Narratives of two excursions to the ports of England, Scotland, and Ireland, in 1816, 1817, and 1818 : together with a description of the Breakwater at Plymouth, and also of the Caledonian Canal / translated from the French of Charles Dupin ... and illustrated by notes, critical and explanatory, by the translator.

Contributors

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NARRATIVES

OF

TWO EXCURSIONS

TO THE

Ports of England, Scotland, and Ireland,

IN 1816, 1817, AND 1818;

TOGETHER WITH A DESCRIPTION OF THE

BREAKWATER AT PLYMOUTH,

AND ALSO OF THE

CALEDONIAN CANAL.

TRANSLATED FROM THE FRENCH OF

CHARLES DUPIN,

CAPTAIN IN THE CORPS OF NAVAL ENGINEERS, AND MEMBER OF THE INSTITUTE OF FRANCE;

AND

ILLUSTRATED BY NOTES, CRITICAL AND EXPLANATORY,

BY THE TRANSLATOR.

——— Quæ ipse vidi.

London:

PRINTED FOR RICHARD PHILLIPS;

BY G. SIDNEY, NORTHUMBERLAND-STREET, STRAND.

INTRODUCTION

BY

THE TRANSLATOR.

So much has been said of the following NARRATIVES, containing a brief sketch of two Excursions made, at different times, to our Naval and Commercial Ports, and a description of some of the great Public Works now in hand, that we have been induced to offer them, in a correct translation, for the gratification of the English reader. They were presented, in 1818, to the Academy of Sciences in Paris, and published as "*Mémoires sur la Marine, et les Ponts et Chaussées de France et d'Angleterre,*" by M. CHARLES DUPIN, a Captain in the Corps of Naval Engineers, and at that time a Correspondent of the Institute of France, of which he is now a Member.

The avowed object of M. Dupin's visits to England was to improve a work on *Naval Architecture*, and, with that view, he brought letters of introduction to the President of the Royal Society, from several Members of the Institute, and, through the mediation of the French Ambassador, he succeeded in obtaining permission to view all our Dock-yards and other Naval and Military establishments.

In this rapid sketch, M. Dupin does not enter much into gegeral details; nevertheless, he occasionally introduces particular topics which do not properly come within the sphere of the pro-

fessed object of his tour, and he likewise suffers an undue bias to warp the accuracy of some of his statements. Every fair allowance is, undoubtedly, to be made to a foreigner, who may, probably, be but little or not at all acquainted with the language of the country, which he visits in search of information. But no reasonable excuse can be offered for such a man, if, while he is profuse in professions of fine sentiment, he throws out insinuations, which, far from tending to the advancement of science, must ultimately produce a contrary effect, by checking all liberal communication.

In the narrative of a scientific tourist, the reader looks for facts, and by that criterion he will judge the author. If M. Dupin merely intended these Narratives as a sort of prelude to his promised great work, that should have prompted him to unbiassed precision in *all* his statements. Accuracy as to facts, generally known and admitted, is no palliation for errors of this particular description with regard to others.

In producing these Narratives to the British public, it has, therefore, been our earnest endeavour to correct those errors and inaccuracies, which, according to their importance, we have sometimes done in the text, and sometimes in NOTES, accompanied by such explanations and observations as appeared to us called for by the subject. Unfounded assertions we have repelled, whenever we have been enabled to do so from positive information, derived from authentic sources. Our humble efforts too have been exerted in defence of *the legitimate offspring of British talent.* We never claim for our countrymen the palm of genius, except when it is justly their due, and cannot fairly be contested; while we as willingly crown the French with the garland of fame, when the laurels have been honourably gained, whether by eminent skill in art, or profound erudition in science.

In theoretical knowledge, the French, (generally speaking) may, perhaps, be thought to excel; and some of their produc-

tions of this description certainly do honour to their respective authors, and to their country. But, to counterbalance any superiority in that respect, Englishmen, unfettered by the prejudices which exalted theoretical speculations too often engender, have displayed great powers of invention, and, in the application of their superior practical knowledge to the useful arts, have greatly outstripped the French. In support of this assertion, we shall adduce the scientific BELIDOR, whose authority, in such matters, cannot be surpassed, and must, consequently, carry conviction to every well-informed mind.

Towards the middle of the last century, BELIDOR, like M. Dupin, visited England in search of information, and afterwards in his Preface to the "*Architecture Hydraulique*," (published in 1737,) in speaking of engines, he expresses himself as follows: "Among the former, I comprehend those (engines) which are "used for extinguishing fire; the others are calculated for sup- "plying a city with water. For example, we cite the finest "that are made in various parts of Europe, put in motion by "animals, the course of rivers, and the power of fire. The "last engines have lately been *invented* by the English, who have "found means to derive, from fire, the most powerful agent that "exists in nature, and to manage it with so much art, that what "they have done, in this respect, may be considered as the *chef-* "*d'œuvre* or *master-piece of the human understanding*."

As we, thus far back, took the lead of the French in this line, so it is evident, from many observations of M. Dupin, that we have now left them very, very far behind. He appears astonished at the great improvements we have made in the construction of our hydraulic and other works, and in machinery in general, within the last five-and-twenty years; and this rapid advancement excites the admiration of all scientific foreigners by whom they are inspected. It must, indeed, be acknowledged that, during that eventful period, the public spirit of the nation

has been manifested in many objects of great utility and improvement, such as the construction of docks, harbours, canals, bridges, roads, &c., as well as in many highly-useful inventions; while the energies of the government have been exerted to keep pace with that public spirit by various improvements made or introduced in our arsenals, in the construction of our ships of war, and of other works of real national importance. In fact, the public mind received an extraordinary impulse from passing events, and the result, in all the respects before-mentioned, has been highly advantageous and striking.

Attracted by these improvements, M. Dupin came, as a scientific observer, to *ascertain their advantages*, and *the particulars of their execution*, and, above all, *to collect information relative to ship-building*, and *every thing connected with the maritime arts*, as *practised in this country*. Whoever, then, regards the object of his visits to England, as a matter of little moment, will certainly not have considered them in their true light. For, as has been most justly observed, "in a maritime and commercial country, like Great Britain, the *art of ship-building*, and the *most effectual management of its naval strength*, are *objects of the first magnitude and importance*. The fleets of a kingdom so circumstanced, are the foundation and the bulwark of its pre-eminence and superior consequence among neighbouring nations; they are also the safeguard of its commerce in time of war. The prosperity of that very commerce, and the safety with which our merchants are enabled to carry it on, depend very much on the excellent construction of our ships."*

* It may here suffice to add, that the greater the general improvements in the present mode of construction, so, in proportion, the strength, the safety, and the durability of merchant-vessels would be increased. Hence great benefits would accrue to the mercantile world; first, by a reduction in the charges of freight, proportioned to the diminution of expence occasioned by the less frequent repairs, and the comparative soundness of the vessel; secondly, by the better preservation and greater security of the cargo; and lastly, by the reduced rate of insurance.

It has also been observed, with equal reason and truth, that "in no instance whatever are consideration and combination more necessary than in the form and construction of ships, particularly such as are destined for war. The complication of their powers, the various casualties to which they are liable, with the variety of requisites expected from them, renders the subject *unfit for speculative theory alone, requiring*, in a much greater degree, *the attention of practice and experiments;* though it is by no means to be inferred, that theory is not of infinite use, where real science is established. But, unfortunately, much elaborate calculation and profound erudition are often employed to raise a fabric according to certain principles and proportions, *without examining the pretended axiom or foundations on which these principles are laid down.*"

This is a species of absurdity to which the French writers on *Naval Architecture* are particularly addicted, and from an indulgence in which M. Dupin ought carefully to abstain in his promised work, if, instead of swelling it by a vain display of mathematical knowledge, he wishes to render it a useful production.

It has been aptly said by a judicious English author, that, for this absurdity, the French have an excuse to plead, which will not bear out any other people; namely, that, with them, the theory is constantly kept separate from the practice of ship-building. This naturally accounts for another fact not less extraordinary than true. It is that the French, although not surpassed by any nation in the construction of ships, as far as relates to the *form* of their bodies, founded on theory, are, nevertheless, as practical ship-builders, inferior to every other maritime people, owing to a want of due combination of Practice with Theory.

Let us hope, however, that M. Dupin has seen enough of our practical superiority in the mechanical branch of the

art, to be able to improve that branch in France, and that, at some future period, England will reap a share of the benefit of his industry and discernment.

We now take leave of M. Dupin, wishing him all desirable success in his great undertaking. We doubt not of his capacity to accomplish much, and as far as Geometry and Algebra may bring him through his task, he may, probably, acquit himself *à merveille.* But, when he gives us to understand that he shall improve on some of the admirable things he has seen in England, the result is much more problematical. He has thereby voluntarily entered into a serious engagement, and (without offence be it said) his failure will not disappoint many ingenious or scientific persons on this side of the Channel.

It only remains for us to express our grateful acknowledgements for the obliging manner in which our doubts have been solved by some of those gentlemen whose names are hereafter mentioned by M. Dupin, either in connexion with *great* PUBLIC WORKS, or INVENTIONS and IMPROVEMENTS *of the greatest utility and advantage to the* PUBLIC SERVICE. In these monuments of their genius, their fame will long endure, and thus be transmitted to succeeding generations.

Our best thanks are also due for the elegant version of M. Dupin's lines, in pages 95 and 96, with which we have been favoured by the MODERN BARD OF CALEDONIA.

ERRATA.

Page 6, line 5 from bottom, *for* 1802, *read* 1805.

Page 87, line 22 from top, *for* covered-ways, *read* covert-ways.

EXCURSION

TO THE

PORTS OF ENGLAND,

IN 1816.

After having exhausted every thing most useful and most ingenious offered to me by France, considered in a maritime point of view, I turned my eyes towards a people who for a century past have held the sceptre of the seas, and, without ever reposing on the superiority of their labours, strive more and more to approach towards perfection.

In my first excursion, I visited the establishments of London which have a direct or indirect connexion with the marine, all the great naval ports, and the two most important ports of commerce, after the capital: I mean Bristol and Liverpool.

London offered itself to my observations in three different points of view. First, as the greatest port for trade in all England; then, as a focus of industry for the maritime arts; lastly, as the centre of the operations of the military marine, or navy. Let us take a rapid glance at the capital of the British empire, considered under these various aspects.

London enjoys, from nature, an advantage which Paris ought to have enjoyed long since through the benefits of art. It is that of being a sea-port. Ships ascend the Thames in full sail, and come to anchor, or moorings, at the very foot of the arches of London-bridge. In setting out from this place, and descending towards the sea, five, six, seven, and even eight vessels lying abreast, are seen on each side of the river, and these tiers succeed each other almost without any interruption, to a considerable distance.

Nevertheless, this is but a small part of the mercantile marine, or merchant-shipping belonging to the capital. All the ships which trade to India have their particular wet-docks, or basins, one for the imports, or homeward-bound ships, another for the exports, or those outward-bound. All the ships which trade to the West Indies, in like manner, have theirs; ships of all nations are received, without any kind of

distinction, into the London Docks; and the Greenland Dock, reserved at first for vessels employed in the fishery on the coast of that name, and increased by subsequent works, has since received a more extensive destination.

Twenty years have not yet elapsed, since this last-mentioned dock, the smallest of all, was the only one existing. War unexpectedly occurred, and we covered the continent with our trophies. Every where, throughout impoverished Europe, the commerce of England seemed to recede before our victorious banners. We imagined that Great Britain, exhausted, was on the brink of ruin. But, while our sight was darkened by the smoke of a noble incense of glory, unlooked for opulence overflowed with its treasures the British empire; the rivers were not wide enough to contain all the ships, and fewer years sufficed for a few individuals to excavate and construct, at their expence, the docks which receive the trading fleets of the two hemispheres, than it required for the triumphant government of France to erect some of the quays of the Seine. These are the prodigies of the seas!*

This great lesson will, perhaps, make us some day comprehend the true sources of national power and prosperity. But here, I ought to speak only of the master-pieces of the arts, and not of their results in the terrible contest which they have engendered, prolonged, and at length decided.

The plan and the construction of the wet-docks, or basins, for keeping ships afloat, differ essentially from the works of the same kind executed in France. Instead of being, like ours, bordered by quays formed by walls with plane faces, either inclined or vertical, and with stones placed in horizontal courses, these walls are concave on the exterior, that is, on the side next to the water, and convex on the side next to the land; the

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* These *prodigies* may be explained in a few words. Under a free government, an industrious nation, possessed of ships, colonies, and commerce, must naturally increase its wealth, and that increase of wealth will consequently give birth to a spirit of individual enterprize in commercial speculation, productive of the most beneficial results, like those here noticed by M. Dupin. Under a different sort of government, trade being fettered by restrictive monopolies, and confidence checked by arbitrary decrees, the reverse will happen. This is at present fully exemplified in Spain, where grass is now growing on the wharfs at Bilboa and other ports which formerly partook of the advantages of commerce.

During the last twenty years preceding the peace, England enjoyed the uncontrolled dominion of the seas. Within the same period, France successively lost all her colonies, and her foreign trade. With the comparatively few colonies she now has, her foreign trade must be proportionably less than when she held the most fertile part of St. Domingo, together with St. Lucie, Tobago, and the Isle of France; and, under such disadvantages, her attempts to rival England in commerce and manufactures, however encouraging to her domestic industry, cannot, in the general result, but fall short of the more successful efforts which she was formerly capable of making. TRANSLATOR.

courses have the direction of their joints, perpendicular to those surfaces. The piles are in like manner inclined, and driven perpendicularly to the lower face of the lowest course.

The entrance of the sluices, or locks, is built according to an analogous system, not less advantageous.

Lastly, the lock-gates, or valves, instead of being formed by two massive planes, bevelled like a wedge, are composed of two vertical cylinders, the convexity of which forms an arch to resist the pressure of the water.

I have demonstrated geometrically, in regard to economy and solidity, the advantage of these curvilinear forms over ours, which are rectilinear.

The works of hydraulic constructions, in England, are distinguished by the constant use of the steam-engine for draining, &c. and for all the manual operations which require the continued exertion of great and long efforts within the same space.

The removal of soil, earth, or rubbish, the conveyance of stones, sand, or lime, every thing is done by little four-wheel carts, drawn by a single horse on iron-railways. These ways are composed of pieces of different lengths, which are laid down and removed with the greatest facility. The advantage which they present is immense. England owes to them a part of her wealth. Never without them could coal, iron-ore, lime-stone, slate, and other raw materials, have been conveyed to such distances, and nevertheless at a very trifling expence.

Excavations under water, when the bottom consists of mud, sand, or gravel, are made by *dredging-machines*, established in lighters or barges, and worked by the steam-engine.

I shall cite as a model for constant cleansing that of the West-India Docks.

A lighter provided with a steam-engine, which works the dredging-apparatus, is conducted into every part of the dock where it is necessary to operate. The mud-lighters, as they are loaded with mud by the dredging-apparatus of the other lighter, are brought and placed under another similar machine on the edge of the dock, worked by a steam-engine established on the bank. The mud or silt is, in this manner, raised and discharged into a fixed receptacle which traverses the boundary-wall inclosing the establishment, and which spreads, like a torrent, this mud into a piece of waste-ground belonging to the peninsula of the docks. This system of cleansing is, as is shown, very simple, perfectly understood, and extremely economical.

By means of a lighter provided with a dredging-machine,

worked by the agency of steam, not only have basins been dug and cleansed out, but small rivers have been rendered navigable that were not so before, and shelves have been made to disappear which obstructed, in certain places, the course of the most considerable rivers.*

Another machine, not less remarkable, employed in all the great hydraulic works, is the *diving-bell.* It has the shape of a truncated quadrangular pyramid, the great base of which is open and turned downwards. In the inside of this truncated pyramid, two men, each seated on a bench, may rise up and work at their ease. Ten lenses, let into the upper part of the bell, collect and refract light enough for a person to see at a considerable depth under water.

A forcing air-pump, which resembles our fire-engines in appearance, serves, by means of a long leathern hose, or pipe, to convey incessantly fresh air into the bell.

Sometimes this bell is suspended by a shackle to a roller, or barrel, moveable on two systems of cogged wheels, which, from their directions and their functions, represent rectangular

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* *Dredging* is the term used to express all these important operations in the practice of the engineer. The apparatus employed for this purpose consists of two kinds, the *spoon-dredging-boat*, and the *bucket-dredging-machine*. The former has long been in use for deepening the extensive tracts of canal in Holland and Flanders, and also on the Thames, where this operation is conducted on a grand scale, under the immediate direction of the Trinity Board of London. The latter is of more modern invention, and being frequently mentioned in these narratives, we are induced to explain it by the subjoined description.

The *bucket-dredging-machine*, which is floated on a barge or lighter, was first worked by men only, when the principles on which it acts were more fully ascertained, horses were employed; but it is now generally worked by the power of steam. The apparatus is somewhat complicated, but the chief part is composed of a succession of iron buckets, connected by an endless chain, made to revolve round a frame. The bucket-frame, which consists of two beams of timber, is supported on a rod of iron with shores of wood; on these beams the full buckets move upon iron rollers fixed to the timber, while the empty buckets and endless chain form a curve in descending to the bottom. The bucket-frame is then lowered with proper precaution till the empty buckets come in contact with the mud, and, according to the tenacity of the stuff, a greater or less impression is made by the buckets on the ground. The crown, or upper wheel of the machinery is placed on the same axle with the upper tumbler of the bucket-frame, with which the train of buckets is made to revolve by means of the endless chain. The buckets at the lower end of the frame are continually filling, while those at the upper extremity are at the same time emptied. Instead of a cylindrical barrel, the tumbler is necessarily formed into a polygonal figure by bars of iron, to which the links of the endless chain are exactly fitted, and, in revolving on its axis, it takes round the chain and buckets, and so produces the complete effect of filling and discharging the dredging buckets into the receiving barge or boat, moored alongside for that purpose. One of the dredging-machines on the River Thames has a bucket-frame working on each side of a vessel of about one hundred tons burthen, furnished with an engine of the power of sixteen horses, which excavates about three hundred tons per day. In another place we shall explain the improved machinery of the diving-bell.

TRANSLATOR.

co-operating axles. By means of these axles, the centre of the bell can be placed in whatever perpendicular may be wished; then it is raised or lowered at pleasure by the help of a tackle fixed to the shackle, and a projecting beam. It is, as is seen, geometry applied to the labours of the arts.

The machinery of which we are speaking is employed for building that part of the walls of a quay which is under water, without having occasion to recur to expensive methods of draining the foundation by coffer-dams or caissoons.

Sometimes the bell is suspended to the stern of a vessel, which conveys it where it is wished for. This particular apparatus is employed for raising, in rivers, roadsteads, harbours, and basins, all bulky or heavy bodies sunk in the water, such as anchors, guns, remains of wrecks, &c.

This machinery is likewise employed for mining and blasting sunken rocks, dangerous to navigation.

I shall not extend farther this enumeration of the means employed by the English in their hydraulic works. The development of those means, of their advantages, and of their inconveniences, is exposed, with details, in the manuscript volume which I have had the honour of presenting to the Institute, and which contains the description of the ports that I visited in my first excursion.

If we actually consider the materials employed by the English in their works, we shall remark an immense change effected within these few years.

The basins or wet-docks, as well as the graving or dry docks, constructed formerly, were entirely built with wood. It was thought, and not without reason, that by devoting a smaller capital to works of this description, the expence of keeping up and repairing those buildings, which did not last long, was recovered with interest. But, when maritime operations assumed an extraordinary degree of activity, it was perceived that their frequent interruption, produced by repairs and rebuilding, occasioned a loss which might be compensated by the disbursement of a little capital. According to this principle, brick and rubble were substituted for wood, in the merchants' yards, and hewn stone, marble, and granite, in the arsenals belonging to the state.

This change is visible on the banks of the Thames, where the oldest ship-yards still offer wet-docks and graving-docks lined with wood, while the more modern establishments present quays and other works faced with masonry.

There are now, by the side of the Thames, but very few of those repairing docks, formed by the hull of an old ship,

buried in the soil of the strand, and cut at its extremity nearest to the river, in order to place there a pair of gates.

Another change, not less remarkable, has occurred in the buildings in wood erected on land. Wherever accidents from fire might be apprehended, iron has been substituted for wood.

Among the works of this kind is a fine shed built by Mr. Rennie, for covering one of the quays of the West-India Docks. This shed is upwards of two thousand four hundred feet in length; it is supported by hollow iron columns; the beams, joists, rafters, and laths, are all of iron.* The parts which have pressure only to support are of cast-iron. The parts which must particularly resist tension are of wrought-iron. The longitudinal materials of this building are combined in such a manner that its different parts may expand or contract without injury or inconvenience.

In the course of this Memoir I shall more than once have occasion to mention many other ingenious and new uses of wrought and cast iron.

The great London Docks are surrounded by cellars, warehouses, and sheds, of immense extent; frequently the quays are provided with iron rail-ways; they are lined with cranes, also of iron, and which present a great variety, in their size, their figure, and their mechanism.†

Near the East-India Docks is established the largest of the merchant-yards to be met with by the side of the Thames. I

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* This is a mistake. The shed on the North Quay of the Import Dock, is 2,700 feet long, and supported by hollow cast-iron columns; but the roof is of wood. There is another shed, on the South Quay of the same dock, 1,314 feet long; the columns by which it is supported are cast-iron, as well as the roof.
TRANSLATOR.

† Notwithstanding the example set at Liverpool in the construction of a wet-dock as far back as the year 1708, which was followed at Hull in 1775, London, though unquestionably the first city in the world for its opulence, its commerce, and its public spirit, was the last to seek the incalculable advantages resulting from those convenient receptacles for loading and unloading ships, called wet-docks. With the exception of Mr. Perry's Dock at Blackwall, and Mr. Wells's at Greenland Dock, there was no establishment of the kind on the River Thames till the year 1800, when the West-India Docks were commenced on the Isle of Dogs. They were opened in 1802, and will contain, with ease, 500 vessels, of from 250 to 500 tons. The money raised for their construction was 1,200,000l. The London Docks, situated in Wapping, were the next undertaken, for the advantage of the trade of the capital, and are generally appropriated to the reception of ships laden with wine, spirits, tobacco, rice, &c.; but others are admitted, on paying the dues. They were opened in 1802, and cost 2,200,000l. there being a necessity for purchasing a great number of houses which stood on their site. The East-India Docks, for the exclusive reception and accommodation of the East-India ships, were the last undertaken. They are situated at Blackwall. The sum raised for their construction was 600,000l.
TRANSLATOR.

there saw an East-Indiaman launched, of thirteen hundred tons: this ship presented the example of great improvement; there were three other ships of the same size on the stocks.

