500 dollars, which is equal to about L.300 sterling; and so much confidence did the owner of the house place in the success and safety of the operation, that he did not take the trouble of removing his fragile property. I understood from Mr Brown that the whole operation of removing this house, from the time of its commencement till its completion, would occupy about five weeks, but the time employed in actually moving the house fourteen feet and a half was seven hours. The sum for which he had contracted to complete the operation was 1000 dollars, which is equal to about L.200 sterling. Mr Brown mentioned that he and his father, who was the first person who attempted to perform the operation, had followed the business of "house-movers" for fourteen years, and had removed upwards of a hundred houses, without any accident, many of which, as in the case of the one I saw, were made entirely of brick. I also visited a church in "Sixth" Street, capable, I should think, of holding from 600 to 1000 persons, with galleries and a spire, which was moved 1100 feet, but this building was composed entirely of wood, which rendered the operation much less hazardous. The only example of the successful moving of structures *entire* in this country, is that of the North Pier Lighthouse at Sunderland, a stone tower, 76 feet 2 inches in height, which was moved when the pier was extended in 1841, a distance of 475 feet 7 inches, by Mr John Murray, C.E.*

NOTE ON THE MANUFACTORIES AT LOWELL.

The largest factories in the United States are those of Lowell, on the banks of the Merrimac, in the State of Massachusetts. The following statistical table, relative to the works at that place, is published at the "Lowell Courier" steam printing establishment, and may perhaps be useful to those interested in that subject. The machinery in all the mills which I had an opportunity of visiting at Lowell, was excellent. No one can fail to be struck with the extent of water power on the Merrimac and other American rivers. A correspondent in writing on this subject says,—

"The enormous amount of the water power of the Northern States of the American Union, and of Upper and Lower Canada, is really one of the most remarkable characteristics of this country; no estimate, that I am aware of, has been made of the total amount, but it must be counted by millions of horse power. In New England, which comprises the six North-Eastern States of the Union, this immense water power is mainly due to the geological formation; the hard character of the primitive rock has enabled it to retain its original shape; in later and softer formations the rocks become degraded by the streams, which flow in deep valleys with a moderate slope; in the primitive formation the deep valleys are not formed, but the streams tumble over the rocks without sensibly affecting them.

"This immense water power is the life and strength of the Northern States, in precisely the same way that coal is the strength of England. A hundredth part of this water power is not yet in use in the States, and in the Canadas

* *Transactions Institution Civil Engineers.* Vol. 3, p. 342.

not a thousandth; we have it however in reserve, and nothing can deprive us of it, and it will be gradually brought into use as the wants of the country require, and the accumulations of capital permit.

"There is a regular way in which the great water powers are brought into use—Take Holyoke, on the Connecticut River, for instance. A company is formed, with a capital of say 2,000,000 dollars; the first step is to buy up the land in the neighbourhood of the falls selected, say 1000 to 2000 acres, sufficient for a large tower; a dam is built, in this case 1000 feet long and 30 feet high, of wood to begin with; then a large canal or mill-race, at the upper end 140 feet wide and 15 feet deep; this is led off for a mile or two, gradually diminishing in size as the water is taken off at the different mill sites. About 20 feet below, another canal is constructed parallel to the first, and 200 or 300 feet distant, giving room for the mills between, the water being drawn from the upper and discharged into the lower. This second canal conducts the water from the upper set of mills to another set, situated on the banks of the river, where there is from 20 to 40 feet more fall, depending on the situation; altogether, provision is made and the river will undoubtedly furnish, ordinarily, 20,000 horse power. This power is disposed of from time to time, with the necessary land, at very moderate rates, say 100 dollars per horse power in cash, and an annual rent of 5 dollars per horse power; the rent is reserved as a fund to maintain the dam and other works.

"The particular investment I have described has not turned out profitably; it was too much in advance of the wants of the country. Five or six similar operations, in different parts of the country, that preceded it, have met with more success; one or two of them with great success. They have altogether put into the market 60 or 70,000 horse power, fully half of which is in daily use at those few places."

Statistics of Lowell Manufactures, co... ...led from a...