London, considered as the focus of industry for the maritime arts, presents a variety of important establishments. The Royal Society of London, the Society for the Encouragement of Arts, Manufactures, and Commerce, the British Museum, and the Royal Institution, are the principal sources where are to be collected materials for the theoretical part. About thirty years ago, a Society was formed for the Improvement of Naval Architecture, under whose direction were made, in Greenland Dock, some very important experiments on the resistance experienced by bodies moved in water. This Society, abandoned by government, and, perhaps, even thwarted clandestinely by men in power, dissolved itself after a few years of commendable labours.*

As for the practical part of the maritime arts, I shall now notice some of the principal establishments which I visited.

Maudslay's manufactory, in Lambeth, is one of the most interesting for the construction of engines and all kinds of machinery composed of iron or other metal. In the Conservatory of Arts and Trades in Paris, may be seen one of the little steam-engines constructed in this manufactory. In the same place were executed the machines of Mr. Brunel, of which I shall have occasion to speak repeatedly. It was there, too, that were made for the English navy seven thousand iron tanks, each four feet square, and containing about sixty-four

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* Government had no concern whatever either in the formation or the dissolution of the Society for the Improvement of Naval Architecture. It consisted of various noble and ingenious men, who most patriotically associated, and, by their individual subscriptions, formed a fund to defray the expences attending the prosecution of such a series of experiments as might tend to develop the scientific arcana, and ascertain the laws of resistance of water to bodies of different forms, moving through it with different velocities. In consequence thereof, during the years 1793, 4, 5, 6, and 7, several thousand experiments were made for this important purpose, under the inspection of proper persons, who were themselves Members of the Society, by a more accurate apparatus than had ever before been used for experiments of this nature.

From the most important part of the results of these experiments, which were published by the Society, in the year 1799, a short time before its dissolution, we take the following abstract. "These experiments will be found both curious and instructive. They explain many things which were before either not at all, or but very imperfectly, understood, and they ascertain new principles; but what is more valuable, they clearly prove, that experiments can now be made, by means of proper models, so as to ascertain the comparative advantages or disadvantages, arising from the form, either of the head-end, or of the midship-body, or of the stern-end, of all kinds of navigable vessels." After the publication of their transactions, their funds being exhausted, the subscriptions were not renewed; some of the leading members died, others ceased to act, and thus the Society was dissolved. TRANSLATOR.

cubic feet of water. The introduction of these tanks on board of ships of war is an incalculable improvement, as it enables them to stow about one-eighth more water in the ground-tier, which cannot but be beneficial to the health of the crews.

It is in another suburb of London that Messrs. Huddart and Brown have established, the one his rope-manufactory, the other his manufactory for iron-cables.

Huddart's ropes, twisted and laid by the agency of steam, are made on the principle of the equal tension of all the yarns, which gives them much greater strength than in following the common method of twisting.*

The cables of Captain Brown are of two sorts, the one made of twisted chains, the other not. The latter seem better calculated for resisting in the direction of their length; but the former, being more pliable, are, in preference, taken on ship-board, while the others are preferred for moorings in anchorages.*

Captain Brown has taken out a patent for the manufacture of iron bridges, which are extremely light and very economical.†

The great advantage of his system is, that in case any parts of the bridge happen to fall to decay, whether from age or from accident, as many of the component parts as may be wished for, can, by means of a very simple apparatus, be taken to pieces and replaced successively, without there being any necessity to erect large scaffolds for that purpose. The bridge may thus be rebuilt or repaired, piece by piece, at very little expence.

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* By the simple machine, invented by the late Captain Huddart, the process of laying a cable of twenty-three inches, which, by the common method, requires the simultaneous exertions of 170 or 180 men for upwards of an hour, is performed with greater accuracy by the attendance of only three persons.
TRANSLATOR.

† Cables made with twisted chains are entirely done away with in the navy, and none but those made with straight chains are now used.
TRANSLATOR.

‡ Captain Brown's *patent iron bridge of suspension* differs from all other bridges of the Catenarian order, being composed of straight wrought-iron bolts or bars, united at their ends by side-plates, with bolts passing through them. By these means, the series in each line of suspension becomes, in effect, one entire bar, which extends over its respective piers, and is secured in the rock or ground. The piers, therefore, have scarcely any other strain to support than pressure: the drag or tension being resisted at points beyond their foundation. A bridge of this description was constructed by Captain Brown in 1813, and is now standing on his premises at the Isle of Dogs, Poplar. It was intended for foot passengers, and weighs only 38 cwt.; but it so far exceeds the strength necessary for this purpose, that carts and carriages safely pass over it. The span is 100 feet.
TRANSLATOR.

The arts which employ iron and hemp have made a great step towards perfection, by the emulation which has been excited between the inventors of the new modes of proceeding, and the sticklers for the old routines. The former, to prove the superiority of the means which they have attempted to introduce, have been forced to make, on a large scale, comparative experiments on the strength of the raw and the wrought materials. Hence has resulted a vast deal of positive information, highly interesting with regard to the ulterior progress of industry.

It is also near London that Mr. Brunel has erected his machinery for sawing wood by means of circular saws. These saws serve to divide enormous logs of mahogany into leaves or veneers, ten out of an inch in thickness. The work is done with so much perfection, that cabinet-makers have no occasion to smooth over with a plane the veneers which come from the saw-pit. Their surfaces are so smooth that they have little more to do than to polish them, and they are then perfectly plane. I have described with great care the structure and the play of these saws, the largest of which is eighteen feet in diameter.

I should exceed the necessary limits of this analytical Memoir, if I wished to give here an idea of all the articles manufactured and sold in London, whether for the mercantile marine, or for the marine of the state.

Let us hasten to consider London as the centre of the operations of the military marine, or Royal Navy.

From the Admiralty-Office, situated in the centre of the public offices, couriers may reach, in half an hour, the dock-yard at Deptford, and, in an hour, that of Woolwich; in four hours, Chatham; in six, Sheerness; in eight, Portsmouth; and in twenty-four, the dock-yard at Plymouth, the most distant of all.

Notwithstanding this rapidity of communications, lines of telegraphic stations afford to the Admiralty the facility of corresponding with all the naval arsenals. Those telegraphs were formerly large frames divided into six compartments, in which various signals were made by means of moveable shutters. Our semaphore is now adopted with some modifications, proposed by Rear-admiral Sir Home Popham, who has made several additions and improvements with regard to the art of holding intercourse by signals.* He himself explained to

* The name semaphore is derived from the Greek noun and verb σημα, *sema*, *signum*, a signal, and φερω, *fero*, to carry or bear; in short, a signal-bearer, and is no more than a new name given to the Admiralty Telegraph by Sir Home

me the establishment of his telegraphic signals on ship-board.

The Admiralty-Board gives general orders; it presides over promotions, rewards, and punishments: the Lords of the Admiralty are liable to be changed as often as a change occurs in the Ministry.

The Navy-Board is charged to direct the execution of the works ordered by the Admiralty, and to provide supplies of stores for the different arsenals, and the equipment of ships, as well as to lay them up in ordinary; in a word, every thing that belongs to the general superintendence of the civil concerns of the Navy is within its department. The Commissioners of this Board are not changed whenever there is a change of the Ministry.

This division, at the same time independent and subordinate, made between art and authority, appears to me a master-piece of the English institutions.

The Victualling-Board (which, since the peace only has been united to the Navy-Board,)* has under its direction every thing that concerns the making of contracts for provisions, and the preparing of supplies of that description for the Navy both at home and abroad. The principal establishment of this department is at Deptford, and from the size of its buildings, it seems to form a town of itself. In time of war, here may be seen every day biscuit made for twenty-five or thirty thousand men. There

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Popham. It is an invention of great antiquity, and only revived in Europe with the French Revolution. Its signals are more distinguishable than either flags, balls, or shutters; they are literal or numerical, and, as worked over the Admiralty, at present, no more than a single letter or number is given in each exhibition, by one or both arms together.

The numbers are worked according to those arranged in a vocabulary of appropriate sentences; as the sentence opposite No. 125 may be—Have you any news? This number requires four exhibitions, viz. 1—2—3, and the stop signal, to separate 1 2 3 from the following number.

The number of changes on a two-arm Semaphore are forty-eight, which admits of an infinite variety of alphabets, and the correspondence is so arranged that the operators and superintendent officer of the respondent stations are completely ignorant of the message, their business being no more than to repeat the signals seen, exactly, to the next station.

We understand that a new vocabulary and a mode of working the signals by *double numeral tables*, have lately been produced, as the invention of Mr. Conolly; which improvements are said to be now before the Admiralty-Board.

TRANSLATOR.

* This is a mistake of M. Dupin. The Transport-Board having been dissolved at the end of the war, its twofold duties were divided between the Navy and Victualling Boards. Those which concerned the hiring of transports devolved on the Commissioners of the Navy, and those which related to the Sick and Hurt department, on the Commissioners of the Victualling-Board, on whom also devolves the direction and superintendence of all the naval hospitals, at home and abroad. TRANSLATOR.

are similar bake-houses near all the great naval arsenals. What struck me, in these bakehouses, is the division of the labour, and the dispatch with which it is executed, as well as the means of discovering at all times negligences or frauds, whether in the workmen or in the chiefs.

The English government would not merely consider as an act of barbarity, but as an act of madness, a saving made at the expence of the health of the men who consecrate their strength and their life to the defence of their country. Every thing is therefore abundant, wholesome, agreeable to the taste, and, I would almost say, delicate in the provisions of the English sailor. When I shall state that the crews of the men of war have cocoa for breakfast, I shall perhaps make the superficial observer smile; but I shall strike deeply the men who, profiting by the lessons of Hannibal, know how much physical strength, added to moral strength, may decide the loss or the gain of battles.

Adjoining to the Victualling-Yard at Deptford is the Naval Arsenal, established in that town; it is the least extensive and the least important of all.* But one must stop with respect in this place, for it was to Deptford that Peter the Great came to learn ship-building, in a private yard near the Arsenal.

In following still the right bank of the Thames, where are situated all the naval establishments, we arrive at Greenwich. There it was that Charles the Second, who strove to imitate Louis XIV. in his faults and his weaknesses, built a magnificient palace, in order to display also the show of his licentious court at the gates of his capital. Soon after, William and Mary, imitating otherwise Louis the Great, made of this palace the asylum of invalid sailors.†

The celebrated Observatory, from which the English Mariners reckon their longitude, stands in Greenwich Park, on a small rising eminence called Flamstead's Hill, an astronomer who first had this observatory under his direction, and rendered it famous from its very origin.

An establishment little known, but not less deserving of being so than those of which I have just been speaking, is the Naval

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* In speaking thus, M. Dupin was, probably, not aware that Deptford dock-yard is, in fact, the general repository of stores and necessaries for the fleet. Its proximity to the capital affords the convenience of receiving from this great mart all the home manufactures and products which may be purchased by contract for the use of the Navy. Hence they are shipped off, as occasion requires, to the home-yards, the out-ports, and the foreign stations. In time of war, these shipments amount to thirty thousand tons in a year. TRANSLATOR.

† Perhaps this is meant as a hint to Louis XVIII. to appropriate the palace of Versailles to a similar purpose, and convert it into an asylum for those who have been maimed in the service of their country. TRANSLATOR.

Asylum, a school where are gratuitously brought up the sons of sailors and petty-officers, who have lost their life in fighting for their country. This other school of the legion of honour is established between the Observatory and Greenwich Hospital.

Woolwich dock-yard merits much greater attention than that of Deptford. From the time of the famous *Harry Grâce de Dieu*, built by Henry VII, to the *Nelson*, a first rate of 120 guns, the largest ships have been built here.

I saw in this dock-yard a machine for bending timber, invented by Mr. Hookey; it has sufficient power for curving pieces intended to form the ribs or frames of a ship. It seemed to me that too little use was made of this interesting invention.

Mr. Rennie is now constructing in Woolwich-yard a smithery, with a forge adapted to it; the lifting and tilt hammers, and all the machinery belonging to this forge, will be put in motion by the steam-engine. The heaviest anchors will here be made, and other iron-work executed in the same manner. This establishment will most certainly be the first of its kind in England, and probably in Europe.

Two or three years ago, experiments were made, on a large scale, at Woolwich, to impregnate timber with a mineral solution which might preserve it from decay. For that purpose was employed a steam apparatus of high pressure, in order that the gas might penetrate more easily between the fibres of the timber, relaxed by the heat. But the heat and the compression were increased so much, that one day all the apparatus exploded with a most dreadful crash, killed or wounded several persons, and committed other serious damages in the circumjacent places. Since then, it does not appear that either the projectors or others have been tempted to renew the experiment.*

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* Here too M. Dupin has been led into an error. The following are the facts. When that most destructive and infectious disease, the dry-rot, had manifested itself to so alarming an height in several of our ships of war, as to announce their rapid and premature decay, recourse was had to various experiments for seasoning of green timber. Among other experimentalists, encouraged by government, was Mr. Lukin, one of whose contrivances was to supply the place of the fluids driven out by heat, with some other substance of an oily or resinous nature, which, while it destroyed the principle of vegetation, should preserve the timber in a compact state. For this purpose, he erected a large kiln in Woolwich dock-yard, capable of containing from two to three hundred loads of timber. At each end on the outside was a retort, in which the saw-dust of the pitch pine was submitted to distillation. From the heads of these retorts were iron pipes perforated with holes like a cylinder, continued along the upper part of the kiln the whole length in the inside. By this arrangement, it was expected that while the heat of the kiln drove off the aqueous matter of the timber, the product of the saw-dust, which resembled weak oil, or rather spirit of turpentine, would drop through the holes in the tubes upon the logs and supply its place. But, before the process of transfusion was judged to be complete, an explosion took place, which proved fatal to six of the workmen, and wounded fourteen, two of

At Woolwich is the principal establishment of the Ordnance Department, which comprehends under its orders the corps of military engineers, the corps of royal artillery, and the ordnance branch of the army and navy.

Under this last point of view, the Royal Arsenal of Artillery at Woolwich certainly was to me an object of particular attention. It contains a great number of machines very worthy of being studied. I shall content myself with speaking of the hydraulic saws and presses.

In the part of my work relating to the English artillery, I have described in detail the hydraulic presses of Pascal, brought into use by Bramah,* and particularly their application to the planing of timber. A horizontal wheel is armed with thirty-two googes equally spaced off, and with two planes situated at the extremities of a diameter of that wheel, which is turned, at pleasure, by a steam-engine. The piece of timber to be planed is moved in a straight line on a carriage, which is made to advance uniformly by the hydraulic power moved, in like manner, by the same steam-engine. If, then, the googe-wheel makes a whole revolution, the gouges will have traced on the timber thirty-two distinct grooves, comprised in a breadth of a third of an inch. Immediately after, the slight asperities that separate the grooves will be taken off by a stroke of the planes which follow the googes, by being placed nearer to the axis of the googe-wheel. In less than a minute the sides or cheeks of the largest ship-gun carriage are planed in this manner. A particular hydraulic press serves to raise more or less the vertical axle of the googe-wheel, in order to be able to plane pieces of timber of different thickness.

Mr. Brunel has established in this arsenal at Woolwich straight saws set in motion by the-steam engine, remarkable, first, from all their apparatus being almost composed of nothing but iron and brass; next, because the transmission and the suspension of the movements is effected with great precision and great simplicity: these saws work with extraordinary quickness, and the labour they perform is immense.

The Board of Ordnance paid Mr. Brunel liberally for this ap-

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whom shortly afterwards died. The explosion was like the shock of an earthquake; it demolished the wall of the dock-yard, part of which was thrown to the distance of 250 feet, an iron door, weighing 280 pounds, was driven to the distance of 230 feet, and other parts of the buildings were borne in the air upwards of 300 feet. The experiment was not repeated. TRANSLATOR.

* Pascal, in having solved the hydrostatic paradox, has certainly done much; but Bramah, in his ingenious application of Pascal's solution to mechanical purposes, has done still more. The former produced a very fine theory, which the latter applied in practice with the most consummate skill and judgment. This is an observation which, as a tribute to departed genius, should here have come from M. Dupin. TRANSLATOR.

plication of his ingenuity, and afterwards remunerated him beyond a fixed agreement, by granting him a pension for life. Shortly after having enjoyed this pension, Mr. Brunel was desirous of receiving its value in a gross sum, which was paid to him. I mention with pleasure this handsome manner of treating artists. Such facts form a better panegyric for a minister than the most refined compliments and the most pompous phrases.

It was at Woolwich that Dr. Hutton made his first experiments with the ballistic pendulum; they have been continued, on a much larger scale, by Dr. Gregory and Colonel Millar. The latter has invented a machine for cutting felloes, &c, which is a very ingenious contrivance. It is called a *Compass-saw*, as being applicable to all purposes of circular cutting, or any irregular sweeps.* In my work on artillery, I have given a description of the fine apparatus now employed for the ballistic experiments.

The Royal Military Academy for the education of Cadets for the Engineers and Artillery, established formerly within the inclosure of the Royal Arsenal of Artillery, is now separated from it, and occupies a spacious building on Woolwich Common. Were I to owe to Sir Joseph Banks, President of the Royal Society of London, nothing but the acquaintance and friendship of Colonel Mudge, Governor of this Academy, it would be enough to lay me under an eternal obligation to that Mœcenas of the sciences in Great Britain.

I am indebted to Colonel Mudge, as well as to the Professors and officers at Woolwich, for materials equally numerous and valuable, and I cannot too warmly express my gratitude for the handsome manner in which they exercised towards me their hospitable attentions.

In descending the Thames as far as the conflux of that river with the Medway, we arrive at the Isle of Sheppey. It is a vast marsh formed by the alluvions of the Medway, which divides itself into two branches in order to embrace it. At the north-west point of this island are the town and dock-yard of Sheerness. It was necessary to form with the hulks of old ships, sunk in the mud, an artificial soil, sufficiently solid to build thereon the edifices of this arsenal. The old buildings are small, mean, and falling to ruins; but the new structures possess much grandeur and beauty. Workmen are now employed in enlarging the arsenal at the expence of the river on one side, on the other at the expence

* This ingenious contrivance has never been described to the public. Its principal peculiarity consists in the application of a piston to the upper part of the saw, which at every stroke makes a vacuum, by which means the saw is kept tight, and what the workmen call *Buckling* is prevented. The machine does its work well, and cuts felloes at about *half* the price of the old mode, with the upright saw in the pit. TRANSLATOR.

of the town. They are also constructing dry docks for building or repairing ships of the largest class, as well as a spacious wet dock or basin, where several ships may lie afloat, and quays for inclosing the yard. For the exterior facing of all this masonry, no other materials are used but granite, which is brought from Cornwall and Scotland, that is, from the two extremities of Great Britain. The New Quay, bordering the Medway, has its foundation on piles driven to twenty feet and more below low-water mark. After the old ships and sand are excavated to the depth of thirty feet, the piles are driven into the sea-sand twenty feet deeper, at the distance of four feet between each pile, and the interstices are then filled up to the height of four feet with brick and rubble, on which the foundation stones are laid. To resist the swelling of the muddy, swampy ground of which the soil of the arsenal is composed, the back of the quay-wall is strengthened by hollow and semicircular counterforts, faced with brick-work in their circumference, and filled with lime-stone. For masts or spars intended for making them, workmen are also building locks, divided into several compartments, for the convenience of depositing the masts in tiers.

Steam-engines, diving-bells,* iron rail-ways, and all the means

* The diving-bell invented by Doctor Halley, was much improved by Mr. Spalding of Edmburgh; but the late Mr. Smeaton first put in practice what had long been proposed by other inventors to enable workmen to examine and repair foundations under water.

The bell, constructed by Mr. Smeaton, was made of cast iron, and of a sufficient weight to sink in water without any extra ballast. In the top were proper apertures for lenses for the admission of light, and also a strong shackle for the chain by which the bell was suspended. A strong leathern hose or pipe was connected with the top of the bell, to convey air into it from an air-pump placed either in a boat or on the shore. By means of this pump, the air is forced down in a continual stream into the bell, whence it escapes from beneath the lower edges of the bell, or from a waste-pipe, as fast as it is supplied; the air is thus kept very pure, and the people in the bell have no kind of trouble to obtain a supply.

A diving-bell of this kind has since been applied to the purpose of building foundations of masonry in deep water, under the direction of Mr. Rennie, who has constructed machinery to move the bell under water in any direction. This bell was used by that eminent engineer in building the foundation-walls of the piers of Howth harbour, near Dublin, and likewise the wharf-wall at the entrance of Sheerness harbour. It would require Plates to describe accurately the whole of this machinery; the principal part consists of two carriages, one of which contains the tackle that suspends the bell, and the other a similar tackle for lowering or hoisting the large stones to be used for building the wall. Each principal carriage runs on indented iron rail-ways, its four wheels being provided with cogs corresponding thereto: and each of these lower carriages has a smaller or upper carriage, running upon it in a transverse direction; the timber-frame of the principal carriage having also at the top an iron rail-way for the wheels of the upper carriage, which contains the windlass purchase and tackle, by which the bell or stone is raised. By means of this machinery, the two carriages can be moved in transverse directions, and the bell or the stone be suspended over any required spot in the wall, and lowered down thereon as the men in the bell direct.

TRANSLATOR.

of art are brought into use for executing these great works with as much economy as expedition. The construction of the new arsenal at Sheerness is, in my opinion, one of the enterprises which does most honour to the experience and the talents of Mr. John Rennie, inspector of the naval works of England. The execution of the plans of this celebrated engineer is skilfully conducted by Mr. Thomas, the resident engineer at Sheerness.

The Isle of Sheppey is, as I have said, nothing more than a vast marsh washed on all sides by salt water. There is not to be found on this island one single spring of fresh water. A few years ago, it was necessary to procure, from Chatham, water for the supply of the inhabitants and the garrison, as well as for the ships lying at the Nore, an anchorage situated on the right shore of the Thames, about three miles from Sheerness. In hopes of finding under the soil some spring of drinkable water, a well was sunk of the depth of three hundred and thirty feet. It was not before that depth was reached that the kind of water sought for was found. Then a very plentiful spring sent forth such a rush of water, that it filled the well to within about eight feet of the surface of the ground; afterwards the water sunk to about fifty feet below that level, and, when not much drawn from, stands nearly at that height, in a very considerable quantity. What is astonishing, considering the nature and the position of the Isle of Sheppey, is, that this water is perfectly pure, and does not contain in solution the smallest atom of marine salt. However, the well furnishes a sufficient supply for the consumption of the town, the dock-yard, and the shipping. Opposite to Sheerness, and on the other side of the Thames, which is several miles wide in this place, has been remarked a reciprocating spring, the risings and fallings of which are said to correspond with that of the new well at Sheerness. This interesting remark deserves to be confirmed by more precise observations.

I visited in the Medway, near the works of the arsenal, the famous ship, the *Bellerophon*, now transformed into a hulk for the reception of convicts sentenced to transportation, who, instead of being sent to Botany Bay, are kept to assist in carrying on these works. In the fitting up and the interior arrangement of this hulk, every thing that the most ingenious humanity can invent has been put in practice to render supportable and comfortable a floating prison.*

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* The words *comfortable* and *comforts* are among the number of the expressions which are wanting in the French language, although we have expressions derived from the same source, *conforter* and *reconforter*. *Comfortable* means both what is agreeable and useful, what removes every painful or repulsive sensation in the satisfying of our wants. *Comforts* are things which thus render our existence exempt from wants and unpleasant sensations. Accordingly, the English,

The convicts are lodged in separate births, where they mess. All these births have large port-holes, inclosed with iron bars or gratings, which permit the air to enter in sufficient quantity. The partitions of the births are formed by iron-railing, and, in several parts, this railing is covered by a canvas skreen, which, being rolled up at certain times of the day, admits to the births a still greater circulation of air.

Lastly, to each birth is adapted a privy, constructed without the side of the ship, and, nevertheless, built in such a manner as to prevent all chance of escape by that place. Let not these details shock our false delicacy: I appeal to those who have languished in prisons, to know what then renders our existence supportable or insupportable.

On Sundays and holidays all the convicts are assembled in a chapel, built near the step of the mizen-mast, where it occupies the height of two decks, by which means a gallery is formed.

In going up the Medway, from Sheerness to Chatham, that river is seen covered with men of war, dismantled and lying in ordinary. Their fresh and brilliant painting contrasts with the hideous aspect of the old and smoky hulks, which seem the remains of vessels blackened by a recent fire. It is in these floating tombs that are buried alive prisoners of war, Danes, Swedes, Frenchmen, Americans, no matter. They are lodged on the lower-deck, on the upper-deck, and even on the orlop-deck. In this last-mentioned place, these unfortunate beings breathe, during the day, only through scuttles about twice as broad as my hand, and, during the night, the air they inhale is never renewed by ventilation. Four hundred malefactors are the *maximum* of a ship appropriated to convicts. From eight to twelve hundred is the ordinary number of prisoners of war, heaped together in a prison-ship of the same rate. The British Parliament has enacted the quantity of cubic feet of air necessary to the health of the young apprentices assembled in the manufactories, purified by air-holes, where fresh air and light are admitted in abundance, and whence these young folks come out three times a day in full liberty. This quantity of air, supposed indispensable for children, is ten times more considerable than that granted, as if reluctantly, to adults, or men grown.

In showing the immense difference made in the ports of England between a convict and a disarmed enemy, I venture to assert, I have no idea of appearing a vain declaimer, nor of calumniating a foreign power, too long our rival, and now our

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who are a people eminently sensual, and who make the happiness of life consist in having their ease in all things, employ every moment the words *comforts* and *comfortable* to designate the whole of the things which they either possess or desire.

doubtful friend. Indeed, I have not been, nor never shall be, afraid of displeasing, or of offending our national prejudices, by rendering to the English government and people a sincere homage for their actions and their institutions, when favourable to humanity. But I shall be still less afraid of displeasing British pride, in proclaiming loudly truths calculated to wound it; and, perhaps, in the eyes of impartial judges, the sincerity of my commendations will gain credit for the only severe remark which I have been compelled to make, from a regard for my fellow-creatures, and for the honour of civilization.

In short, if there is a time when philanthropy may raise its voice against the gratuitous ferocity of any military institution, disparaging to the nation that renders itself guilty of such conduct, it is most certainly in the midst of peace, when men's minds are no longer bewildered by hatred, and when, in consequence of easy and daily communications re-established between two great people, each of them may, in a manner, be summoned, in the presence of attentive Europe, to the tribunal of opinion, excited by the other nation.*

The dock-yard of Chatham, situated, like that of Sheerness,

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* This *tirade* certainly comes with a bad grace from a French officer of a scientific corps, the professed object of whose visit to England was the improvement of an intended great work on *Naval Architecture*, and who, on that account, received extraordinary favours. The late war differed, in many respects, from all former wars, and among the *new* evils attending it was the long confinement of the prisoners taken on both sides. But if (as we have reason to believe) the government of France refused its assent to a regular exchange on a fair and equitable basis, is not that government fairly chargeable with the consequences? With regard to the treatment of the French prisoners in this country during the late war, we assert, from our own intimate knowledge and frequent observation, that they were well treated in every respect. Their provisions were good in quality, and their clothing sufficient; but, owing to their unconquerable propensity to gambling, many of them frequently deprived themselves of their due allowance both of food and raiment. As to fresh air, wind-sails were always pointed below, in the prison-ships, to promote its circulation; and medical attendance was always at hand for the sick.

The long duration of hostilities, combined with our resplendent naval victories, and our almost constant success by land, as well as by sea, increased their number so much as to render the confinement of a great proportion of them in prison-ships a matter of necessity rather than of choice, there being, in 1814, upwards of 70,000 French prisoners of war in this country. Among maritime nations, it is by no means an uncommon practice to deposit prisoners of war in these "floating prisons," where the sight of the green fields, and the variegated scenery of the surrounding country may, no doubt, occasion the loss of liberty to be felt more poignantly by persons in the enjoyment of health and vigour. But, how comes it that M. Dupin, from "his regard for his fellow-creatures, and for the honour of civilization," never suffers one expression of regret to escape him, in consequence of the bitter recollection of the sufferings of the poor unfortunate Italian and Spanish prisoners of war, who were compelled to labour, in chains, at the construction of the basins and docks at Cherbourg, for which labour they were neither paid, nor better fed than if they had remained inactive at the *Dépôt*? TRANSLATOR.

on the right-bank of the Medway, is more spacious than all those of which I have already spoken. In this yard more ships are built and repaired, and consequently there is more bustle. There, too, are deposited, in immense storehouses, and ranged with remarkable order, all the rigging and other articles of equipment for the dismantled men of war lying at moorings in the Medway.

The building-slips and dry-docks, still existing, are faced with wood, according to the old custom. Although they have not been rebuilt for upwards of forty years, this mode of construction has been so well executed originally, that it is still in good condition; whilst at Deptford, at Woolwich, and above all at Sheerness, the wood-work of the old slips and docks is, in general, in a state of decay, which forms a striking contrast to the sumptuous solidity of the new buildings.

At Chatham, people are now employed in excavating a dry-dock, which will be faced with granite and Portland-stone. This is the commencement of very extensive works undertaken during peace, in order to render the arsenal susceptible of more active operations in time of war.

What is most remarkable in Chatham dock-yard, is the saw-mill and its machinery, recently established by Mr. Brunel; this mill is built on an eminence at the farther end of the arsenal.

The mechanism of the saws is, with a few exceptions, the same as those at Woolwich. A steam-engine, of the power of thirty-two horses, here, in like manner, sets in motion all the operations of this mill. The saws are placed in a regular building, the interior frame of which, by a judicious combination of iron and wood, appears to me a model of its kind. This was also planned by Mr. Brunel.

But what characterizes this establishment and gives it an appearance which belongs to it alone, is the whole of the operations employed for raising the large balks of timber from the level of the water to the mill, and for removing them afterwards, whether to lower them again into the water, or to stow them in a long timber-birth, prepared for that purpose.

A tunnel, or subterraneous canal, serves for bringing the rough logs from a pond, where they are kept in reserve, to the bottom of a large circular basin, or reservoir. Arrived there, the logs are successively loaded on a platform, suspended to two iron chains. The chains pass to the top of the well through leading blocks, and go, with their other end, to hold in suspension an iron tank, capable of containing ten tons of water. This water, furnished by the recipient of the steam-engine, when it is admitted into the tank in sufficient quantity, overbalances the weight of the log of wood, which then rises of itself to the top of the reservoir. There, workmen hook it on to chains which hang

from the gibs, mounted on each side of a moveable carriage, the combination of which is complicated, but very ingenious.

This carriage, which is moved in a longitudinal direction by the action of the steam engine, can bring and carry back the logs from the reservoir to the workshop, and to the different parts of the timber-ground, which is nine hundred feet in length. One man, who accompanies the carriage, can at pleasure stop it, set it again in motion, turn the gibs in any direction required, present the logs of timber to the piles to which they belong, load and unload these logs, &c.

All these operations, which are performed with as much ease as precision, display the pliability and the fecundity of Mr. Brunel's talent for the invention of machines. But, as for the establishment of the reservoir, and the construction of the apparatus for hoisting up the logs and of its dependences, it must seem evident, after an attentive examination, that it would have been more simple and more economical to mine, blow up, and level the hill or eminence in which the reservoir is dug, and on which are established the timber-ground and the saw-mill. In this manner would have been saved all the power necessary for raising daily the timber to be sawed, as well as the coal and the water necessary for the steam-engine. This is the first objection that was mentioned to me by Dr. Wollaston, when I conversed with that celebrated man of science, on the subject of the sawing-machinery at Chatham; and that objection is worthy of so judicious a person.*

It was at Chatham that Mr. Seppings first put in practice the improvements which he suggested in the building of ships. In

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* It is not a little singular that M. Dupin, in his anxiety to impress his readers with an idea of his extraordinary share of knowledge as an engineer, should lose himself so much as to condemn Mr. Brunel for that which, in the opinion of every unbiassed person acquainted with the real state of the case, constitutes, in this instance, his greatest merit, namely, the judicious adaptation of his plan to the ground on which the saw-mill is situated. The hill was there, thirty-eight feet above the level of the Medway at high-water, and this was exactly the elevation wanted to enable Mr. Brunel to accomplish his object. Had Mr. Brunel blown up or levelled the hill, as here recommended by M. Dupin, he would thereby have lost the important advantage of the gentle descents by which he has been enabled to distribute the timber to its destination. As for the authority of Dr. Wollaston, valid as it is in general, here it has no weight; because an inspection of the plan of the works, which we have seen and carefully examined, would convince him, as it has ourselves, of his error, or, to speak more correctly, of that of M. Dupin.

This mill is supposed to be equal to the power of fifty saw-pits, and nearly a hundred sawyers, and is capable of supplying the dock-yards at Chatham and Sheerness with all the straight sawn timber that they can require. But the great advantage of the plan is, in the application of the steam-engine to the management and arrangement of timber, by which the labour and expence of a great number of horses are saved. The whole of these operations are conducted by ten or twelve men. TRANSLATOR.

order to attain that object, he had to triumph over those numerous and venerable axioms, consecrated by the pride of our ancestors, and preserved religiously by the self-love of their descendants—"That English men of war perform very well at sea, and last long enough such as they are at the present day; that it would be rash and unreasonable to introduce any innovation in so perfect an order of things, adopted by so many nations, and practised for such a length of time; and dwarfs, leaning on their little pillars of Hercules, exclaimed, that (*God be praised!*) the art had reached the happy period when not one step could now be made beyond the fixed limits." But Mr. Seppings is one of those tenacious men who listen to no arguments against their system. He had powerful friends out of the body of the master-shipwrights; and he obtained from authority what he could not obtain by persuasion, and rendered, as it were by force, to the English navy one of the most signal services that it has ever received.

I have endeavoured to make known, in France, the real advantages of the system introduced by Mr. Seppings. I met with more obstacles than he did, and, less fortunate, I have not yet triumphed over them. I have given demonstrations; but that was vain like the theory; calculations, and one would have thought that I was treating of imaginary quantities; in short, when I wished to support myself by the authority of experience, I was told that, in England, they were at present abandoning the system which I was desirous of getting adopted in France.*

I then went to England, and I saw, with my own eyes, in 1816, in 1817, and in 1818, that there were ships on the point of being finished, and built according to the system of Mr. Seppings. I saw others half-built and put together according to that system; in short, I saw in the arsenals of Great Britain old ships, originally built according to the old system, daily brought into the dry-docks, and thoroughly repaired agreeably to the system of Mr. Seppings.

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* All this was written towards the end of my second Excursion, when I was still in London. I found, on my return, men's minds infinitely brought back to the ideas which I had endeavoured to cause to be adopted. They acknowledged the falsehood of the assertion *that the English themselves were abandoning the pretended improvements of which I had become the apologist*. Then the question changed its aspect, and an examination was again entered into of the things themselves, at the same time stripping them of the favourable or unfavourable authority of example. I am convinced that an examination made by men equally eminent from their experience, their knowledge, and their regard for the public good, would bring into full view that which, in the new system, is essentially defective, in order to reject that part, and that which, on the contrary, is essentially advantageous in order to proclaim its utility, and introduce it in the French navy.

According to all these reasons which are the substance of what I have said and written, for upwards of two years, in France and in England, it will doubtless be imagined that Mr. Seppings and his partisans consider me as one of their proselytes, and rank me among their adepts; very far from that! For, while I admit the excellence of the improvements due to that skilful ship-builder, I maintain, with *the proofs in my hand*, that the principle of them has long been known and even practised among us and elsewhere; it is in vain for me to proclaim and defend the merit and the originality of that principle. On the other side of the water I am ranked among the detractors and the antagonists of the author.*

For several years past, the officers belonging to the dock-yard at Chatham have subscribed to form, at their expence, a school, where the young apprentices are received during the winter evenings. They are taught reading, writing, arithmetic, and even, as I understand, the first elements of geometry. They are admitted without any distinction and free of all expense, but dismissed on the first serious fault they commit, or merely if they cease to be punctual. I am fond of mentioning such institutions, because

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* If, *by the proofs in his hand*, M. Dupin means that either Bouguer, in his *Traité du Navire*, or Chapman, the Swede, in his *Architectura navalis mercatoria*, or any other foreign ship-builder, has made known, much less practised, the *new* principle of constructing ships of war, introduced into the British navy, by Mr. Seppings, why has not M. Dupin pointed out *when* and *where?* This we challenge him to do, and till he takes up the gauntlet, and establishes his assertions by positive proofs, what he says, in that respect, must be regarded as mere declamation.

The advantages derived from the employment of forces acting obliquely to each other are, as Mr. Seppings observes, well known to every carpenter, and M. Dupin too must know that the method is adopted in the construction of almost every wooden fabric in which stiffness or fixedness is required, such as a common gate for instance. Therefore, that principle is not *new*. But the substitution of the triangle for the rectangle in the internal framing of a ship of war comprehends the principle of the *new* system, the use and advantages of which, under the name of a *diagonal trussed frame*, are thus explained by Mr. Seppings.

"The arrangement of the materials in the triangular mode is such, that the pieces disposed horizontally, are acted upon as ropes are by a strain of the fibre; whilst the other parts composing a series of triangles, are pressed upon as pillars; in other words, the pressure acts in the direction of the fibres of the wood; whereas, upon the rectangular or old plan, the fibres are acted upon transversely, or across the grain, in the same manner as a stick is when placed across the knee, and pressed by the hands at each end, which first bends, and then breaks. To prevent any transverse action upon the fibre of the timber, is one of the benefits arising from the new system, and to impede a longitudinal extension of the structure is another. For, as the diagonal trussed frame, composed of a series of triangles, aided by diagonal trussing between the ports, prevents the fabric from being acted upon transversely to the fibres of the materials horizontally placed; so the wales, the planking, the shelf-pieces, the improved waterways, and the decks systematically secured, become the *tie-beams* of the structure. In a word, the system of triangles is so constructed, in conjunction with the planking of the ship, as conjointly to possess that property of a triangle already explained: viz. that its figure is as unalterable as the compression or extension of the fibre of the timber will admit it to be." TRANSLATOR.

they show what is in England the enlightened beneficence of the various classes of society.

It is at Chatham that the government has established, within these five or six years, a practical school for the corps of artificers of the engineers, that is, the sappers and miners. The instruction given in this school, and the operations and exercises of every kind to which the military artificers are thus habituated, appear to me very deserving of being known.

The dock-yard the nearest to Chatham, after all those of which I have just spoken, is that of Portsmouth. It is the most spacious of all, and the one which presents the handsomest buildings, and the most comprehensive display of work.

The dry docks are numerous, and they exhibit a skilful arrangement. Below the level of their bottom has been dug a reservoir sufficiently large to contain all the water which surrounds a ship when she is taken into the dock. By this means a ship may then be laid dry instantly, her repair proceeded on immediately, and the water, which has been turned off into the reservoir, pumped out at leisure. This water is raised by a chain-pump, the saucers of which are nearly two feet in diameter. The pump is worked by a steam-engine. General Bentham, to whom the British Navy owes several essential improvements, superintended the construction of the basin, of the dry docks which are connected with this basin, and of the reservoir for the water of these docks.

Portsmouth dock-yard is, in many respects, the general manufactory for the supply of the other naval arsenals. It is here that various objects of art are fabricated on a singular plan, in order to be distributed afterwards to all the places where they may be wanted.*

The block-machinery is what Portsmouth offers most interesting in this kind of general manufacturing.† This block-machinery,

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* Here are an iron-mill, a copper-mill, and a copper refinery, at which is remelted and rolled all the old copper taken from ships' bottoms; and here also are cast bolts, gudgeons, and various articles of copper used in the Navy. The number of sheets manufactured here in one year of the war amounted to about 300,000, weighing about 1,200 tons, on which it has been calculated that a saving of at least £20,000 was effected for the public. Most of these mills were constructed under the direction of General Bentham. TRANSLATOR.

† As every one who happens to inspect Portsmouth Dock-yard, makes a point of visiting the block-machinery, it may be a matter of some curiosity to know the result of this system. The whole of the machinery is put in motion by a steam-engine of thirty-two horses' power, which, however, is applied to a great variety of other purposes, wholly independent of that of making blocks. This is effected by means of straps passing over drum-heads, by which the several movements, numerous as they are, are carried on without the least noise. It has been found, by calculation, that *four* men with the machinery, as it now stands, can complete the shells of as many blocks as *fifty* men could do by the old method, and that *six* men will furnish as many sheaves as before required *sixty*, and that

with all the apparatus of which it is composed, is the creation of a Frenchman, whose establishments I have already thrice mentioned. In reflecting on these great services which he rendered, during the last war, to a people who then showed themselves our most mortal enemy, perhaps some offended Frenchman will regret that he has not consecrated his talents to the defence and the glory of his own country. But, without speaking of the misfortunes which forced so many friends of their country to fly from it in order to save their life, and which detained them in a foreign land long after the dangers of the storm, have we a right to address to the person whose talents we repulsed, (even now when they are expanded and shining in all their lustre) the reproach of having abandoned us when they were still unproductive! Two Archdukes of Austria and an Emperor of Russia have, since 1814, visited Great Britain. They made to Mr. Brunel the most tempting offers in order to induce him to carry to their states his industry and his experience; all these Mr. Brunel refused. Since 1814, he has twice attempted to consecrate his talents to France, and twice has France rejected his overtures.*

I return to the machines of this artist. Those which he employs for making blocks are all moved by the blind and constant action of steam, combined with the intermittent and accurate action of a workman. These machines, which are of brass and iron, occupy very little room, and are independent of each other; there is a great variety of them. They are described at great length in Rees's Cyclopædia. I hope to add to that description some interesting observations on the advantages and inconveniences peculiar to each machine, as well as on the results of its manner of working.†

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these *ten* men, in displacing the labour of *one hundred and ten* men, can furnish, in one year, from 130,000 to 140,000 blocks of different sorts and sizes, the total value of which cannot be less than £50,000, and this is stated to be the average number which has annually been made from the year 1808 to the conclusion of the war. To the completion of this ingenious machinery, Mr. Brunel gave his whole attention from September 1802 to June 1808, and the total amount he received for compensation, &c. was £20,000. From that time to the present, the block-machinery has been in full and constant employment, without requiring the least alteration and very little repair; and its advantages to the public service have been so great and so quickly felt, that the whole expence of the concern was cleared in four years. TRANSLATOR.

* It is but right to declare that this assertion of M. Dupin is incorrect. With respect to the offers of the Archdukes of Austria and of the Emperor of Russia, as none were made on the part of any one of them, so no refusal was given on the part of Mr. Brunel. The object of Mr. Brunel's visit to France, in 1817, was the construction of water-works, as a speculation imprudently entered into by British subjects, and the expences of which were to be almost entirely defrayed by British capital. TRANSLATOR.

† There is certainly no accounting for the vanity of some people. However, it must appear paradoxical to every unprejudiced mind, that the piercing eye of

The Royal Naval Academy or College, is placed in the arsenal at Portsmouth. In the summer, the pupils have a yacht for exercise, in which they are embarked on fixed days, in order to learn successively how to work a ship, and give the necessary orders.

Near the school for young midshipmen for the Royal Navy, is building in the dock-yard a handsome pavilion, in which is to be placed the new school for Naval Architects. A thing which will not easily be credited is, that, in certain respects, the English do not blush to acknowledge their inferiority, when it is clearly demonstrated to them. For many years past, they have been complaining loudly, and perhaps even not without exageration, that their ship-builders are very far behind the French naval architects, in regard to theoretical knowledge. These complaints reverberated to the Parliament of England; and it was at the suggestion of a Committee of this great legislative body, that the school for Shipwrights' apprentices has been established. I am persuaded that, in a few years, Great Britain will derive unexpected benefits from this establishment.*

At Gosport, a sort of suburb to Portsmouth, situated on the south shore at the entrance of the harbour, there is a good private Naval Academy, under the direction of Dr. Burney. This learned Professor has lately published a new edition of Falconer's Marine Dictionary. I found in this edition several interesting things respecting the most recent progress of the art in England. I have taken care to extract therefrom for my work every thing that appeared to me of real importance.