CORPORATIONS.	Merrimack Manufacturing Company.	Hamilton Manufacturing Company.	Appleton Company.	Lowell Manufacturing Company.	Middlesex Company.	...olk Manufacturing Company.	T...
Incorporated,	1822	1825	1828	1828	1830	1830	
Commenced Operations,	1823	1825	1828	1828	1830	1832	
Capital Stock,	2,500,000 dol.	1,200,000 dol.	600,000 dol.	2,000,000 dol.	1,000,000 do	...,000 dol.	600
Number of Mills,	6, and Print-Works	4, and Print-Works	3	1 Spinning, 1 Carpet, 1 Cotton	4, and 3 Dy... houses	3	
Spindles,	82,720	48,512	18,920	7016 Wool, 8050 Cotton	16,340	21,986	2
Looms,	2,336	1,382	700	200 Power Carpet, 205 Cotton, 49 Fancy Check	200 Broad-cloth, 200 Narrow	800	
Females employed,	1,650	850	400	800	730	533	
Males employed,	750	400	120	500	575	150	
Yards made per week,	380,000	235,000	150,000	25,000 yards Carpet, 14,000 P. Stuffs, 78,000 yards Osnaburgs, 50 Rugs	24,000 Narrow, 6000 Broadcloth	154,000	23
Cotton consumed per week, pounds,	85,000	80,000	60,000	55,000	...	60,000	65
Wool consumed per week, pounds,	...	...	...	66,000	25,000	...	.
Yards Dyed and Printed,	340,000	112,000 printed, 18,000 dyed	...	...	...	...	.
Kind of Goods made,	Prints and Sheetings, No. 25 to 40	Prints, Flannels, Ticks, and Sheetings, 14 to 30	Sheetings and Shirtings, No. 14.	Carpets, Rugs, Cotton Cloth, and Pantaloon Stuffs	Broadcloth and Doeskins Cassimere; Shawls	Drillings, No. 14	Shee... No. Shirt... No.
Water-wheels, diameter,	6 Turbines, 5 ft.; 4 do. 8 ft. 6 in.	9 Turbines, 3 Breast wheels	5 Turbines	3 Turbines—7 4-12ths feet diameter; 1 do. 8 4-12ths feet do.	12 and 17 fe	Turbines	4 Turb... 8 feet diam...

Average wages of Females, clear of board, per week, 2·00 dollars. Average wages of Males, clear of board, per day, 0·80 cents. Medium produce of a Loom, No. 14 yarn, 45 yards per day. Medium produce of a Loom, No. 30 yarn, 33 yards per day. Average per Spindle, 114 yards per day.

The Population of Lowell in 1828 was 3532; in 1840, it was 20,796; in 1850, it was 33,385. Increase in ten years, 12,589. In 1855, it was 37,553.

A *Reservoir*, of great capacity, has been built on the high ground in Belvidere, east of the city, for the purpose of furnishing a ready supply of water to any part of the city in cases of fire. The water is conveyed into the Reservoir by force pumps from the Lowell Machine Shop. Pipes are laid from the Reservoir to various parts of the city, at which points hose can be attached to the hydrants without delay, when necessary.

The Proprietors o... in 1792, are the ow... Companies water-p... company is owned ... the water-power; t... tenance of the pow... dered more durable ... also keep up a staff ... power.

...nufactures, co... ...led from authentic sources, January 1858.

...well ...acturing ...pany.	Middlesex Company.	...folk Manufacturing Company.	Tremont Mill.	Lawrence Manufacturing Company.	Lowell Bleachery.	Boott Cotton Mills.	Massachusetts Cotton Mills.	Lowell Machine Shop.
...28	1830	1830	1830	1830	1832	1835	1839	1845
...28	1830	1832	1832	1833 and 1834	1832	1836	1840	1845
...00 dol.	1,000,000 do...	...0,000 dol.	600,000 dol.	1,500,000 dol.	300,000 dol.	1,200,000 dol.	1,800,000 dol.	600,000 dol.
...nlng, ...rpet, ...tton	4, and 3 Dy... houses	3	2	5	Bleachery and Dye-works	5	6	4 Shops, Smithy, and Foundry
...Vool, ...otton	16,340	21,986	20,448	58,624	...	54,936	58,512	...
...ower ...pet, ...ton, 49 ...Check	200 Broadcloth, 200 Narrow	800	760	1,852	...	1,430	1,971	...
...0	730	533	550	1,300	40	870	1,300	...
...0	575	150	130	300	360	262 including mule tenders	400	800
...yards ...14,000 ...uffs, ...yards ...rgs, 50 ...gs	24,000 Narrow, 6000 Broadcloth	...54,000	230,000	360,000	...	300,000	507,000	...
...00	...	60,000	65,000	140,000	...	90,000	175,000	2000 tons wrought and cast-iron per annum
...00	25,000	...	...	...	...	...	...	...
	...	...	...	...	15,000,000 yards dyed per annum	...	...	...
...Rugs, ...Cloth, ...taloon ...fs	Broadcloth and Doeskin Cassimere; Shawls	Drillings, No. 14	Sheetings, No. 14; Shirtings, No. 14	Drillings, Printing Cloths; Sheetings and Shirtings, 14 to 30	8,000,000 lbs. bleached per annum	Drillings, No. 14; Sheetings, Shirtings, Jeans, Printing Cloth, No. 30	Sheetings, 13 Shirtings, 14 Drillings, 14	Cotton Machinery, Locomotives, Machinists' Tools, and Mill-work
...nes— ...s feet ...ter; ...-12ths ...do.	12 and 17 fe...	Turbines	4 Turbines, 8 feet 4 in. diameter	6 Turbines, 9 feet; 6 Breast, 17 ft.	...	6 Turbine, 7 ft. 8 in., & 2 Centre Vent, improved by Mr Francis, 9 ft. 4 in. diameter	12 Breast, 17 feet; 7 Turbines	2 Turbines, 6 ft. 10 in. diam. each; and 1 Breast-wheel, 13 ft. diam. by 13 ft. long.