The Victualling-Office at Portsmouth is on a plan proportioned to the size of the port, and to the activity of the armaments during war. In the last war, the greater part of the fleets and con-

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M. Dupin should, almost at a glance, be able to discover advantages and inconveniences which would require the constant inspection of six weeks or two months by other persons, not altogether unacquainted with these subjects. In his intended great work on the operations in the ports of England, M. Dupin will probably condescend to explain, why Mr. Hubert has not yet been able to bring his block-machinery at Rochefort to greater perfection, even since he has had the eminent advantage of borrowing so many new ideas from M. Dupin's inspection of Mr. Brunel's machinery at Portsmouth. TRANSLATOR.

* The former part of M. Dupin's statement is correct, the latter is erroneous. the facts are as follow. The Commissioners for revising the civil affairs of the Navy, (in their Third Report, page 194,) in speaking of that mixture of theory and practice which enables us to build better than the French, observe, "Where we have built exactly after the form of the best French men of war that we have taken, thus adding our dexterity in building to their knowledge in theory, the ships it is generally allowed, have proved the best in our Navy."

In consequence of this suggestion, by the King's Order in Council, dated Sept. 20, 1809, a Superior Class of Shipwrights' apprentices has been established in the Royal Naval College in Portsmouth dock-yard. This is a judicious establishment, which is calculated to furnish our king's yards with master-shipwrights, who will combine a knowledge of the Theory with the Practice of ship-building. TRANSLATOR.

voys destined for great expeditions and long cruises, sailed from Portsmouth. From this port were also sent the supplies of military stores and provisions destined for Spain and Portugal.

Accordingly, the Victualling-Establishment at Portsmouth is the largest after that at Deptford, and the repository of the Ordnance Department there is, after the Central Military Arsenal at Woolwich, the most spacious, the best built, and the richest in *matériel* of every kind, as well in respect to artillery as to ordnance stores. There, all transportable articles are ranged in such order, and kept in such quantity in chests, casks, &c., that, in four and twenty hours, may be delivered and shipped the equipment of a great expedition. This prodigy was repeated more than once during the last war.

I was at Portsmouth when Admiral Lord Exmouth returned from his short, but brilliant expedition against Algiers. I visited two, among some others, of the ships of his squadron which bore the brunt of the battle, the Leander, armed with sixty guns and carronades, and the Queen Charlotte, a three decker, and the flag-ship of the Commander-in-chief. I could not behold, without admiration, the austere simplicity of the Admiral's cabin; furniture where nothing is for show, where every thing, without exception, can be removed, packed up, and carried away at the moment of clearing the ship for action; in short, the apartments are as fully provided with pieces of cannon as the rest of the gun-decks. Hence it may be imagined that the cabins of the captains and subordinate officers of the fleet are neither sumptuous, nor disposed in such a manner as to diminish the military means of the ship; and, nevertheless, the English men of war present every thing than can render pleasant and supportable the rough existence of the seamen.*

The last thing that remains for me to speak of at Portsmouth, is the Naval Hospital. It is the most spacious of all those established near the Arsenals. However, as for general arrangement and the salubrity which must thence result, I still prefer, I acknowledge, the Hospital at Plymouth. Nine pavilions, equally distant from each other, and distributed on the three sides of an immense rectangular court, contain the wards of this last-mentioned hospital. A piazza, supported by granite pillars, surrounds the three sides, in front of the pavilions. Lastly, in the interval which separates the insulated buildings, other buildings, smaller but similar to each other, and ranged in like manner

* The English seamen are as fond of the *comforts* of life, and, in many respects, they enjoy them, as well as the most opulent citizens. The well-being which they experience consoles them for the austerity of discipline, and they make no difficulty in remaining afloat for two or three successive years, without quitting the ship, in the most fatiguing voyages, and the most boisterous cruizes.

behind the piazza, comprise all the offices necessary for the service of the sick. A building, situated at a little distance from this spacious group, contains the necessary accommodations for those patients who may require tepid and vapour baths. The laundry and the drying-yards which it contains, also deserve to be noticed.

When Howard, that illustrious friend of humanity, visited, for the first time, the prisons and the hospitals of England, he had to draw a disgusting picture of the sad condition in which he found the greater part of those establishments; he had scarcely any fault to find with the hospital at Portsmouth, and still less with that at Plymouth. Thus, the Navy was beforehand with the rest of society, in the assistance and the relief invented by the most beneficent of the arts, the art of healing.

The dock-yard of Plymouth stands but in the second rank, in point of its extent, and the development of its habitual labours. Nevertheless, in no establishment of this kind, has art done more to conquer nature. It was necessary, in order to gain more room, to blast a part of a long hill of marble, the natural declivity of which extends almost to the sea-side. This work was continued, with unexampled perseverance, for upwards of fifty years. Plymouth contains the largest and deepest dock in England. Thither the Admiralty are obliged to send, to be repaired, the three deckers or other line-of-battle ships, which draw too much water to be docked at Portsmouth. In this latter port, it is intended to construct a dry or graving dock on the same scale, and possessing the same advantages as that at Plymouth. Nature has done every thing for the harbour and roadstead of Plymouth. The harbour, where are moored all the dismantled ships of war in ordinary, is a natural basin, the narrow entrance of which insures the smoothness of the water, and which, in a length of three or four miles by a considerable width, presents a sufficient depth for the anchorage of men of war of all rates.

Plymouth Sound, which is about three miles wide at its entrance, stretches to nearly the same extent, between two promontories, which, with the hills of Plymouth and Plymouth-dock, shelter it from all winds, except those from the offing. To stop the violence of the sea when these latter winds blow, a jetty or breakwater is now building with large blocks of marble. Mr. Rennie, who is charged with this work, has availed himself of all the experience which we have acquired at Cherbourg; and, as the local advantages are much more in his favour than they were in favour of our engineers, Mr. Rennie will obtain results more satisfactory in regard to the safety of the roadstead.*

* Is it not somewhat extraordinary that in all M. Dupin's tour, he scarcely sees any thing deserving of particular notice, without at once deciding that the

In my work on the Ports of England, I have described, with particular care, the series of labours necessary for extracting the materials from the quarry, for carrying them to the water side, shipping them, unshipping them, and putting them in place on the break-water. Since the period when I drew up that description, Mr. John Barrow, a literary character well known, and second Secretary to the Admiralty, has published a description of these same operations, in the Supplement to the *Encyclopædia Britannica*, a work to which some of the most celebrated writers of Great Britain contribute. The account written by Mr. Barrow is extremely interesting. It may easily be conceived that, with regard to the history of the operations, their expence, the motives of the enterprise, and the discussions which have exhibited these motives in their true light, a Secretary of the Admiralty could recur to sources of which I had not even an idea, and to which I could have no access. But, in general, with respect to the description of the operations, I find myself to agree with Mr. Barrow, and to be as complete as he is. I own that this conformity must give me some confidence in the fidelity of my descriptions, where I have not had occasion to enter the lists against so formidable a competitor.

There is one more naval establishment, still in its infancy, but which will some day become one of the most important in England; it is the dock-yard at Milford-Haven. The bay or haven of Milford is a natural basin far more spacious than Plymouth Sound, and better sheltered on all sides by high hills. It is situated towards the western point of the coast of South Wales. This port

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idea of it was either partly or wholly borrowed from Frenchmen? But, surely every one will admit, that there was no occasion for Mr. Rennie to avail himself of the experience so *dearly bought* from the *erroneous principles* adopted by the French engineers at Cherbourg, when he had the means of consulting the substantial authority of a skilful Englishman. We allude to the Memoirs of Sir Hugh Cholmley, who was sent by Charles II, in 1669, to construct the mole at Tangier, and who has therein minutely detailed the whole of his proceedings. As well might M. Dupin affirm that it was from the experience of a Frenchman, that Nebuchadnezzar was enabled to erect the first mole, built at ancient Tyre, when the name of France did not exist. But, not to go back to antiquity so very remote, have we not the celebrated mole at Istria, mentioned by Pliny, besides the mole at Genoa, and several others in the different ports of the Mediteranean, to furnish us with experience, without recurring to the *jettée manquée de Cherbourg?* As for "the local advantages in favour of Mr. Rennie," as above stated by M. Dupin, it remains for him to explain his meaning. To every person who reflects on the subject, it must be evident, that in a roadstead, exposed, like that of Plymouth Sound, to the tremendously heavy seas which come rolling in during the gales of wind from the S. W. to the S. E., no breakwater could resist their force and impetuosity, unless it was constructed on the soundest principles. Therefore, we recommend M. Dupin, in his intended great work, to correct his expression, and state the plain fact, that the *satisfactory results* will be obtained, not from the local advantages, but from the sound principles conjointly acted on by Mr. Rennie and Mr. Whidbey, in the construction of the Breakwater at Plymouth. TRANSLATOR.

is destined solely for building new ships; there will be constructed twelve building-slips, and all the work-shops and storehouses necessary for the labours which such a project implies. The first ships built at Milford were under the direction of a French ship-builder, much esteemed in England, M. Barailler the elder.

Such are the establishments of the military marine, or Navy. In visiting them, I was every where struck by the order that reigns in the arrangement of the different articles of stores, as well as by the silent activity with which all the individuals employed seem to be animated. Every where are seen the signs and the effects of economy; *but of economy well understood, which knows how to make sacrifices bordering almost on prodigality, in order to reap afterwards with usury the fruits of its advances.* Nevertheless, such a degree of perfection is not the result of a great many years; it may be dated no farther back than the last war. In the midst of danger, and in the embarrassments of a convulsive activity, some determined characters contrived to vanquish all obstacles, triumph over prejudices, and give birth to an order of things which might be considered as the result of long and peaceful meditations. This example shows us how little time suffices for authority to work miracles, when, by chance, it falls into the hands of superior men.*

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* In these observations M. Dupin is perfectly correct. Nevertheless, without depreciating the merit of any persons concerned either in the direction or the execution of the earlier measures tending to so desirable an object, it should seem that they were afraid of doing too much good in a little time. Fortunately for the interests of the country, their successors have advanced with bolder steps in this laudable career, as will be seen by a brief detail of the principal results. What must be acknowledged of paramount importance are the very considerable improvements that have been introduced, within the last eight years, in the combination of the materials which compose the fabric of our ships of war, as it regards their strength, their safety, and their durability. In all these respects, the new mode of construction is decidedly superior, and promises great advantages to the country. The system of building after a selection of ships of the most approved qualities and dimensions, and the reduction of them to as few Classes as possible, is also a judicious measure, which will prevent many inconveniences before experienced in our Navy. The introduction of machinery into our Naval Arsenals, the principle of working the people by a given rate for a stated quantity of work, and likewise the introduction of one uniform system of management in all the King's Yards, the regulations of which were formerly as dissimilar in some respects as can well be imagined, are great and beneficial points gained to the State, in the prevention of frauds, in the saving of labour and materials, and in securing better workmanship in the construction of our men of war. Nor should the roofing of the various dry-docks and building-slips pass unnoticed; for, though such has long been the practice among some of the foreign maritime powers, it is only of late years that roofs have been erected in the Royal Dock-yards of Great Britain. These noble fabrics will, no doubt, prove extremely beneficial in preserving our ships of war from premature decay, and the health of our artificers, employed under them, from the injurious effects of inclement weather. The judicious arrangement of the ships in ordinary, is likewise a matter of considerable importance, and the new regulations by which they have, of late, been governed, must tend to preserve our dismantled fleet, in a state fit

The commercial ports cannot inspire the same kind of interest as the great naval ports; ship-building, there, is not pursued on so large a scale, nor has it the same means. But they are not, on that account, the less deserving of close examination. It is in the ports of trade that are formed the first elements of maritime power; there it is that the State finds, when wanted, sailors, shipwrights, and naval stores of every kind. The strength of the naval ports is singularly expensive, and that of the commercial ports essentially productive. In short, in Great Britain, these latter ports are, above all, worthy of being studied, because their prosperity is entirely owing to the perseverance, the boldness, and activity of the inhabitants. Jealous to excess of their independence, it would be sufficient for the government to wish to intermeddle in the administration or direction of any mercantile enterprise, or of the construction of any work, for all the individuals concerned to withdraw therefrom their shares instantly.

Bristol and Liverpool, after London (as I have already said) the two largest commercial ports in England, are situated on the western coast. Bristol stretches far inland, at the conflux of the river Avon and the little river Froom, near twenty miles from the mouth of the former. Ships go up with the flood and drop down with the ebb tide. Beginning from the conflux of the Froom and the Avon, in following the respective directions of their bed, there have been formed two wet-docks, or basins for keeping ships afloat, which are both wide and deep, and of a great length, especially the last. Regulating-locks keep the water of these docks to the height of high-water mark of spring tides. To facilitate the habitual flow of the waters of the Avon, there has also been dug a lateral canal, which takes its rise above the basins, and rejoins the old bed of the river below these wet-docks. This last-mentioned work was executed between the years 1805 and 1809. Between the river and the two long basins is a very spacious dock where ships are daily taken in, partly unloaded if they draw too much water to go into the basins, and completed in their lading if they must be brought to a draught of water that surpasses a certain limit. I was witness to the cleansing of this dock, an operation which was performed with as much economy as expedition. Twelve stone bridges and four

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for service, whenever wanted. In a word, the important changes which have taken place in the construction and preservation of our national bulwarks, and the no less important improvements which have been introduced into all our Royal Arsenals, as well as the enlargement of those of Chatham and Sheerness, together with the construction of the Breakwater at Plymouth, and the other works connected with that great undertaking, are measures worthy of a great nation, and do honour to the government which has carried them into execution. TRANSLATOR.

wooden bridges are thrown across the basins and streams of water which traverse Bristol. There are on the canals and along the quays iron draw-bridges and cranes, which are remarkable for their strength and easy working.*

Numbers of ship-yards, graving-docks, and building-slips are spread on the banks of the wet-docks, near the side of the river. In fine, Bristol contains a variety of manufactories of different kinds. It is an individual of Bristol, Mr. Wellington, who has invented a very simple manner of covering buildings with removeable plates of wrought iron. I remarked in Woolwich dock-yard a building-slip covered with a similar shed or roof.†

Liverpool, the commerce of which is much less ancient than that of Bristol, has risen much higher in wealth and industry; it has got hold of the greater part of the trade of this rival city. No where has prosperity shown itself under a more astonishing aspect; forty years ago only, the trade of Liverpool was estimated but at the forty-second part of the total commerce of England, of which that town is now reckoned to have a sixth part. It has, therefore, prospered seven times more than the mass of a people who astonish us by the extent and the rapidity of their general advancement. If we seek for the cause of this unexampled improvement, we shall find it in the situation of Liver-

* The great facilities and advantages arising to the trade of the port of London, from the recent construction of spacious docks, quays, and warehouses, near the side of the Thames, were speedily sought by the merchants and shipowners of Bristol, and on a plan suited to the importance of the object. Accordingly, in the year 1803, an Act of Parliament was obtained by the Bristol Dock-company for converting about seventy acres of the old and crooked course of the Avon into large docks for ships to lie afloat, and for cutting a new channel for the river. By this plan, much labour and expence of excavation was saved, and these new docks were thus formed out of the bed of the Avon. Here, ships of considerable burthen are inclosed with a sufficient depth of water, confined within flood-gates, to keep them afloat, and are brought to the quays to take in or discharge their cargo with the greatest ease and convenience, and without hazard or loss of time; the quays affording a sufficient extent of ground for the reception of goods imported from most parts of the world. In May, 1804, these works, were commenced under the late Mr. W. Jessop, and completed in about six years. Their construction does infinite credit to all the parties concerned, as one of the greatest improvements of the kind that could have been devised for the port of Bristol. TRANSLATOR.

† The roofs recently built over the docks and slips in the King's yards, are constructed so as to be capable of having the sides and ends occasionally closed according to the quarter for which the wind may blow; and, by this contrivance, the timbers, composing a ship's frame, are prevented from being, at different times, swelled and soaked by rain, shrunk by heat, or rifted by the wind or frost; while the health of the shipwright is preserved from injury, and his work proceeds without interruption. The light is admitted through numerous windows placed in the roof, which is supported by a row of wooden pillars, and covered with plates of iron, slate, or shingle. There is one lately built over the Prince Regent at Chatham; its span is 100 feet, and the extreme width 150 feet, supported on the principle of trussing, without a single beam. These immense roofs, constructed after a plan of Mr. Seppings, cost each something more than 7000l. TRANSLATOR.

pool, at the outlet of innumerable canals, which traverse the most industrious and most active manufacturing districts of England. It is, therefore, to Liverpool, that in bringing their produce, they come in quest of other raw materials besides those which are indigenous. At Liverpool was constructed the first dock seen in Great Britain for keeping merchant-ships afloat. At this day the Liverpool docks, taken together, cover a superficies of about forty acres, extending from a mile and a half to two miles along the shore of the Mersey.†

The most spacious and the finest docks are either just finished, or are still advancing towards completion. The extreme distress of British commerce in 1818, did not put a stop to these works. They even resumed fresh vigour by a considerable subscription, which was raised and employed to set the poor to work on the new docks in the winter from 1816 to 1817.

In examining the different docks, the construction more or less recent of their quays and their gates, as well as of their draw or swing bridges, it is easy to discern the progress of art. I have applied myself to make known in what consist the improvements successively introduced in these different works.

It may readily be conceived that a sea-port as large and as full of trade as Liverpool requires spacious dock-yards, and numerous slips and docks for building and repairing ships, together with work-shops of every kind, relative to the maritime arts, &c. I carefully visited the most interesting among them, and I made a point of remarking what they offer different from our establishments of a similar description.

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† The docks at Liverpool were the first of the kind that were constructed in this kingdom, by virtue of an Act of Parliament passed in 1708; and from that period the town of Liverpool has rapidly raised itself from a poor fishing village, and a port for coasting vessels, to be the *second* commercial town and port in the empire, and the plan of improvements now carrying into execution for the enlargement of the docks, will, when completed, render it the very first, London even not excepted. These docks not only produce to the town and corporation of Liverpool a large revenue, but insure to the merchants every possible facility in refitting, loading, and unloading their ships, without being exposed to the unavoidable risks, losses, delays, and inconveniences attendant on those operations in a rapid tide-river. In the ten years ending with 1808, the number of ships that entered the docks at Liverpool was 48,497, tonnage 4,954,204. In the ten years ending in 1818, the number increased to 60,200, tonnage 6,375,600.

TRANSLATOR.

EXCURSION

TO THE PORTS OF

ENGLAND, SCOTLAND, AND IRELAND,

IN 1817 AND 1818.

In my first excursion to England, I had visited the six ports belonging to the State, and the three most considerable ports of commerce. I had taken particular care, not only to collect numerous materials, but to form in my own mind a precise idea of the value of those materials. However, I did not disguise from myself, that in embracing so wide a field, I could not, in a short space of time, submit to close examination and profound criticism both the facts and the ideas of which I had formed a collection. When one sees a great deal and in quick succession, it is impossible not to be deceived respecting several objects, and the wise maxim, "*errare et humanum est*," has always inspired me with a salutary doubt respecting the results of my observations.

On my return, when I wished to re-assemble by a rational connexion the scattered fragments which I had collected, without any other order than that of opportunities and times, the concordance of analogous objects, or their disparity, served me as a fair criterion to judge of the value of the *data* in my possession. This is not all; in several places, it was not in my power to continue this connexion for want of essential materials; of these I made a memorandum in order to make them the object of my subsequent researches.

I therefore returned to England to clear up my doubts on such of my observations as could not stand the test of a severe analysis, and to acquire the information which had escaped me, or which I had not been able to collect in my first excursion. I had submitted to two of the most eminent engineers of Great Britain, Messrs. Rennie and Telford, the description which I had given of several works of the first order, executed on their plans. Notwithstanding the multiplicity and the importance of their occupations, those two excellent men had the complaisance to read my papers attentively, and to point out to me in detail, either the additions or the corrections which it was indispensable to make in my work. I consulted in like manner other skilful men, in order to acquire, in the particular branches to which they applied their talents, the information I wanted. But I did not confine my views to the correction of the descriptions of my first

excursion. I determined to travel along the coast of England, setting out from the place where I had stopped, and likewise to visit the shores of Scotland and Ireland. Of this part of my labour I shall now give an account.

An operation of which I had ardently wished to be a spectator, but which had not taken place during my first stay in England, was the launching of a man of war. I had this time an opportunity of seeing one of these ships launched from the dock-yard at Deptford. I particularly remarked, as an innovation equally safe and economical, the substitution of short chains of wrought iron for those ropes which are employed to retain the ship on her cradle.

At Woolwich, Mr. P. Barlow, Professor belonging to the Royal Military Academy, was so obliging as to repeat before me his principal experiments on the strength of timber. These experiments come in support of mine, and confirm the theory which I have given in a Memoir approved by the Institute of France, and published in the *Journal de l'Ecole Polytechnique*, tome xiv. année 1814.

The Royal Society of London, by a favour too little merited on my part, has published in the first part of the *Philosophical Transactions for* 1817, the theoretical, practical, and historical researches which I have made on the improvements recently introduced in the construction of English ships of war. The honour of the first idea of these improvements has thus, in an authentic manner, been rendered to France.* But France has

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* M. Dupin will perhaps pride himself less on the publication of his Memoir above-mentioned in the *Philosophical Transactions*, when he finds few persons to disagree with him in thinking "the favour too little merited on his part." If in every thing he has advanced on this particular subject, he was equally correct, we should have nothing more to offer. Impartiality seems to have claimed that this Memoir, having appeared where it has, should have been followed by the observations of Mr. Seppings. As it is, we deny that the honour of the first idea of Mr. Seppings's improvements has at all been rendered to France, much less in an authentic manner. For, what M. Dupin has therein brought forward is quite sufficient to prove that none of the French ship-builders whom he quotes, have either made known or practised the mode of constructing ships of war with a *diagonal trussed frame*, like that introduced by Mr. Seppings, and now generally practised in the British navy. M. Dupin says, "About the middle of last century, Duhamel proposed to cross the ceiling or inner-planking of our ships of war by oblique iron riders. In 1755, Cauchot renewed the idea of substituting oblique riders to common riders placed in the ordinary manner. Groignard, more celebrated as a ship-builder, proposed for the greater security of the bow only a system of planking, framing, and lining, which presents parallelograms strengthened by diagonals. In 1772, Clairon des Lauriers put this idea in practice, in the construction of the *Oiseau* frigate. Bouguer placed in the direction of the diagonal, which tends to elongate, iron bars strongly united by their extremities to the keelson and under the orlop-deck. These bars resemble *ties* in common buildings. Chapman, the Swedish ship-builder, has, on the contrary, placed, according to the direction of the second diagonals, which tend to contract, pieces of timber well fastened on the keelson, and under the

yet to receive the benefit of those improvements ; while our rivals, more confined in their views, and more bold in their essays, are advancing rapidly in this new career.

As soon as I had visited in London, and in the environs, what I had to see or to see again, and collected the letters of introduction which were necessary for my purpose, I followed, towards the north, the east coast of England. But I first visited Cambridge, as one of the great repositories of knowledge and of the study of the natural sciences in Great Britain. I there had the pleasure to become acquainted with Mr. Woodhouse, one of the most able mathematicians in England, and author of a very good work, entitled "*The Principles of Analytical Calculation.*" In one of the libraries at Cambridge is a collection of fifteen manuscript volumes, digested in the reign of Charles II. by Samuel Pepys, formerly Secretary to the Admiralty, in his time, one of the most distinguished Members of the Royal Society of London. These manuscripts, all relative to the navy, are doubly interesting when considered in a historical point of view, and in connexion with the progress of art.

From Cambridge, I went to Kingston-upon-Hull. This town, which is commonly called Hull, is at this day the fourth commercial port in England. The whale-fishery,* the navigation of the oceanic coasts of Holland, France, and Spain, the Baltic and Mediterranean trade, &c. are the principal sources of the wealth of Hull. Two spacious wet-docks became insufficient, and the merchants were going to construct a third, which, when

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orlop-deck. These pieces of timber, which resist by opposing all compression, perform the office of *abutments*."

It will at once be perceived by all that M. Dupin has here advanced, that a *diagonal trussed frame*, on the plan introduced by Mr. Seppings, had never entered into the contemplation of any of these French ship-builders, or of the ingenious Swede. Consequently, the introduction of *trussing* into the fabric of a ship, and omitting at the same time the *whole of the ceiling or inner-planking, together with the perpendicular riders, breast-hooks, crutches*, &c. cannot be considered as an imitation of their feeble attempts at improvement; but must be admitted as a *new* system of construction *originating in England;* and the more especially, as this trussing must be introduced in the way now practised in our King's yards, namely, by a *diagonal framing*, thereby obtaining a square or right-angled abutment for the trusses. Hence a continuity of uniform support is afforded from one extremity of the ship to the other, which not only resists an alteration of position in a longitudinal direction, but opposes external pressure, whether from grounding or any other cause, as no alteration can take place without forcing the several parts of which this frame is composed into a less space. TRANSLATOR.

* The town of Hull had the honour to give birth to that hazardous, but profitable branch of trade in this country. As far back as the year 1598, (being only forty-five years after the discovery of Greenland by Sir Hugh Willoughby,) the merchants of Hull fitted out some ships for the whale-fishery, and were the first who attempted that enterprising traffic. As Hull was the first to engage in the attempt of catching whales, so it still continues to employ more ships in that trade than any other port in England, except London. TRANSLATOR.

joined to the two others by locks, would have formed round the old town an inclosure of floating ships; but the peace of 1814 occurred. Then, the commerce of England, finding again rivals in all the nations to which the seas were re-opened, that commerce declined all on a sudden; therefore, every project of enlargement in the sea-ports was abandoned. However, in 1817, scarcely had some gleams of increasing prosperity revived hopes of better times, when the inhabitants of Hull, without waiting for the effects of that prosperity, resumed with ardour the execution of their projects for the improvement and enlargement of their maritime establishments.

From Hull, I repaired to Sunderland, in order to examine there a cast-iron bridge, of a single arch, thrown between the two banks of the river Wear. This celebrated bridge is of sufficient height for the ships belonging to the port of four or five hundred tons to pass under it with their topsails set. It was asserted, that this bridge showed symptoms of twisting or giving way, and that, from the unavoidable effect of the expansion of the iron in summer, which widens the spandrils, and from its contraction in winter, this will end by detaching the foot of the iron arches from their abutments. Then, the bridge would fall into the river, as, from another cause, that did which had been thrown across the Thames at Staines. This objection made against large arches of iron, is, as I took pains to satisfy myself, destitute of foundation in regard to the bridge at Sunderland.

The yards for ship-building, which are extremely numerous, the form and construction of the keels or barges, of the iron rail-ways, of the wharfs and places for the shipping of coal, the coal-mines even, the glass-houses, and the lime-kilns; every thing on the banks of the river Wear which runs to Sunderland, excites the greatest interest, and deserves a most attentive examination. As much may be said of North and South Shields, and of Newcastle, towns situated on the banks of the river Tyne.

It is most assuredly an admirable thing to behold, on an extent of coast which a pedestrian may travel over in three or four hours, two rivers discharging themselves into the sea, which rivers, on an average, annually receive sixteen thousand ships, and send them back laden with the produce of their shores.* I saw, for the first time, at Newcastle, mills for spinning flax, worked by the steam-engine. This flax-yarn is afterwards employed in the manufacture of coarse household linen and sail-cloth. I also visited at Newcastle a tower about one hundred and twenty feet in height, built for a shot-manufactory. In

* On the river Tyne, there are no less than thirty-five sorts of coals, or rather the produce of as many pits, usually shipped from this river to London, amounting to 700,000 chaldrons in a year. TRANSLATOR.

making the melted lead run, from the top of the tower, through an iron sieve, it falls to the bottom into a large vat full of water, and striking this water with great force, that shock increases its density. I saw similar towers at Chester and at London, on the Surry side of the Thames.

On the banks of the river Tyne, at some distance from Newcastle, I visited a very fine machine for making paper of an indefinite length. Every thing is put in motion by the steam-engine; at the top of the building, the rags are thrown under cutters, by which they are shred into exceedingly fine filaments, and, passing from trough to trough in successive gradation, they are macerated and reduced to pulp of a very liquid nature, which is then received in a large vat, where it is continually stirred by instruments, called hogs. From this vat it is turned off into a trough at the head of a machine that spreads it upon an endless wire-cloth, from which it is taken by cylinders covered with felt, which compress it, dry it, and give it consistency; and, after passing between two metal cylinders, the paper is then wound on reels, on which it is cut into sheets of any required length. M. Didot, the brother of one of our celebrated printers, is the inventor of this beautiful machine. By what fatality does it occur that our most ingenious mechanics thus carry to a foreign country the treasure of their industry?*

Not far from this paper-mill, is a manufactory less interesting in itself, perhaps, but which was much more so to me; it was a manufactory of mineral tar. The rough materials of this tar, extracted, as is well known, by sublimation, pass into casks which have pretty much the appearance of Wolf's grand apparatus. Afterwards these materials are distilled in a great alembic, in order to separate therefrom the oleaginous part, by means of a gentle heat. This oil serves for many purposes. As for the tar, it remains pure and limpid at the bottom of the alembic. The smoke that evaporates by sublimation, in coming out of the furnaces, is conducted by tubes through a great many compartments which present, as a whole, a superficies exceedingly extensive. This smoke deposits on these partitions a very fine lamp-black, which is remarkably light. This is a product very indifferent in appearance, but which, nevertheless, yields a very lucrative profit,

* Most probably, because their industry meets with so little encouragement at home, as to render it an unproductive treasure. The first idea of this curious machine came from France, but it has been brought to its present state of perfection in England, as may be ascertained by the specification of the different patents successively taken out for improvements made on it by various persons. Nevertheless, it is justly considered as one of the most important inventions which has been applied to the manufacture of paper, since the fourteenth century, when the method was first discovered of making that article from linen.

TRANSLATOR.

from the immense consumption that is made of it in Great Britain and in foreign countries.

When I was at Newcastle, I was shown a very handsome silver-gilt service of plate, intended, by the proprietors of the coal-mines, as a tribute of their gratitude to Sir Humphrey Davy, for his safety-lamp, of which I saw a trial made in the mines. Since that period, when Sir Humphrey Davy passed through Newcastle, a committee presided by Mr. Lambton, a Member of Parliament, and consisting of the owners of mines, as well as of all the most distinguished persons in the County, at a sumptuous entertainment, presented publicly to Sir Humphrey the present which they intended for him, and, through the free channel of the public papers, the particulars of this entertainment were known to all England. It is thus that, in granting to the beneficent labours of genius noble and public rewards, a people proclaim both their talent and their virtue, and deserve that new discoveries should increase their industry, wealth, power, and glory.*

After having quitted Newcastle, in order to repair to Edinburgh, I went to Berwick, where a long pier or jetty is now building, with a view to diminish the bad effects of a growing bar at the mouth of the Tweed. Over this river is an iron-chain bridge, constructed, I believe, from a plan of Mr. Telford, the engineer.

Edinburgh and Leith, which is its sea-port, offer a crowd of important objects in the sciences, in literature, and in the arts. Edinburgh is the Athens of the north, and the Scotch people join the urbanity of the Greeks to the hospitality of the Arabs. It is a literary phenomenon extremely remarkable, and very worthy of the attention of philosophers, to see at the most remote extremity of a great empire, and almost under the frigid zone, a city, ceasing to be capital, abandoned to its own resources, rise through the genius of its inhabitants, seize the sceptre of history and of political economy, produce talents of the first order in mineralogy, chemistry, and in medical and chirurgical science; and, not content with having so many claims for receiving from other nations the palm of celebrity, erecting in its own bosom a literary tribunal which makes despotism turn pale, and the decrees of which suffice to exalt or to overthrow many an European reputation. I return to my subject.

In Leith harbour, basins or wet-docks, graving docks, and store-houses, &c. are either already constructed, or in progress. These works are more remarkable for their perfect execution than

* It is strange that M. Dupin should construe a subscription entered into by private individuals into a national reward granted or paid by the public.
TRANSLATOR.

for their size, at the point where they are now intended to stop. If the projects were realized which had been formed a few years ago, that is to say, at the moment when British commerce was at the height of its prosperity, there would be added to the basins or wet-docks already made, or nearly completed, a new basin still larger, and the entrance of which opening into a part of the Firth of Forth, deep, and without a bar, will permit ships of considerable burthen to come into the harbour, even at low water. I am persuaded that the Scotch will scarcely have ceased to dread the stagnation of their commercial prosperity, before they will resume their projects of enlarging the accommodations of the port, and pursue them, in spite of all obstacles, with that perseverance which is their characteristic.

Mr. Jardine, a very skilful civil engineer, who displayed extreme liberality in his communications with me, conducted me to the yard of a merchant ship-builder at Leith, in order to show me the application of iron-ways in the launching of vessels. The ground-way is an inclined plane, and laid according to the greatest declivity of the slip. The cradle is a large carriage on small rollers; it serves equally for launching ships into the sea, and for heaving them up again on the slip. This last operation, which is the only one attended with trouble, may be performed by five or six men, for a vessel of two or three hundred tons.

I visited a very fine steam-boat, intended for towing vessels from Leith to the mouth of the Great Canal that opens into the Clyde, near Glasgow. It since appears that this operation, which had not then been attempted, was perfectly successful. I crossed the Firth of Forth, and visited the little harbour of Kirkaldy. Not far from there, is the fine estate of Raith, the owner of which, Mr. Ferguson, possesses a magnificent cabinet of mineralogy. On quitting Raith, I gained the banks of the Tay, which I crossed in order to repair to Dundee, where a new harbour is making, partly excavated from the rock. Mr. Logan, the engineer, who conducts these works, and who was also employed in the constuction of the light-house on the Bell Rock, communicated to me his plans and all the practical knowledge that he possesses, with a liberality which I cannot acknowledge without bestowing on him all the praise he merits.

From Dundee I went to Abroath, which is opposite to the new and celebrated light-house on the Bell Rock. Contrary winds, and the roughness of the sea, did not permit me to go immediately to the rock on which this light-house is erected, twelve miles in the offing. I slept two nights at a farm-house, near the sea-shore, observing each night the intense brightness of the lights on the rock, and the perfect distinction of their colours, alternately white and red. I was taken to the Bell Rock, in the

vessel belonging to the Commissioners of the Northern Light-houses. I studied the structure of this light-house, the work of Mr. Rennie, executed under the care and immediate direction of Mr. Stevenson. I particularly remarked the mechanism of the lamps, and the disposition of the glasses which produce the coloured lights. The keepers of the light-house have a library, not very extensive, indeed, but composed of sound books on literature, moral philosophy, and the natural sciences: they subscribe to one of the monthly journals, which treat of those subjects. Simple occupations thus beguile the leisure of solitude, in the middle of the sea, by striving to follow the progress of reason and of the human understanding. It is by many a local observation of this nature that I have been enabled to convince myself of the general knowledge and information possessed by the Scotch people.

The keepers of the light-house have a register, in which they request the persons who visit this rock to inscribe their names, and to add a few lines containing the expression of their ideas on the subject of this fine building. I found nothing remarkable in this singular album, but an impromptu of six lines, by Walter Scott, written when he visited the Bell-Rock light-house. Walter Scott, as every one knows, is the modern bard of Caledonia, and the most beautiful sites in that picturesque country owe to his genius a celebrity which they never would have obtained from their own chastened or wild grandeur. Here are Scott's verses, of which I was allowed to take a copy.

"Far in the bosom of the deep,
O'er the wild shelves my watch I keep.
A ruddy gem of changeful light,
Bound on the dusky brow of night,
The seaman bids, my lustre hails,
And scorns to strike his timorous sails."

Let me here offer a very free imitation of the above verses.

Au milieu des déserts de l'immense océan,
De perfides écueils formant sa large base,
Le phare, dans les cieux au loin resplendissant
Comme un astre immobile et qui change de phase,
Apparaît, disparaît, reparaît tour à tour;
Variant ses clartés comme l'astre du jour,
Tantôt verse à longs flots sa lumière argentine,
Puis de l'aurore il prend le teint purpurine.
Protégé par ces feux, l'heureux navigateur,
Se jouant des périls que recèlent les ondes,
Vient raser les écueils, et même sans terreur,
Au lieu de s'éloigner vers les plaines profondes,
Cinglant à pleine voile au milieu de la nuit,
Des brisans sur les rocs, il entend le long bruit.

In continuing my journey towards the North, I visited the ports of Montrose, Stone-haven, and Aberdeen.

Immense works have been begun to render Aberdeen a great commercial port, and fine piers have been constructed at its entrance. The river Dee, forced to accelerate its course between these artificial mounds, has almost washed away the bar, which, within less than twenty years, scarcely allowed any but fishing-craft to enter the harbour of Aberdeen. The wet-docks, or basins for keeping vessels afloat, projected in the inside of the harbour, are abandoned, because the company which had undertaken them, is not rich enough to complete them.

When I passed through Aberdeen, I there met with Dr. Olinthus Gregory, who was returning from the Islands of Shetland, where he had been to join M. Biot and Captain Colby, in order to continue the triangulation of Great Britain, and to prolong to that point towards the North, the measure of the meridian, extended by the French as far as the Balearic Islands towards the South.* Dr. Gregory showed me at the University an observatory, rich enough in instruments; and, if I mistake not, poor enough in observations. Another thing interested me much more, because it shows a natural talent and calling for the sciences; the Doctor also took me to the abode of a currier and last-maker, who, in the leisure left him by his humble trade, makes barometers, thermometers, and large reflecting telescopes, which appeared to me very perfect; he can, at pleasure, mount them on the outside of the roof of his dwelling, on the platform of a small shed, which one reaches by a trap-door. There, he exhibits to the curious the sun and the moon, as well as in an observatory of the first order. But it may be conceived that on

* This is not an accurate statement. The specific objects of this joint expedition to the Shetland Isles in 1817, were to ascertain the latitude of a particular spot with the utmost possible precision, and to determine the length of a pendulum vibrating seconds in that high latitude, for comparison with the known length in other places, in order to ascertain the ratio of the Earth's axes, and to effect this simultaneously on the same spot with both French and English instruments, not only for the sake of greater accuracy, but as a test of their comparative excellence. The scientific party having sailed together to Shetland, a liberal plan of harmonious co-operation, with a regular exchange of all the registers of observations and experiments made on both sides, was proposed by Dr. Gregory. This was declined by M. Biot. However, a convenient station having been jointly selected, in the little island of Balta, (about lat. 60° 45′ N.) tents were pitched, and suitable buildings begun for carrying on the necessary operations, when M. Biot suddenly removed, with all his apparatus, to the Island of Unst, leaving Dr. Gregory and Captain Colby to finish their experiments alone, on the spot which he himself had previously admitted to be the best that could be found for the purpose in the Shetland Isles. Thus, one of the objects of honourable association, for the advancement of science, was entirely defeated through the strange conduct of M. Biot.—Why did he withdraw?—Had he heard or seen enough of the English instruments to induce him to shrink from a fair comparison of them with those he had brought from France? TRANSLATOR.

so tottering a base as that where the instruments are fixed up in this manner, it would be impossible to make observations which require perfect immobility of position.*

On leaving Aberbeen, I travelled into the highlands of Scotland as far as the mouth of the Murray Firth, where the army of Agricola stopped, disheartened by the aspect of the steep mountains and rocks of the opposite coast. From Inverness, at the head of the Murray Firth to Fort Augustus, and from thence to Fort William, I kept along the banks of the Caledonian Canal; an immense work, which will permit ships of five or six hundred tons burthen, and frigates of a small class, to pass from the Atlantic Ocean into the North Sea, without making the circuit to the northward of Scotland and the Orkney Islands, or attempting the more dangerous passage between them, called the Pentland Firth. Wood was wanted for the construction of the lock-gates, all the heel-posts, head-pieces, and ribs of which have been made of cast-iron. I saw gates weighing as much as thirty-two tons, opened and shut with the greatest facility by two men only. I collected on the structure of these gates many interesting particulars.

On leaving Fort William, where ends the Caledonian Canal, and crossing again chains of mountains, almost absolutely barren and desert, I reached the banks of Lock Lomond, then Dumbarton, and at length Glasgow.

Glasgow is among the number of those cities which exhibit every thing that can be produced by activity, perseverance, and industry. In the space of a century only, it has increased tenfold its population, its wealth, its trade, and its manufactures. It is more easy to visit the establishments and manufactories of Glasgow, than those of any other town in the British empire. The liberal spirit of the inhabitants is, in that respect, carried as far as it can be by a manufacturing people, who must naturally dread, and try to prevent, not only the loss of its preponderance, but all foreign competition.

The rich inhabitants of Glasgow have founded an Andersonian Institution, where, in the winter evenings, Professors deliver lectures on the elements of geometry, mechanics, physics, and chemistry, applied to the arts. These lectures are particularly

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* Having made the necessary inquiries, we find that M. Dupin has not overrated the skill of the Aberdeen currier and last-maker in the construction of *reflecting telescopes*. Those which he makes are of high power, and the *specula* are admirably polished. One of the Professors at King's College, Aberdeen, has a telescope made by Herschel, for which, we understand, he gave 200 guineas, and which he considers as inferior to those made by the Aberdeen currier. He is now employed in making one of high power for the use of the Observatory at Edinburgh. We much regret that we cannot at present give the name of this ingenious artist. TRANSLATOR.

intended for young artificers, who have to pay for that benefit only about a crown for the season. So slender a subscription is required in order to have none but students prompted by a fondness for learning, and who are willing to make for it at least a trifling sacrifice. The Andersonian Institution has produced astonishing results. It is an admirable thing to see at this day, in a great many manufactories in Glasgow, common workmen possess and explain, when required, the principles of their operations, and the theoretical means of attaining the most perfect practical results possible. The principal Professor of the Andersonian Institution, Dr. Ure, known by his kindness to strangers, and above all to Frenchmen, conducted me himself to all the most important manufactories, a great number of which are at present under the direction of his pupils.

If the ingenuous detail of particulars which pourtray the mind of a people, and the intelligence of the inferior classes of society, do not too much alarm delicate readers, in order to give to persons of that description an instance of the education of the common journeymen of Glasgow, I shall here speak of two brothers, bakers by trade, who, in the interval between one baking and another, employ themselves in making machines and philosophical instruments. They have cast, turned, and fitted all the pieces of a little steam-engine, the humble boiler of which derives its heat from being placed by the side of the oven for baking pastry. The engine is of the power of about two men; its mechanism is very ingenious; it serves for working a turning-lathe, by means of which our two artists turn metals, and shape lenses for optical instruments. They have constructed a small apparatus for lighting with gas their shops and their apartments. The tubes for the conveyance of the gas have flexible joints, which allow of transmitting the light to the places where it is wanted for the moment. These young men are well acquainted with the physical and mathematical principles of the instruments and machines which they construct. Some day they will quit their profession, in order to cultivate the natural sciences, and, I venture to predict, with success. But their fortune depends on an uncle, who infinitely prefers the business of a baker and pastry-cook to gasometry and astronomy, and who, jealous of the hereditary title of his family, wishes to transmit to the sons of his nephews the kneeding-trough of his ancestors. Alas! how many men among us are, without suspecting it, like the uncle of the two bakers and pastry-cooks!

At Glasgow, preparations are making, on a large scale, for lighting with gas all the streets of that great city. At the time of my excursion to Scotland, the leading pipes were already cast, and

workmen were employed on the construction of the gasometer and the furnaces.