...s of Males, clear of ...day. Medium pro... ...r day. ...3,385. Increase in

...east of the city, for ...fire. The water is ...s are laid from the ...drants without de...

The Proprietors of the Locks and Canals on Merrimack River (J. B. Francis, agent), incorporated in 1792, are the owners and managers of the water-power. They have leased to the Manufacturing Companies water-power amounting in the aggregate to about 10,000 horse-power. The stock in this company is owned by the Manufacturing Companies in the same proportions in which they hold the water-power; the rents paid are only sufficient to pay the expenses of management and maintenance of the power. This company carry on the Burnettizing process, by which timber is rendered more durable. From one to two millions of feet are prepared by them annually. They also keep up a staff of engineers for purposes connected with the use and distribution of the water-power.

CHAPTER XII.

LIGHTHOUSES.

Parts of the United States in which Lighthouses have been erected—Great extent of Coast under the superintendence of the Lighthouse Establishment—The uncultivated state of a great part of the country, and the attacks of Indians a bar to the establishment of Lights on the Coast—Introduction of Sea Lights in America—Description of the present Board of Lights, and numbers of Lighthouses.

The parts of the territory of the United States in which lights have been erected by the American Lighthouse Board, are,—*first*, The eastern coast of the country extending from the boundary between the American and British dominions to the Gulf of Mexico, a distance of 3000 miles, exposed to the Atlantic Ocean; *second*, The courses of the rivers and bays, including the Mississippi and Hudson Rivers, and the Bays of Chesapeake, Delaware, &c.; and, *third*, the southern shores of Lakes Ontario, Erie, Huron, and Michigan, embracing a line of coast of not less than 1200 miles in extent. In addition to these great outlines, lights have also been placed on some of the smaller rivers and lakes.

The western coast of the country, which is washed by the Pacific Ocean, is entirely cut off from any communication with the inhabitants of the United States by a great tract of uncultivated and unexplored land, stretching from the northern to the southern extremity, and flanked by the rugged ridges of the Rocky Mountains. The United States of America, therefore, are quite unapproachable from the Pacific. The western coast of the country (a great part of which has never been explored), is still far removed from the limits of civilization.

The whole extent of coast under the jurisdiction of the American Lighthouse Establishment embraces the three compartments which have been enumerated, and is not less than 5450 miles, while the coast of Great Britain and Ireland may be stated at 2800 miles, and that of France at 1100 miles. The uninhabited and desolate condition of a large part of the coast proves a great bar to the regular and efficient establishment of lighthouses. This fact has been strikingly exemplified, and its consequences severely felt, in the State of Florida, which is said to be the most dangerous coast in the United States of North America. The country in this State is still, in a great measure, uncultivated. It was originally peopled only by remnants of Indian tribes, who showed their hostility to the introduction of anything like civilization, by opposing the erection of lighthouses on the coast, and in some places burning the lighthouse towers, and even murdering the keepers. In one instance, a light-keeper on the coast of Florida, after defending himself for a considerable time against an attack made by a body of Indians, was at last forced to take refuge in the balcony of the lighthouse, where he was shot by the arrows of the assailants. The following extract, taken from a letter addressed by the Fifth Auditor to the Secretary of the Treasury of the United States, shows the difficulty that was encountered in transacting the business of the lighthouse establishment:—"A contract was made in the month of July last, for rebuilding the lighthouse at Cape Florida, and the contractor proceeded to that place with materials and men to execute the work; but finding that hostile Indians were in the neighbourhood, he returned to Boston (a distance of about 1300 miles) without effecting his object. When the contract was made, there was just reason to believe that the Indian war was at an end, and that the work could be done with safety."