For laying on the water necessary for the consumption of the inhabitants, there has been adopted a plan which I have never seen put in practice in any other town. The water of the Clyde, brought by a tunnel, or subterraneous canal, to the foot of a steam-engine, is first raised to the height of eighty feet above the level of the river, and received in a large reservoir; from there, the water passes into subterraneous conduits, which run in a parallel direction. The bed of these conduits presents two faces of equal declivity, and paved like a gutter; they are covered by large stones, forming an arch, and leaving between them interstices, which have not been filled up. Smaller stones are placed irregularly on the former, and lastly, the whole is covered with sand. Parallel to the conduits thus formed, and perpendicularly to the middle of their intervals, are pits in the sand. The water, descended from the reservoir into the conduits, tends to rise again between the large stones, the small ones, and the sand, in order to regain its level with the water remaining in the reservoir: thus it runs into long parallel ditches, after having been perfectly purified. This is, as may be seen, a method of filtering which differs from that commonly used in our houses in France, only by its being prepared for a hundred thousand souls. The filtered water is afterwards conveyed, by cast-iron pipes, to the different houses of the city, which it supplies, by cocks, to the very highest stories.

A work which greatly contributes to the prosperity of Glasgow, is the Great Canal from the two seas which joins the Clyde, a little above that city, to the Firth of Forth, a little above Stirling. I was invited to visit this canal with the directors of the company, who are its proprietors. I had the pleasure of making this instructive excursion with the celebrated James Watt, an old inhabitant, and civil engineer belonging to Glasgow. By a favour I little deserved, the First Class of the Institute of France named me their correspondent in the place of Mr. Watt, when they had appointed him their foreign associate. To that honour, and to the indulgent recommendation of M. Berthollet, I was indebted for the acquaintance and kind attention of Mr. Watt. It was with a respect, mingled with admiration, that I saw this fine old man, of eighty-three years of age, preserving the vigour of his mind, as well as his physical strength; he informed me of a variety of particulars relative to the progress of English industry, of which, more than any other inventor, he has accelerated the advancement. It is to Mr. Watt that England owes, in a great measure, the immense increase of its wealth within the last fifty years. He invited me to go down from Glasgow to Greenock, on the Clyde,

by one of the steam-boats, and to communicate to him my observations, which, he said, would be particularly interesting to him, because his son was then making, on a large scale, some very careful experiments on the steam-boat, called the *Caledonia*.

Not long ago, the Clyde was not navigable up to Glasgow, but for very small vessels. At this day, ships of five hundred tons ascend it with facility. Immense embankments have given to agriculture extensive grounds, before inundated every day by the flood-tides; the bed, made narrower, is become deeper; and dredging machines, worked by a steam-engine, have completed this great work, in the places where the natural current of the waters did not suffice for producing that effect.

*I should wish that the example of the Clyde and of Glasgow might lead to similar efforts, and be the means of obtaining similar results with regard to the Seine and to Paris.**

Every day sixteen steam-boats descend and ascend the Clyde, from Glasgow to Dumbarton, Port Glasgow, and Greenock. Some extend their trip much farther, and proceed along the coast, and into the numerous circumjacent bays. In this manner, they go as far as one hundred and twenty miles from the place of departure; this great distance is accomplished in a day. In navigating on board the steam-boats, and comparing the *momenta* or propelling powers with the head-way, or progressive motion of two boats which had started at the same time, and were following the same route, I endeavoured to ascertain the mathematical law of the proportion of those powers to the rate of going of the boats. The result I obtained from my calculations, corresponded with those procured by Mr. Watt. I made a memorandum of the prime cost and expense of keeping in repair the best steam-boats, as well as of their dimensions and mechanical powers: this will be useful to French industry, which does not appear to have yet obtained, in this way, decisive success.

Port Glasgow is a spacious quadrangular basin, containing large ships which trade to the East and West Indies, and draw too much water to go up to Glasgow. This port is scarcely three miles above Greenock, on the left shore of the Clyde. At Greenock the Clyde is extremely wide, surrounded on all sides by high hills, and offers a spacious, deep, and safe roadstead. Workmen are employed in improving, enlarging, and, in some measure, re-constructing the basins or wet-docks at Greenock. From Greenock

* It is affirmed that, at this moment, a petition from the Chamber of Commerce of Paris, is addressed to the Chamber of Deputies, in order to obtain the means of rendering the Seine navigable, for sea-going vessels, from its mouth to Paris. One cannot too much applaud the enlightened patriotism of such a request, and every thing must encourage the hope that it will receive all the attention it merits.

to Port Glasgow the coast is lined with yards for ship-building. At Greenock, I visited a cable manufactory, the machinery of which is worked by a steam-engine. This machinery is established on principles similar to that employed by Captain Huddart; but it is here reduced to its most simple elements, which admits of its mechanism being better ascertained.

Before I quitted the environs of Glasgow, I had nothing more at heart than to visit the famous foundry of Carron, near Stirling; I wished at least to try to see it, for I knew that admission was given there but to very few Englishmen, and to no foreigners. Thus it was that the Archduke Nicholas of Russia, notwithstanding all the royal recommendations with which his Highness was provided, had not been able to obtain admittance.* As for me, I was humbly, but warmly recommended, as an amateur, *un dilettante di belle cose.* I first underwent an examination in due form. "Are you a merchant, a trader, or a manufacturer?" "No; and not even interested in the smallest undertaking." "What is your object in travelling?" "As a friend of the sciences and arts, for my instruction." "Admit that gentleman."

The works of Carron are immense, especially during war. In this foundry are cast almost the whole of the cannon and carronades for the British navy, as well as the shot, shells, &c. The carronades are called by that name, because the first pieces of that description were cast at Carron. Independently of the artillery, I saw a great many articles of cast iron, as diversified in their forms as in their uses, from the large boilers employed in the colonies, for the preparation of sugar, to the slight and delicately-shaped pots, which are manufactured with great facility, yet which no one has hitherto been able to make but with British iron. I remarked also articles of luxury, such as stoves, grates, &c. these are embellished by sculpture, moulded with great delicacy of execution, and even with no small degree of taste in the design. Immense cylindrical bellows, with air reservoirs, in order to render continual the action of the wind, appeared to me very worthy of observation. Steam-engines of great power, streams of water very abundant in autumn, in winter, and in spring, are the agents employed for executing the principal operations.

Nature has placed the mines of iron and of coal very near to the establishment. These raw materials are brought partly on iron rail-ways, and partly on the Great Canal, which communicates with the foundry, by means of an adjoining canal. The products of the manufactory can, in this manner, by a very short

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* The fact is, that the Archduke Nicholas declined to inspect the works at Carron, when his Highness was given to understand that he could not be accompanied by his suite. TRANSLATOR.

cut, be conveyed by water, either into the Atlantic Ocean, or into the North Sea.

To avoid the winding navigation of the Clyde, below Glasgow, and especially below Greenock, where the river flows between high promontories, the Earl of Eglingtoun has adopted the project of forming a harbour at Ardrossan, and of connecting it with that of Glasgow, by a canal already finished as far as Paisley. Some parts of these works are in active progress.

A spacious bay, which presents the form of a crescent, offers, at its north point, the harbour of Ardrossan, and, at its south point, a harbour called Troon Bay, intended for the exportation of pit coal. An iron rail-way, ten miles in length, brings the coal from the mines, from Kilmarnock, to the colliers lying in Troon Bay; these vessels generally carry their cargoes to Ireland, where, it may be said, that scarcely any coal-mine is worked. I saw some diligences established on the iron-railway from Kilmarnock to Troon Bay; they convey the idea of an enormous wandering vehicle, and nevertheless are drawn, without difficulty, by a single horse.

I visited the harbour of Air, which, like all those placed at the mouth of some river, cannot admit vessels but of a very small draught of water, unless the entrance thereof is deepened by immense works: this has not yet been done for the improvement of Air. After having examined these different ports, I took the road to England, and quitted Scotland, crossing the river Esk, in order to repair to Carlisle.

If I had been able, in so short a narrative, to give not only a general idea of all the institutions, and of all the works undertaken within these few years, for the prosperity of Scotland, I should have presented one of those pictures the most calculated for exciting the admiration of all men, and for affording an object worthy of the meditation of sages. It is highly gratifying to behold a poor people exerting their activity, their perseverance, and their genius, to triumph over rugged nature, to conquer the climate, and render sterility itself productive; and, thinking of the riches of the mind as well as those of the senses, causing agriculture, commerce, and industry; instruction, morality, and liberty, to flourish at the same period.

In travelling along the west coast of England, I visited some of the sea-ports between Carlisle and Liverpool. They are almost deserted; industry, shipping, capital, all is swallowed up at Liverpool, which, for that extensive coast, is the sole centre of attraction.

I had already visited and described Liverpool in my first excursion; I saw it again with renewed satisfaction. After an absence of a year only, I found there a thousand new things; immense

docks, half-finished twelve months ago, now completed, filled with water, and covered with ships; other docks in a state of forwardness; quays and buildings of every kind rising up as if by enchantment; trade which languished not long since, flourishing anew; such I found to be the improved condition of Liverpool at the time of my second excursion. Great preparations are making at Liverpool, as at Glasgow, for lighting all the town with gas; but the works for that purpose are much farther advanced at Liverpool. I again visited the great rope-manufactory, where all the cordage is spun, twisted, and laid, by the power of steam; as well as other roperies offering patent-machinery more or less ingenious, and a fine manufactory of steam-engines, with high pressure.

I crossed and re-crossed the river Mersey in a steam-boat, constructed in a manner analogous to the double proas of India. Two floors, or bottoms, of equal size, long, narrow, and parallel to each other, are covered by a large platform, which carries the steam-engine. The paddle-wheel acts upon the surrounding water between the two bottoms; a rudder is fixed at each end, in order to save the trouble of putting about to follow opposite routes. The funnel, through which the smoke of the steam-engine escapes, serves as a mast to the vessel, and can, when required, carry a square sail. In the middle of the large platform which constitutes the deck of the boat, are a cabin for the passengers, and another apartment for containing the steam-engine. Forward, abaft, and on the sides of these cabins, the platform is roomy enough to carry sheep, oxen, horses, carriages, &c.

I went up the Mersey as far as the mouth of the duke of Bridgwater's canal, which terminates at Runcorn, in Cheshire.* This

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* It has been some time in contemplation to construct an iron hanging bridge over the Mersey, at Runcorn, near this entrance of the Duke of Bridgewater's Canal. Mr. Thomas Telford (who erected the great acqueduct which conveys the Ellesmere Canal over the River Dee, at Pont-y-cyssylte in Derbyshire) having been selected by the Runcorn-bridge Committee to be their Engineer, has, with that view, made a regular series of experiments upon rods of malleable iron, varying from thirty to nine hundred feet in length, and from one-twentieth of an inch to two inches in diameter, from the result of which it appears that the medium ultimate strength of this metal is about twenty-seven tons to the square inch section, and that the strength, within certain limits, is proportioned to the area. The whole weight of the Runcorn bridge, independent of any passing load, is estimated at 574 tons. According to the plan proposed by Mr. Telford, the span of this bridge is to be 1000 feet; but, the undertaking being considered of so much magnitude and novelty, the Committee wished personally to make some experiments to the full extent of the intended bridge at Runcorn. A Sub-committee having been selected by the General Committee, an experiment was tried over a valley or dingle in the neighbourhood of Liverpool, to the extent of 1000 feet, the result of which experiment not only confirmed, but exceeded the calculations that had been delivered in by Mr. Telford, as to the strength of iron, under different degrees of curvature. Doubts previously entertained being

entrance presents three parallel basins dug by the side of each other, but in regular stories, and lined with handsome store-houses; then a succession of locks reaching to the top of a hill. The whole of these works shows what can be done by the wealth, industry, and spirit of enterprise of a single individual, prompted by a noble regard for the public good.

In quitting Liverpool for the last time, I repaired to Chester, the trade of which with Ireland, formerly very flourishing, is at this day almost annihilated by the formidable competition I have already mentioned. Chester has long since acquired a great name for the building of merchant-ships; it seemed to me, from the vessels which I visited on the stocks, that this reputation was justly deserved. The Sessions-house and the *panoptic* prison of Chester are united in the same building, which, most assuredly, is the handsomest of this kind that is to be seen in Europe. The interior arrangements are well-contrived and bespeak much regard for humanity; the architecture is equally simple and majestic.

From Chester I went into Wales, in order to visit the aqueducts of the Ellesmere Canal. To me the most important object was the aqueduct of Pont-y-cyssyllte, elevated one hundred and twenty-six feet above the rapid river which flows in the vale of Llangollen. This aqueduct, for the length of upwards of a thousand feet, presents an aerial canal of wrought iron, which is navigated by barges that carry to Ellesmere coals and the produce of the iron-works, &c. in the vale of Llangollen.*

After a long and fatiguing walk, I entered this vale, in a fine evening in autumn, a little after sun-set. Never did a more imposing sight strike my eyes. Amidst a vigorous vegetation, still

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thus entirely dispelled, subscriptions which had, on that account, been withheld, were now put down to a considerable amount, and, as soon as the requisite sum shall be raised, a bill will be brought into Parliament to enable the subscribers to carry the measure into effect.

The principle here recommended of constructing bridges by suspension is not new, though it has hitherto been but little practised in England; the novelty consists in its application to so wide a span. Hanging-bridges were in existence over rivers and deep ravines in South America, previously to the arrival of the Spaniards in that country; they have also been carried to a great extent in the East Indies and China, and, of late years, eight have been constructed in North America. "If these, (says Mr. Telford) with very inferior materials and work-"manship, have been carried to about 500 feet in length, it is certainly not as-"suming too much in expecting more from British dexterity exercised on supe-"rior materials. In point of economy and expedition, hanging bridges of mal-"leable iron, affording to a certain extent still greater facilities than those of "cast-iron, promise to become of at least equal importance."

TRANSLATOR.

* There is an engraving of this aqueduct, taken from a well-executed drawing by Mr. Yates of Oswestry, lately published by Colnaghi and Co. in Cockspur-street. This plate furnishes a far better idea of that interesting work than can be conveyed by any written description.

TRANSLATOR.

preserving all its freshness, the fires of the forges, and of the lime and coke kilns, throwing up their curling clouds of flame and smoke; villages, manufactories, and country-seats, displaying themselves, in the form of an amphitheatre, on the sides of the valley; in the back-ground a rapid torrent; above, the aqueduct or canal, offering its iron frame, placed as if by enchantment on lofty and slender pillars of masonry; and this magnificent work, the fruit of the happy boldness of one of my friends! Lost in the contemplation of these beauties of art and of nature, which, by the waning gleams of an expiring light, varied their aspect every moment, I remained in a sort of ecstasy, till the close of twilight forced me to quit this spot in order to seek an asylum at a few miles' distance. This is what I saw, and what I cannot pourtray without stripping it of the charms of reality, and which, nevertheless, still makes my heart beat at the recollection of the emotions I felt at the sight of this admirable landscape.

Mr. Telford, the engineer, who projected and built the aqueduct of Pont-y-cyssyllte, was so obliging as to give me the plans of it. He also gave me a letter of introduction to the director of the foundry where the materials of the aqueduct were manufactured, as well as the iron framing and plates of the great lock-gates of the Caledonian Canal. In this foundry, I acquired some further information respecting these gates, which have been improved, by being each made ten or twelve tons lighter, without their solidity being in the least impaired.

In following the route to Ireland, on the edge of which is situated the aqueduct of Pont-y-cyssyllte, I passed over a cast-iron bridge of a single arch, built with much elegance and lightness. Afterwards, I proceeded along the road by the side of the slate-quarries, and of the iron-rail-ways which lead from the quarries to the sea. The working of those quarries appeared to me one of the most interesting objects of the kind.

I quitted the land of England at Bangor, in order to cross over to the Isle of Anglesea, where there was nothing remarkable for me to see but the harbour of Holyhead. There are four principal lines of communication between Ireland and Great Britain; in the north, by Scotland, from Belfast to Port Patrick; in the south, from Cork to Bristol, and from Waterford to Milford Haven; lastly, in the centre, from Dublin to Holyhead. This last line is in the direct road from London to Dublin; it is that by which all government dispatches are sent, and for that reason is the most important.* Independently of this kind of utility, Holyhead is

* Whenever the subject of improving the great line of communication between Dublin and London has been considered, the inconvenience and danger of crossing the Menai Strait, which separates the Isle of Anglesea from Carnarvonshire,

the port naturally resorted to by vessels which, not being able to clear St. George's Channel, are forced to seek shelter, from stress of weather or contrary winds. In front of this harbour, a magnificent pier, of very great length, is now building. From the shelter it will afford, ships of five or six hundred tons will be able to enter the harbour, both at low and at high water, and as well with northerly as with southerly winds. In the inner harbour, are to be constructed large basins for vessels to lie afloat that may put in here, and also docks for the repairing of vessels that may have sustained any damage.

The passage from Holyhead to Dublin is effected on board the regular packets, which are large smacks, well-built, well-equipped, and fitted up with all the convenience and elegance suitable to vessels intended for that service; they are manned too by experienced seamen, and, not unfrequently, commanded by old naval officers. Notwithstanding these advantages, passengers are fleeced on board and on shore, in embarking and disembarking.

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has been constantly discussed both in and out of Parliament. For effecting a regular passage in the place of the present Ferry at Bangor, numerous plans of cast-iron bridges have been proposed, the least expensive of which, projected by Mr. Telford, was estimated to cost £127,331. The chief difficulty in constructing this bridge was fixing proper centering, which, from the rocky bottom of the channel, and the depth and rapidity of the tide-way, could not be accomplished by ordinary means from below. Mr. Telford was, therefore, under the necessity of establishing a new mode of suspending the centering from above. But, some years afterwards, reflecting on the experiments he had made to ascertain the strength of iron for the Runcorn bridge, and the facility and economy of constructing an iron hanging bridge, where the shores are bold and high, he was led to consider a bridge of this description as peculiarly well adapted for crossing the Menai Strait, a little to the westward of Bangor Ferry. The plan, submitted by Mr. Telford to the Commissioners for improving the Holyhead roads, was approved; and, after they had examined some of the most eminent engineers and iron-cable manufacturers, together with Mr. Barlow (who had made the necessary calculations in regard to the strength of the materials) and had also taken the opinion of the Brethren of the Trinity House with respect to the navigation, the Report of the Commissioners was made to Parliament, and the necessary funds having been voted, directions were given for the commencement of the work.

The iron hanging-bridge to be constructed over the Menai Strait consists of one opening of 560 feet between the points of suspension, and 100 feet in height between the high-water line and the lower side of the road-way, and the road-way being horizontal, this height is uninterrupted for the whole 560 feet, except where the natural rock, which forms the western abutment, now interposes. But, in addition to these 560 feet, there are to be four arches on the western, and three on the eastern side of the main opening, each 50 feet span, that is, making in all 850 feet of opening. The road-way will consist of two carriage-ways, each twelve feet in breadth, with a foot-path of four feet between them, so that the platform will be about thirty feet in breadth. The whole is to be suspended from four lines of strong Iron Cables by perpendicular Iron Rods, placed five feet apart, and these rods will support the road-way framing.—The suspending power is calculated at 2016 tons, besides the weight of the cables; and the weight to be suspended, exclusive of those cables, is 342 tons, leaving a disposable power of 1674 tons. The estimated expence is £70,000. TRANSLATOR.

Dublin, from its population, its size, the beauty of its public buildings, and the regularity of its modern part, is one of the most remarkable cities of the British empire. It is situated at the head of an immense bay, on the banks of the river Liffey, where ships go up and anchor, as at London in the Thames, in the very heart of the city. A pier, upwards of a mile in length, has been erected in order to extend, to the middle of the bay, the west bank of the Liffey. In 1796, very spacious basins or wet-docks were dug for keeping afloat there large trading vessels. Unfortunately, the entrance of those docks is precisely at the conflux of the Liffey with another small river; and the effect of this conflux is to form constantly a bar, which hinders ships of any size from entering into the docks.* Workmen are employed in digging new docks near that magnificent edifice, the Custom-house; they will be capacious and regular; the first stone of these was laid in the summer of 1817.

At the north extremity of the bay of Dublin have been erected, on the rocks, two piers, which embrace a space nearly rectangular, and large enough for containing all the packet-boats necessary for the communication between Dublin and Holyhead. The basin has been deepened, by blasting the rock under water by mines, made with the help of the diving-bell. The entrance of this port, called Howth harbour, is indicated by a light-house with coloured lights, like those on the Bell-rock. The undertaking of these works, the expense of which is immense, in comparison to the services to be derived from them, is, if I mistake not, one of those operations which the Irish call a *job*.†

A harbour which will be more important than the *job* harbour of Howth, is that now forming at Dunleary, in the bay and outside of the bar, which unfortunately obstructs the entrance of the Liffey. The means employed for transporting and unloading the

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* Swift, Dean of the Cathedral of Dublin, affirmed that in Ireland the public buildings were placed very near, but always by the side of the most convenient spot possible. It seems that it was intended to justify that sarcasm of the celebrated satirist, by thus fixing the situation of the old docks of Dublin.

† With respect to the harbour at Howth, it is but justice to Mr. Rennie, who furnished the plan, to declare that M. Dupin is completely mistaken. It would lead us too far to state every thing that might be adduced in proof of this assertion; but a few facts may suffice to show that, as an engineer, M. Dupin here betrays great want of judgment. Howth harbour being intended for the reception of other vessels besides the packet-boats sailing between Holyhead and Dublin, in its construction regard was had to that twofold object; first, by making it of a proper size, and secondly, by maintaining in it a proper depth of water. The area, contained within the piers, is not less than 55 acres; yet a considerable part on the western side is rocky ground, on which vessels cannot safely anchor. But the remainder affords secure accommodation for shipping, and thus the first point is gained. To attain the second, it was absolutely necessary that the harbour should be large enough to receive, on the flood, a body of clear oceanic wa-

blocks of granite, which serve for the construction of the piers or jetties are well deserving of attention. Ships of six hundred tons will be able, even at low water, to enter the harbour of Dunleary. To complete this fine work, and give to it all the advantage of which it is susceptible, it will be necessary to cut a canal of four or five miles, in order to communicate with the docks belonging to the port of Dublin. But these works, and the large canals which traverse Ireland in different directions, are beforehand with the civilization of the country. Industry must not only create wealth, in order to occasion demand for imports, but diversified produce also, to form a return-cargo for ships. Hitherto, this produce has been confined to the fruits of the earth, to cattle, provisions, and linens.

The only establishment in Dublin which presents a character at once honourable to humanity and industry, is an immense drying-house, the interior arrangement of which is well-contrived and economical. There, for the most moderate sum, the poor mechanics are admitted to dry their dyed wool, whether spun and wound into skains, or spread in the woof, their woollen stuffs recently manufactured, &c. In a damp and cold country, it is an immense advantage to the indigent class to have this general focus of heat prepared for their labours at so trifling an expence; and this advantage turns to the profit of society, by lowering the price of clothing of a nature indispensable in northern climates.

Although in Ireland individuals are free in their manners, and rank hospitality among the virtues of which bondage has not been able to deprive them, yet all the establishments of Dublin bear the stamp of illiberality. Their regulations are so drawn up as to be useful to the smallest possible number of individuals. No stranger is admitted to enjoy the benefit of the scientific repositories, nor to read the periodical publications in the great reading-rooms, established by subscription, nor to consult the books depo-

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ter, brought by that tide, sufficient to prevent its being choked up by the deposition of the silt or mud, successively brought down, from the Channel of Baldoyle, by the ebb-tide, which, on the contrary, chiefly consists of water resembling that of a puddle-river, from the vast quantity of alluvial matter that it holds in suspension. The flood, setting in from the S. E. fills this whole area of 55 acres with clear water, which, on the turn of the tide, discharges itself through the narrow entrance between the two piers, with such velocity, as to prevent any of the muddy water from entering the harbour.

We have substituted this Note to one of a very different nature introduced here by M. Dupin, which we have omitted, because its insertion would have required us to annex to it some argumentative observations, and we consider politics not a fair subject of discussion in the narrative of a tour, professedly undertaken for the benefit of science and the improvement of the maritime arts.

TRANSLATOR.

sited in the libraries. In the library of the University, which I visited, introduced and conducted by a doctor belonging to the said University, and which I went over, according to the rules, *not stopping any where*, I wished to approach a window from which a tolerably fine prospect was to be enjoyed; but the doctor, who accompanied me, held me back; in his presence and in that of a door-keeper who did not lose sight of us, there was a possibility of my putting a book in my pocket.—There are countries where men are first rendered despicable, in order that a right may afterwards be assumed to treat them as such.

At Dublin I visited the archives of Ireland; they are kept in very good order. The keeper of that establishment, Mr. Shaw Mason, is preparing a general statistical account of Ireland, on the same plan as that compiled by Sir John Sinclair, respecting the differents parts of Scotland.

I should have much wished to travel over Ireland as I had travelled over Great Britain; but the season was very far advanced; and a serious fall, after having confined me a month to my room, scarcely allowed me to walk. I was therefore under the necessity of relinquishing both excursions, and of thinking of my return. I particularly regret not having been able to visit, in the south, the harbour of Waterford, where great works are in progress, under the direction of Mr. Nimmo, a skilful engineer, with whom I am intimately acquainted; and, in the north, Belfast and its environs, peopled by a colony from Scotland, which presents the activity, energy, and prosperity of the mother-country.

I returned to London without stopping, and I there employed myself in the purchase of some productions of art, the introduction of which into France appeared to me of no common advantage; afterwards, I thought of nothing but my departure. Such is the too brief indication of some of the objects which fixed my attention during my second excursion.

In speaking of the remarkable establishments which I visited, and praising them to an extent which I seek as little to lessen as to increase, it would be wrong to imagine that I have blindly abandoned myself to enthusiasm. I purposed, beforehand, neither to exalt nor to depreciate; I endeavoured to divest my judgment of the influence of all system, and to see in every thing only the simple truth. I have, indeed, scarcely noticed any objects but such as are worthy of praise and admiration; this is owing to the idea which I formed to myself of a scientific excursion. Had I had an intention to form a collection of defects, fooleries, and absurdities, I should not have wished to cross the water at a great expence, and with so much fatigue. I should have found all of these on the continent, and I found them all in abundance beyond the sea. But I disregarded them, except when the influence of such

irregularities, weaknesses, and vices of the human mind, might be attended by bad consequences against public power, or against humanity; and I should, I confess, from no other desire than to appear *piquant*, have been ashamed to go about picking up, with meanness and malignity, what appeared to me the refuse of reason. I treated men as I did things. I did not go to seek or to meet, ignorant, foolish, or wicked men, in order to distinguish and stigmatize their character. More than once I found myself put off by such, deceived, and repulsed; I did not even conclude from this, that they were wrong, and I was right. I merely thought that if I had acted less incautiously, I should have succeeded.

On the other hand, every man is free to communicate or to keep to himself the treasures of his talent; and the traveller who should ask for those riches, at the same time threatening their possessor with the poniard of satire or the rod of ridicule, would resemble a little too much, in my opinion, the frequenter of the highway, who impudently demands a man's purse or his life.

I prefer dwelling on favours nobly conferred, and on the gratitude which they inspire. In a thousand places I met with kindness and hospitality, and almost always liberality in communications, particularly from engineers, both civil and military. Every where, men of science and artists honoured me with a little kindness, and some of them with their friendship. In general, except in London, and there even among very few persons, I did not find in them that cold and disdainful pride which repulses every man, who, not being already celebrated, cannot help to increase the fame of the egotist to whom he is introduced. Had the means of my small income been less circumscribed, or had I possessed more reputation to compensate for less opulence, I should, no doubt, have obtained more information. But, confined as I was in a narrow sphere, I venture to believe that I have done all that could be accomplished by a patient, active, and persevering man. I neither feared useless steps, nor mortifying refusals, nor vain researches, nor unavailing fatigues. I went in order to endeavour to learn, and I should have learned nothing, if I had not wished to endeavour to learn but when certain of success. But it was not from men alone that I had difficulties to conquer; I had also to contend against the obstacles of nature. In crossing stormy straits, sailing along dangerous coasts, and travelling over mountainous and wild regions, I encountered all the dangers and inconveniences arising from raging seas and dreadful weather; I endured hunger, thirst, storms, and wounds, and all with pleasure, in the hope of rendering one day those misfortunes useful to my country.

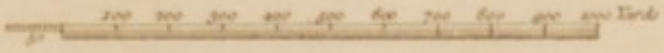
In terminating this Narrative, I ought to pay the debt of

gratitude to the Frenchmen whom I had the good fortune to meet with in the principal stations of my excursion. Thanks to the letters of recommendation of the Consul-general of France in London, M. Le Chevalier Séguier, who rendered me a thousand other services, the Consuls at Dublin, Liverpool, and Edinburgh, Messrs. Romain, Maselet, and Hugot, as well as their agents, lavished on me their good offices. M. Maselet made, on my description of the works and the institutions at Liverpool, notes, which will be to me of the greatest use, and which have served to correct several errors of detail that I had involuntarily committed.

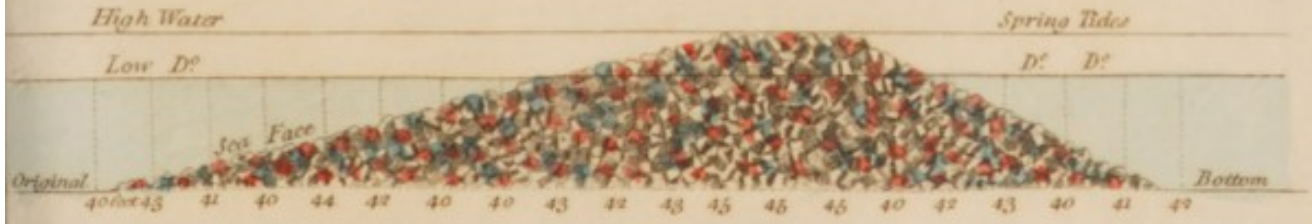
Lastly, M. le Marquis d'Osmond, Ambassador of France in England, to whom I was indebted, in my first excursion, for the permission to visit the military and naval arsenals of Great Britain, continued to me his kindness during my second excursion, for which he was even pleased to solicit a prolongation of the leave of absence I enjoyed. The account of this latter excursion will be drawn up on the plan which I followed in the account of my former excursion. A special Memoir will make known my new observations on the arts relating to the department of the Military Engineers and the Artillery. A second Memoir, or rather a volume, will offer a description of the hydraulic works in the ports which I visited; lastly, another volume will present the results of my researches on the NAVAL ARCHITECTURE OF ENGLAND.

BREAKWATER.

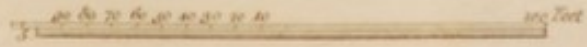
NB. The Space between the Red Lines, describes the part finished.
D.o between the Red and Blue Lines appears from 5 to 13 Feet above LWST.
D.o between the Blue and Green Lines the part approaching the Surface.



TRANSVERSE Section *of the Finishd part of the* BREAKWATER.



NB. The first Stone was laid August 12.th 1812.
The Quantity of Stone deposited to April 30.th 1819.
1,412, 252 Tons.



Wade & Son, 20 Strand

CONSTRUCTION

OF THE BREAKWATER

IN PLYMOUTH SOUND.

The Sound and the harbour of Plymouth are, perhaps, the places where nature has done the most for the navy, and in the situation the most important to the safety of Great Britain. Industry, power, and wealth, have united their efforts in order to derive from this situation all the advantages which it was possible to expect. On the confines of Devonshire and Cornwall, are seen on a coast deeply indented, and within an extent of three miles only, three rich and populous towns, Plymouth, Stonehouse, and Plymouth-Dock. Two rivers, the Plym and the Tamar, widening at a little distance above their entrance, form two spacious basins, Catwater and Hamoaze, and blend their waters in front of these three towns, in another basin still more extensive than the two others. This is the roadstead of Plymouth, called the *Sound*.

The establishments of commerce and the town of Plymouth are situated on the right bank of the Plym, on the margin of Catwater. The establishments of the Navy and Ordnance, as well as the town of Plymouth-Dock, are, on the contrary, on the left bank of the Tamar, on the margin of Hamoaze. The two towns are insensibly united by the increase of a third, called Stonehouse, which extends along an intermediate valley. These three towns present a mass of habitations, peopled by upwards of sixty thousand individuals.

Plymouth and Stonehouse are not surrounded by fortifications; they are protected, on the side next to the sea, by a citadel erected on a promontory. The fire from this citadel crosses with that of an island, which nature seems to have placed at the entrance of Hamoaze, in order to render still more secure the anchorage of ships in that capacious inner-harbour. This is *Drake's Island*.

I am rejoiced to see that national gratitude has given to this island the name of the illustrious Drake, who, in peace, went to discover new countries, and share the glory of Americus and Columbus; who, in the war against Spain, sailed from Plymouth to go and defeat the *Grand Armada*, as Themis-

tocles left Athens to go and subdue the fleet of the great Persian King; who was, after the battle, the father of the warriors his genius had led to victory; and who, by prudent economy, contrived to find, in the scanty, but continual savings of all the heroes, wherewith to render happy the declining life of the veteran that the scythe of battle had but partially struck, and also to shelter from distress the widow and orphan of the seaman who had died in the service of his country.

With these titles, which must render the name of Drake venerable to Englishmen, and dear to the friends of humanity, is also blended a more direct cause for commanding the gratitude of the inhabitants of the banks of the Plym and the Tamar. From the mountains in the vicinity of Dartmor to Plymouth, that is to say, in a space of upwards of twenty miles, is an aqueduct, constructed by the direction of Drake, and entirely at his own expence: afterwards, he made a present of this fine monument of public utility to the corporation of Plymouth.

Drake's Island divides in two the entrance of Hamoaze; on the north side, it crosses its fire with that of the citadel, as we have already mentioned. On the west side, it crosses its fire with that of the batteries on Mount Edgecumbe.

Mount Edgecumbe is seated on a large base; it rises and advances like a great promontory, in forming the western boundary of Plymouth Sound. Old plantations spread over its sides their majestic shade, and from its summit may be enjoyed one of the most beautiful prospects that England can offer. To the east, the spectator perceives, as it were at his feet, the Sound, and the men of war lying there at anchor. In directing his looks successively towards the north, the west, and the south, the eye first reaches up the natural basin of Catwater, at the head of which it discovers the dikes, the drained grounds, the woods, and the mansion on the beautiful manor of Saltram. On the opposite bank of this basin, and nearer to the point of sight, the town of Plymouth spreads itself on an extensive slope. A long and narrow line is delineated by the houses of Stonehouse, in front of which rise the citadel and the insulated barracks of the Royal Marines. Behind are discovered the Artillery hospital and the magnificent hospital for the Navy. Still more to the left, Hamoaze, like a vigorous trunk which shoots forth in every direction strong branches, extends on its two banks numerous and deep ramifications. In a length of upwards of four miles, its principal channel is filled with ships of the line, frigates, and smaller vessels of war, either entirely dismantled, or rigged and ready to complete their equipment, in order to proceed on

immediate service. Lastly, to complete this magnificent picture, the plains, the hills, and the lofty mountains of Cornwall and Devonshire form to the east, to the north, and to the west, an immense amphitheatre of cultivated and fallow grounds, meadows, heaths, forests, and rocks. The two wings of this amphitheatre extend, by insensible degrees, as far as the ocean, the immense expanse of which offers to the sight no other object but the Eddystone light-house.

This remarkable edifice, established on a narrow base afforded by an insulated rock, twelve miles in the offing, rises to a great height. Nevertheless, when the sea is rough, it often entirely disappears, enveloped in the thick mist of the waves which dash against its feet, and rise in sliding up the inclined surface of its exterior casing. An old light house existed, not more than a century ago, in the place of that which now excites admiration. A storm came on in the middle of the night; and when the day appeared, nothing was to be seen but the naked rock on which had stood the monument for the direction of mariners. Then the celebrated Smeaton was charged with the construction of a new light-house. He was supplied with granite, iron, and men; he surpassed himself, and made a *chef-d'œuvre*, which appears likely to resist the rage of the sea for a long succession of ages.

Now we have made known the admirable topography of the environs of Plymouth Sound, let us describe the great work which was wanting to this roadstead, in order to render it a safe anchorage, for the retreat or the rendezvous of a fleet of ships of war.

Plymouth Sound, which is wide and deep, is surrounded to to the east, to the north, and to the west by hills and lofty mountains; it is sheltered from all winds from the south-east to the north, and from the north to the south-west. Of the four right angles which form the extent of the compass-card, there remains, therefore, but one, the direction of which can materially disturb the tranquillity of the waters in Plymouth Sound. But, as this last angle corresponds to an open sea that is not broken off by any island, the waves from the offing roll into the Sound with all the violence which they display in precipitating themselves against an unsheltered coast. The bight even into which they come and ingulf themselves, far from diminishing their impetuosity, increases their depth and power, from the same effect which renders the tides much stronger in straits and contracted gulfs, than in wide seas the motions of which are not counteracted by any obstacle.

To render Plymouth Sound an anchorage perfectly safe for ships of war, the English have imitated the example which

we set them, in constructing the pier or jetty at Cherbourg. But they have not, as we have, had to make great and costly experiments. They have saved the immense sums which we spent in ascertaining how far the rage of the sea may be braved, and its most powerful efforts resisted, by a simple dike of stones promiscuously sunk.* Two miles in front of the head of the Sound, they have drawn a straight line, nearly from east to west, to the length of one thousand yards; then they have prolonged this line by two ends of three hundred and fifty yards each. These ends are rectilinear, and stand at an angle of fourteen degrees inward from the long line before-mentioned. Thus the total length of the line on which the profile of the Breakwater is constructed, is one thousand seven hundred yards. When the Breakwater shall occupy the whole of it, there will remain

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* Here M. Dupin resumes his preceding observations on the Breakwater, at Plymouth, alluding again to that of Cherbourg, as if the latter had been the first rubble pier ever attempted to be erected. We shall first remark, that to have imitated the example of the French in the construction of the pier at Cherbourg, would have betrayed the greatest disregard of effects resulting from natural causes. From the outset, the French engineers employed there, committed a series of blunders. After first putting the nation to an immense expence, by endeavouring to shelter the roadstead of Cherbourg by a line of cones, filled with small rubble stones, these wooden fabrics burst, as might naturally have been expected, and, at the expiration of seven years, it was found that all the labour was useless, and all the money thrown away. The next plan adopted was the construction of a Breakwater on a line of 1950 toises in length. In 1791, this work was begun, with the intention of casing over the whole surface of the dike, as it then stood, with large blocks of stone, and of carrying it to a sufficient height for batteries to be erected on its summit.

At the commencement of the war in 1803, the centre of the dike had been brought above high-water mark. Here was erected a battery, in which was constantly stationed a detachment of soldiers. In the year 1809, a tremendous gale of wind occurred, when the battery, all the buildings standing on this part of the Breakwater, the men, women, and children, composing the garrison, together with several workmen, were swept away by the impetuosity of the waves; two corvettes, lying at the time in the roadstead, were also driven on shore and dashed to pieces. This disaster proved the want of common foresight and observation in the French engineers. The effect of sinking the large stones upon the small ones, already rounded by constant attrition, could not be otherwise; the latter acting as so many rollers, carried out the former even beyond the extremity of the base, to which the Breakwater had naturally been brought by the action of the sea. After this disaster, the dike or breakwater of Cherbourg, seems to have been abandoned; very few parts of it are visible, except at low water, and the greater part is then four feet below the surface of the sea. However, it is sufficiently high to break the force of the waves, and, in some winds, render the roadstead a safe anchorage; but we have the strongest reason to believe that it has occasioned such a deposition of sand within it, as also to render the general depth of the water there much shallower.

From the preceding premises, it is obvious that the immense expence of the great experiments made by the French at Cherbourg, to ascertain "how far the rage of the sea may be braved," arose entirely from the radical errors of the different plans proposed by the French engineers, and that to have imitated their example, or adopted their proceedings, would have manifested equal want of consideration and judgment.

TRANSLATOR.

two channels for entering the roadstead. The east channel is less than a third of a mile in width for ships of the line; but, at some distance without the Breakwater, there are several small spots of rock by which this channel is, in one place, a little contracted. The west channel is about half a mile wide for ships of the line. Both channels are navigable for any ship at low water of spring tides. The west end of the Breakwater is 1460 yards, and the east end is 740 yards, distant from the nearest land.

In sounding the roadstead, in the line in which the Breakwater is to be constructed, it is found that the mean depth is thirty-six feet at low water. In the equinoxes, the difference between the highest tide and the lowest is eighteen feet; it is not at present intended to carry the work higher than high water of spring-tides. This raises then to fifty-four feet the mean height of the Breakwater. Its breadth is about two hundred and ten feet at the base or foundation, and thirty feet at the top. The transverse section of the Breakwater, is, consequently, a trapezium. To construct the immense solid, the dimensions of which we have just stated, the choice lay between the white Portland stone, furnished by a coast at no great distance, the granite which forms the bed of the primitive mountains of Cornwall and Devonshire, and the marble which constitutes the secondary mountains, and is covered by a slight stratum of vegetable mould; as it could be most conveniently obtained, in regard to quality, cheapness, and celerity of conveyance, the preference was given to marble.*

The hills, consisting chiefly of grey marble, which skirt the left bank of the entrance of the Plym, that is, on the eastern shore of Catwater, are cleared of their earthy surface; and, by blasting the rock, by means of gunpowder, large blocks are detached, weighing from three to five tons each. These masses are thrown into the sea without any particular order, but in the limits determined by the line of the Breakwater. By sounding with a hand-lead, it is ascertained at what point it is necessary to stop in each part of the interior or exterior slope. At the part which shows itself at low-water of spring-tides, the largest blocks of marble are employed. These are let in so as to produce the greatest possible resistance to the waves of the sea. Nevertheless, they are not united in such a manner as to form outwardly a continued surface. They present sharp asperities, which really form a *brise-lame* or breakwater.

The interior slope, from the level of the lowest tides to the

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* A rock of limestone or rather grey marble, situated at Oreston, on the eastern shore of Catwater, consisting of a surface of twenty-five acres, was purchased from the Duke of Bedford for the sum of 10,000l.

TRANSLATOR.

top, as well as the horizontal part of the top, form an even and continued surface. But the materials, trimmed, and laid even on the exterior surface, are not squared on the other faces. The blocks are deposited the one between the other, and represent perfectly as to their shape, their mass, and their connexion, those ancient buildings celebrated for their solidity, and known by the name of *Cyclopean* structures.

After having given an idea of the construction of the Breakwater, we have to speak of the means employed to extract the marble from the quarries, in order to ship it in vessels, peculiarly adapted to that purpose, and discharge it at the proper place. These means are generally as simple as ingenious, and seem to us to merit the particular attention of persons connected with the art.

The hills, from which the marble is extracted, extending to the margin of the Plym, quays have been erected on this shore, in order to procure convenient places for shipping the stone where several vessels might load, or take in their cargo at the same time. These hills are every where covered with a stratum of vegetable mould of greater or less thickness. This top-soil is gradually removed before the rock it covers is blasted, and the quarry-men proceed to work the hill from top to bottom, by cuts nearly perpendicular. The earth which is removed, and the small splinters of marble proceeding from the excavation, are heaped together, and form an artificial hill that rises by the side of those which are gradually seen to disappear. With iron chains, flying-bridges have been thrown from the top of the new hill to the top of the primitive hill. The workmen, with hand-barrows, accomplish on these bridges the removal of the top-soil. The working of this quarry did not appear to me to present any particular proceedings, it is only much easier, when the marble is found in perpendicular strata, than in those which are horizontal. A geological fact, which is not unexampled, but which still appears remarkable, is, that there are, in the same hill, strata nearly horizontal, contiguous to others nearly vertical. The largest blocks, which are reserved for the outward and upper parts of the Breakwater, are extracted from these latter strata.*

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* In working these quarries, an extraordinary phenomenon was discovered in the very body of the great mass of this old marble rock. At the depth of sixty-five feet from the summit of the rock, and twenty-five from the margin of the sea, a cavity, or rather a nodule, of clay was discovered, of twenty-five feet long, and twelve square, or thereabouts, in the midst of which were found several bones of the rhinoceros, in a more perfect state, and containing less animal matter in them, than any bones that have yet been dug out of rock or earth. The particulars, as given by Sir Everard Home, may be seen in the first part of the *Philosophical Transactions* for 1817.

TRANSLATOR.