The fact of a lighthouse system having been extended to the remotest corners of so extensive a coast, under circumstances so inauspicious and unfavourable, is what could hardly have been looked for, and is certainly highly creditable to the government of the United States, and to the officers of the Lighthouse Establishment. Even the most superficial observer could not fail, at the time of my visit in 1857, to discover that there was a striking contrast between the regulation of that establishment and the efficient and admirable systems pursued by the Lighthouse Boards of Great Britain and France; but I was rather disposed to admire the activity and zeal which had extended the benefit of lighthouses to remote and unhospitable regions, of difficult access, than to wonder at the defects of the system which had been established for the purpose of carrying that important object into effect.

The date at which the first sea light was exhibited on the coast of America is not exactly known; but the management of the lighthouses appears to have been undertaken by the Government of the United States, and a system for conducting them regularly organized in the year 1791, at which period they were only ten in number. These appear to have been erected in the States of Massachusetts, New York, and Virginia, which were the earliest settlements in the country. The whole number of lighthouses, including harbour lights (which are also under the control of the General Lighthouse Board), in 1837, was 202. Of these about 172 were situated on the sea coast, and the remaining 30 were on the great lakes and rivers. There were also 26 floating-light ships, moored in the vicinity of particular dangers on the coast, and varying in size from 50 to 225 tons register, according to their position and importance. In addition to the duties connected with the management of the lights, the Board had also the charge of upwards of 600 buoys and beacons placed on different parts of the coast.

Since 1837 considerable changes have been introduced in the management of the American Lighthouses; and their number and efficiency have been greatly increased.

The management of the lighthouses is now intrusted to a Board, which was organized in conformity to an Act of Congress approved in 1852. This act proceeded upon a report made in terms of the instructions of the Government of the

United States, by a Committee appointed to report upon the lighthouse system of the United States, and also the systems pursued in England and France. That Committee made an elaborate report, in which they detailed the systems adopted by the Trinity House in England, the Commissioners of Northern Lights in Scotland, the Ballast Board in Ireland, and the Commission des Phares in France. They suggested various improvements in the management of the lights; and as regards the system of illumination, they state:—The Board recommend, "that the Fresnel or lens system, modified in special cases by the holophotal apparatus of Mr Thomas Stevenson be adopted as the illuminating apparatus for the lights of the United States, to embrace all new lights now or hereafter authorized, and all lights requiring to be renovated, either by reason of deficient power or of defective apparatus."

The distinctions adopted are as follows:—

1. Fixed white; 2. Fixed red; 3. Flashing; 4. Short eclipse or fixed light, varied by flashes; 5. Fixed white with red flashes; 6. Revolving.

One result of the formation of this Board has been a great increase in the number of lights, which now amount to 490.

The classification given by the Americans to their lights is as follows:—

1. Primary sea-coast lights (corresponding to our first-class lights) the number of which is, . .	58
2. Secondary sea-coast lights, and lake-coast lights (corresponding to our second class lights and larger harbour lights), ...	85
3. Light vessels (chiefly moored in the bays), .	49
4. Sound, bay, river, and harbour lights (which are all of a character corresponding to our smallest harbour lights), ...	298
	490

The local management of this extensive range of lights is entrusted to 12 inspectors, who are appointed to the charge of the 12 districts into which the country is divided; while the whole management is entrusted to the General Lighthouse Board of the United States.

THE END.

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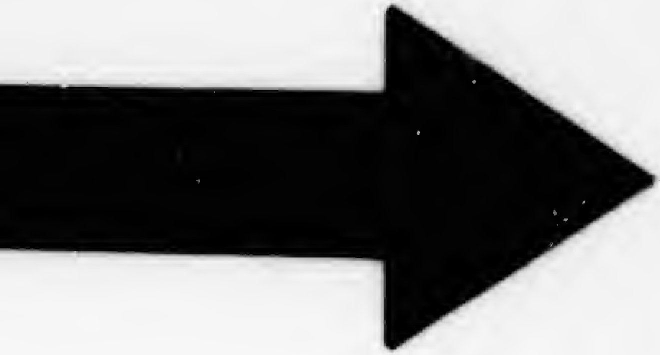

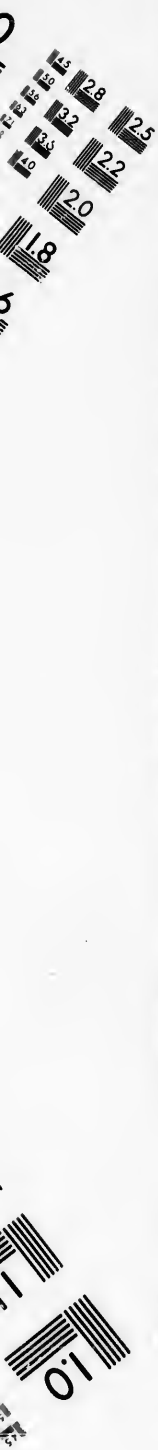

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