At the foot of each cut of the hill is a row of cranes established in a manner extremely simple. Their foot rests upon a metal socket, fixed in a square frame of wood, so that the whole can slide together as wanted, the crane standing erect; their head turns in an iron collar furnished with rings, to which are fixed iron chains. These chains, to the number of four or five, are directed, some downwards, and are fastened to hook staples fixed in the ground; the others upwards, and are fastened to the summit of the hill. As the excavation proceeds, the fastenings of the chains are altered, and the row of cranes is advanced, as required, so that the blocks of marble detached from the quarry, and thrown down by the workmen, may every where be laid hold of by some crane. Each of them is worked by means of a double winch, on the axis of which is a pinion; this pinion turns a cogged wheel which catches the pinion fixed to the cylinder or roller, on which the chain that is to raise the load is wound and unwound. Two men are sufficient for managing each crane. One hooks together the two ends of the chain round the block to be lifted; the other turns the winch. As soon as the block is disengaged from those which surround it, the labourer who has fastened the chain to it pushes it with his hands, and makes the crane turn round on itself, till the load plumbs a truck, which runs on four small wheels of cast-iron, and of equal diameter. The block being placed on this truck, the two men who work the crane, proceed to extract another block of marble, and to load it on another truck.

These little trucks are provided at each end with two strong iron handles for hooking on the traces of a horse, either before or behind; according as it is wished to make the truck proceed forward or backward, as it cannot turn on its wheels. The wheels traverse on the grooves of an iron rail-way, prepared for that purpose. These rail-ways lead to the different parts of the quays, and branch out to each of the cranes, the working of which we have just described. As soon as a truck is loaded by these cranes, a driver comes with his horse, whose traces he hooks to the iron handles at the fore end of the truck. He sets off, and goes a little before his horse, in order to lay aside all the iron turn-plates, which serve as a border to the iron rail-way, at the places where two roads crossing each other, their border must take two different directions in this point of intersection.

The rail-ways lead to the place for shipping the marble parallel to the quay. It is necessary to cause the truck driven in this direction to take a little sweep, in order to be able to ship it in the vessel that is waiting for it at the margin of the quay. For that purpose, at the end of the rail-way, is placed a circular plate of cast-iron, having, on two parallel curved lines, ribs or

borders which form the continuation of the track of the rail-way. This plate is suspended on a pin beneath its centre (which is in the middle of the track) there being a circular ring under its circumference, which moves round freely, by means of a considerable number of small wheels or rollers, whose axles are fixed therein, upon another circular plate of iron, fixed in the ground, which prevents it from tilting on one side or the other.

The driver having brought his truck to the plate, the two borders of which then lie in the direction of the track, he takes off his horse, and turns with his hand the plate with the truck, till the borders of the plate are in a line with those of the short piece of rail-way that leads to the vessel, lying perpendicularly to the quay. A strong beam is stedfastly let into the edge of the quay. Two beams laid perpendicularly to this on the continuation of the sides of the short piece of rail-way, are fixed with solid hinges in front of the immoveable beam. The iron ribs of the road are laid along these two beams, which can be raised or lowered, by means of the hinges fastened to the fixed beam. This disengaged end of the two beams is placed on the sill of one of the stern-ports of the vessel to be loaded. According as the tide is high or low, the beams change their inclined position; but, on that account, they do not cease to rest on the port-sill.

The vessels employed for carrying off the large blocks of marble are of a peculiar construction, adapted to convey, wih ease, masses weighing from three to five tons each, and more; and to take these on board, they lie with their sterns to the quay. They have but a single deck on which are fixed two iron rail-ways; one on the starboard or right side, the other on the larboard or left side. Two similar rail-ways are fixed in the same direction in the hold. A winch established in the middle of the vessel, and set in motion by means of iron wheel-work, causes the truck to advance from the circular plate on which we left it, and bring it on board with its burthen.

The two stern-ports are made sufficiently large to receive the trucks with the stones upon them, and the after part of the deck under the tiller is divided into two parts, length-ways, and made to move up and down, the fore-parts being secured to a beam by hinges. This moveable deck allows the stones to go down into the hold. Each truck is passed separately through the port-hole, on an inclined plane, and run to the fore part of the vessel on the iron rail-way before-mentioned. To prevent accidents, from its weight carrying it down too suddenly, to the hind part of the truck, is hooked a relieving tackle, the rope or fall of which is eased off gradually. It may easily be conceived that, to insure the stability of the vessel, no more trucks are put

on one side than on the other; the two sides of the hold are calculated to contain eight of these loaded trucks, which, at five tons on each truck, gives eighty tons of stone for one cargo, independently of two or three trucks which may be carried on each side of the vessel's deck.* With a single horse to bring the trucks on the circular plates, serving to turn the trucks and back them towards the vessels, the driver of this horse, and six or eight men for attending to the winch and the tackles, a cargo of sixty tons and upwards is shipped in *fifty* minutes.

The sight of the operations which I have just described, those enormous masses of marble that the quarry-men strike with heavy strokes of their hammers; and those aerial roads or flying bridges which serve for the removal of the superstratum of earth; those lines of cranes all at work at the same moment; the trucks all in motion; the arrival, the loading, and the departure of the vessels; all this forms one of the most imposing sights that can strike a friend to the great works of art. At fixed hours, the sound of a bell is heard in order to announce the blasting of the quarry. The operations instantly cease on all sides, the workmen retire; all becomes silence and solitude; this universal silence renders still more imposing the noise of the explosion, the splitting of the rocks, their ponderous fall, and the prolonged sound of the echoes.

Near the quarries are established several work-shops for repairing the tools and the trucks, as well as for supplying the vessels with necessary stores, &c. A small square building serves as an office for the superintendent and a few clerks, who, with proper officers under him, are sufficient for keeping and controlling the accounts of an undertaking the annual expence of which amounts to two millions five hundred thousand francs.†

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* The stones being frequently longer than the trucks, the number carried in the hold must be proportioned accordingly. In bad weather, it is unsafe to send many trucks on deck; and, in general, not more than four are sent into the Sound, in that way, at one time. The amount of the cargoes, therefore, varies according to circumstances, from forty to sixty-five tons; the largest stone hitherto deposited being about eight tons. TRANSLATOR.

† The small establishment for constructing the Plymouth Breakwater, and the expeditious manner in which that work has been carried on, under the skilful and judicious direction of Mr. Whidbey, form a very striking contrast to the multitude employed on the Breakwater at Cherbourg, and the time occupied in that undertaking. The whole number on the Breakwater establishment at Plymouth, including quarrymen and labourers employed under the contractor, masons, blacksmiths, carpenters, &c. together with the warrant-officers and all the seamen employed in the stone-vessels, and the assistants, clerks, &c. to the superintendent, amount to about 650 persons. At Cherbourg, the numbers of artificers of different descriptions employed was prodigious, and with the labourers, amounted, on the average, to upwards of 1500, to whom were generally added 3000 soldiers, making an aggregate of between 4000 and 5000 men. TRANSLATOR.

Two contractors are charged with all the operations; the one, with the conveyance of the stone by the vessels; the other with the working of the quarries and the construction of the pier or Breakwater.

All the vessels employed in carrying the materials have been previously gauged. This gauging is indicated by scales, marked on the stem and stern-post of each vessel. Consequently, it is sufficient when a cargo is complete, to read on these scales how deep the vessel is in the water, to know the weight she carries. This weight is the basis according to which all the operations are paid. On the one hand, so much per ton is given for the marble conveyed by the vessels, and on the other, so much for having extracted that ton from the quarry, and deposited it in its assigned place on the Breakwater.

The work was begun four years ago, that is, in 1812. One hundred thousand pounds have been appropriated to it every year, and it will still require five hundred thousand pounds to complete all the intended operations, in the course of five years. Thus, the Breakwater in Plymouth Sound will have cost, when completed, twenty-two millions five hundred thousand francs.*

The quantity of marble deposited in the line of the Breakwater, on the 20th of September, 1816, was nine hundred and forty-four thousand five hundred and one tons. Supposing that, at the end of the year, there was, in all, but a million of tons sunk, they will have cost ten millions of francs: which gives an average of ten francs for the quarrying, the transport, and the placing of a ton.†

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* M. Dupin is mistaken in saying that, since 1812, 100,000l. a year have been appropriated to the construction of the Breakwater; so large a sum never having been granted in any year; in 1817, no more than 50,000l. were voted for that object. The whole sum expended on the Breakwater and the new watering-place at Staddon Point, to the end of the year 1818, amounted to about 500,000l.

TRANSLATOR.

† The quantity of stone deposited from the 12th of August, 1812, when the work was commenced, to the 30th of April, 1819, is 1,412,252 tons. The original contract price for quarrying the stone was 2s. 9d. per ton, and the original price for conveying it to the Breakwater 2s. 10d. per ton; since which the former has been reduced to 2s. 3d. and the latter to 1s. 10d. per ton. The cost of each ton of stone sunk on the Breakwater, including the building of quays, purchase of land, salaries, and every other expence, according to the nearest calculation, amounts to about 8s. 1½d.

At this time (May 1819) the whole base or foundation of the Breakwater is laid to its intended length of 1700 yards, 1500 of which are dry at low-water of spring-tides, and 500 yards of this great work are completely finished. With respect to the probable period of its completion, that will entirely depend on the money which Parliament may think fit to grant annually for that purpose; but, on the supposition that the sum should be equal to what has generally been voted for this national work, it may be finished in six years, or sooner if required, and at an expence considerably less than the original estimate.

TRANSLATOR.

When the vessels arrive close to the Breakwater, they first make fast to buoys, laid down in lines parallel to the direction of the pier, one row within, and the other without; they afterwards place themselves in the exact position which may be assigned to them. They let down their stern-ports by which they took in their cargo, and which then become the ports for discharging it. These ports turn on very strong hinges fixed to their lower side; while their upper side is kept in a horizontal position by means of strong chains, which, when the port is lowered, are made fast to a timber-head above the stern. The runner of a tackle is hooked to the fore-part of the truck to be unloaded, and lashed down to the after-end over the stone, which prevents the latter from slipping off the truck, in its progress up the inclined plane near the stern-port. By means of the winch on the deck of the vessel, this truck is drawn up the inclined plane to the edge of the port, when the lashing being slipped, the runner being still fast to the fore part of the truck, as before-mentioned, raises it up as the winch goes round, and by that means, the stone is canted, and falls overboard. This being done, the empty truck is hoisted up to the after part of the deck, and then run forward to make room alternately for the others, in succession, till all the trucks have been discharged. In this manner, the operation of discharging a cargo of sixty or eighty tons is completed in the space of forty or fifty minutes. There are upwards of fifty vessels employed in these operations.*

To manage the enormous blocks which must be systematically deposited, from the level of low-water spring-tides to the top of the pier, a vessel with a substantial and bulky prow is employed, on whose deck is erected a pair of sheers, with their

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* It is to be observed that there are but ten vessels of this peculiar construction, so extremely well calculated for carrying large masses of stone, which were built in the King's yards. All the others, employed in carrying stones from the quarries are hired by contract, and are about fifty tons each. The contractors' vessels, not being of a construction so peculiarly well adapted to the purpose as those in the immediate employ of Government, carry stones of less weight, which are hoisted out of the hold by a chain and winch, and thrown overboard. It requires about three hours to discharge a cargo of fifty tons from one of these vessels. TRANSLATOR.

The greatest quantity of stone sunk by all these vessels, in any one week, is estimated at 15,379 tons. The proportion of the different sizes of the blocks deposited in the line of the Breakwater, during the first four years of its construction, that is from the 12th of August, 1812, to the 12th of August, 1816, is stated to be nearly as follows:

Of one ton each and under	423,904
— one to three tons each	309,706
— three to five tons each	150,593
— five tons and upwards	12,760

In calms, the stone-vessels are warped across the Sound by means of small tow-lines passed round the barrel of the winch fixed in the plane of their deck. TRANSLATOR.

heels well secured, and from their head, which is also strongly lashed, descends a tackle, worked by a winch fixed on the deck; while, by means of a hawser passed round a crab or small capstan, the vessel is brought close to the Breakwater, or otherwise, as may be required. It appears to me impossible to employ machinery more simple or more advantageous for lifting and placing stones on a slope very little inclined, which, consequently, requires that the sheers, established on board the vessel, should have a very considerable projection; in order that the vessel may not be under the necessity of lying so close to the pier as to strike against it, while in the act of weighing the stones and carrying them to their proper places.

Other small fixed cranes which have nothing remarkable, are established at different points of the pier, for the purpose of moving and placing, as required, the stones last deposited.

Such is the rapid sketch of the great operations pursued in the construction of that national work, the Breakwater in Plymouth Sound. The admiration excited by the sight of such an undertaking, is considerably increased by the idea of the celerity of its execution. This at the same time reflects no less credit on the enlightened government, which causes to be made at an immense expenditure, with a view to attain an object eminently advantageous to the public service, than on the diligent and skilful men, who, by means the most quick, the most ingenious, and nevertheless the most simple, have contrived to surmount the greatest difficulties.

It was my friend, Mr. John Rennie, who furnished the plan of the Breakwater at Plymouth, in concert with Mr. Joseph Whidbey, the immediate superintendent of the works, who projected the different modes of proceeding which we have made known. Mr. Whidbey accompanied Vancouver in his voyage of discovery round the world, and has displayed his talent for mechanics in an interesting Memoir on the method employed for raising the *Ambuscade* frigate.* I am indebted to his excessive kindness for the

* In the *Philosphical Transactions* for 1802 may be found Mr. Whidbey's account, illustrated by drawings, of the simple means which he so ingeniously applied to raise or weigh this Dutch frigate Ambuscade, which, on the 9th of July, 1801, went down by the head near the Great Nore, in half an hour after she had left Sheerness harbour, not giving the crew time to take in the sails, nor the pilot or officers more than four minutes' notice before she sunk; by which unfortunate event twenty-two of the crew were drowned.

This extraordinary accident was owing to the hawse-holes being extremely large and low, the hawse-plugs not being in, and the holes being pressed under water by a crowd of sail on the ship, a sufficient body of water got in, unperceived, through these large apertures, to carry her to the bottom. The instant she sunk, she rolled over to windward across the tide, and lay on her beam ends; so that at low-water, the muzzles of the main-deck guns were a little above the surface of the sea, and pointed to the zenith, with thirty-two feet of water round

explanation, given, as well ashore as afloat, of all the operations which he directs with indefatigable zeal and attention.†

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her. The merit of Mr. Whidbey, in this instance, consisted in the process he employed *to remove the effect of cohesion*; the idea was *new*; and, as he himself very justly observes, if the same principle had been acted on in the attempt made to weigh the Royal George, sunk at Spithead in 1782, there is every reason to think it would have succeeded. TRANSLATOR.

† The beneficial results of this great work deserve to be more generally known, in order to be more fully appreciated. It has completely answered the expectation of its warmest advocates, there being no appearance of any deposition of mud or silt collecting within it, which it was apprehended, by some, would take place, and, of course, lessen the depth of water. In southerly gales, the sea is so much broken down in the Sound, that ships of war of all rates, as well as merchant-vessels, in great numbers, now run in and bring up behind the Breakwater, where 25 or 30 sail of the line may find a secure anchorage. To increase its advantages as a convenient rendezvous for a fleet or squadron, a large reservoir, capable of supplying a quantity of water sufficient for 50 sail of the line, has lately been constructed above Bonvisand Bay. This water is brought down in iron-pipes to Staddon Point, where a jetty is building from which it will be furnished to the boats of the ships lying in the Sound.

But it is not only to ships in the Sound that the Breakwater affords safe shelter, its advantages also extend to those lying in Catwater, which is thereby rendered a secure and commodious harbour. In the tremendous hurricane which occurred during the night of the 19th of January, 1817, when the Jasper sloop of war and Telegraph schooner were lost in consequence of having anchored without the Breakwater, none of the shipping, then in Catwater, sustained any damage; and it was the general opinion that, but for the protection of the Breakwater, the whole of them must have been wrecked, and all the buildings in that quarter, near the sea, been entirely swept away, the tide having risen six feet above the ordinary height of spring-tides. Previously to this tremendous gale, none of the stones in the Breakwater appeared to have moved; but, afterwards, it was found that several of them, in the upper part, had been carried over to the northern slope. In fact, this hurricane has had the desirable effect of bringing the stones to their natural position, so that no danger is to be apprehended from any future southerly gales, although the heavy seas which they bring into the Sound, may, no doubt, occasion some of the stones recently deposited to settle and find their base, until the whole sea-face of the fabric shall acquire the exact slope which the sea will give it, and ultimately become so consolidated by the action of that unruly element, as to brave the impetuosity of its most violent efforts.

Before we quit the subject of the Breakwater, it may not be uninteresting to state, that the construction of a pier (by means of large blocks of stone promiscuously sunk on an intended line, and there left to find their own base and natural position) in order to shelter a port from the violence of the waves of the sea, is not a new thing in this country. There is a rubble pier or Breakwater of this description, now in a perfect state, not far from Plymouth, at a place called Port Wrinkle, situated nearly in the middle of Whitesand Bay. It may be seen in Mudge's large Map of Devonshire. There are accounts of vessels having frequented this port as far back as 150 years; but, before that period, no information can be obtained respecting it, nor is there any clue for tracing when, or by whom, it was constructed, or any further particulars about it whatever. It is now used as a fishing-station, and for laying up the boats belonging to a company engaged in the pilchard-fishery.

From the statement of this fact, M. Dupin may learn that the English had, close at hand, a rubble pier, erected by their ancestors, to refer to (if necessary) in constructing the Plymouth Breakwater, without looking across the Channel in order to imitate the radically-defective example of the French, in the construction of the pier at Cherbourg. TRANSLATOR.

DESCRIPTION

OF THE

CALEDONIAN CANAL

PRECEDED BY A FEW

Observations on the State of the Highlands of Scotland.

THE Caledonian Canal alike merits the attention of engineers, economists, and statesmen, from the magnitude of the operations which it requires, and the difficulty of their execution; from the influence of that great national undertaking on the industry and the culture of the surrounding country; and in short, from the commercial revolution that must be produced by changing the route of the ships which are now, with no trifling danger, compelled to go to the northward of the Orkney Islands, or through the Pentland Frith, in order to proceed to the Baltic from the Atlantic Ocean, and *vice versa*; while, henceforth, those vessels will find a much shorter and safer route for effecting the same passage.

The celebrated James Watt, to whom Europe is indebted for the application of steam-engines to the useful arts, and who, at the commencement of his career, exercised the profession of a civil engineer at Glasgow, made, as far back as the year 1773, a survey of the central Highlands of Scotland; a mission which was intrusted to him by the Commissioners or Trustees of the estates forfeited in consequence of the rebellion of 1745. Among the means of improvement proposed by Mr. Watt for these districts, were the formation of the Crinan Canal,* and also of the Caledonian Canal, which he proposed to open between Inverness and Fort William. We shall first explain the motives which have led to the construction of this canal; they are essen-

* The object of the Crinan Canal is to shorten the passage for ships between the Irish Sea and the River Clyde, by means of Loch Finnhe, and thus avoid the navigation round the peninsula of Cantire, an isthmus which it traverses. It commences at Loch Gilp, and terminates at Loch Crinan. It is said that, by means of this canal, a passage may be made in three or four days, which not unfrequently took up three weeks. It was commenced in 1793, under the direction of Mr. J. Rennie, and completed in 1817, under Mr. T. Telford. Parliament, at sundry times, granted upwards of 70,000*l.* towards its completion. The total expence was 200,000*l.* TRANSLATOR.

tially connected with the political state of the Highlands of Scotland.

When, in 1745, the Pretender to the crown of England endeavoured to recover the throne occupied by his ancestors, it was into the Highlands of Scotland that he first came to seek partizans. The heads or leaders of the clans* had only to raise the standard of rebellion, and blow the martial bagpipe,† in order to assemble their vassals, ever ready to take up arms on the slightest symptom of commotion. With men inured to fatigue and despising danger, the Pretender, carrying all before him, proceeded, as in triumph, to the very heart of England. At length, after many hasty and inconsiderate exertions, and various partial successes, his little army was defeated; he fled, and left his partisans, a prey to the vengeance of the established government.

The first act of that vengeance fell on the feudal system, which kept in a state of ignorance and dependence the people of the Highlands. A great number of chiefs had fallen in battle, others had fled their country, and others died on the scaffold. The estates of these men were confiscated, and the lairds, who, more fortunate, were able to escape from the general disaster, lost for ever their political and military influence over their clans. Most of them soon ceased to reside in the midst of their vassals; some got into the parliament; others attached themselves to the court; others again, by acquiring English manners, found themselves disgusted with home, and were infected with the mania of travelling. At the expiration of a few years, this transmigration of the *lairds* produced a complete revolution in the state of the Highlands.

The lairds, when they formerly resided on their estates, derived their power and their importance from the number of men that they were able to lead to the chase during peace, or to the field during war. They had, therefore, then every thing to gain by increasing the population of their domains. They permitted and encouraged the division of their lands into a great number of small parcels, each of which was sufficient for the scanty existence of a sober and numerous family.‡ But when this feudal

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* The clans are distinct tribes that marched to war under independent chiefs, and, as a sign of independence, wore garments of chequered plaid, the squares of which varied in colour according to the respective clans.

† The bagpipe is still for the Scotch regiments what the fife is for the regiments from the south of France. During battle, the bagpipe plays favourite Highland tunes, and this barbarous music kindles in the heart of the Highlanders all the enthusiasm of the heroes of ancient Caledonia.

‡ This division of lands, and the sub-division of the lots or portions, were renewed, at certain periods, between the vassals, and without the interference of

patronage had been rendered nugatory, by the enlargement of the royal authority; when the lairds, disgusted with a residence which no longer afforded to them the charms of absolute power, and attracted by the seductions of the capital, and the offers of the court, had deserted their mountains, they considered their feus merely as farms which it was necessary to cultivate according to the general principles of domestic economy, that is to say, with the fewest possible hands, and also in order to obtain from them the most money possible. The little fields, which sufficed for the support of so many families, were soon thrown into extensive pastures.

It happened, then, that the children of Caledonia were dispossessed, all at once, of the land which, for some thousand years past, they had cultivated and preserved free, even from the yoke of the Romans. It was in vain that endeavours were made to entice them to the more fertile regions of England and of the Lowlands of Scotland. When one leaves the paternal roof, one must remove so far that no external object recals it to mind! The unfortunate Highlanders turned their eyes towards America, and they quitted, in immense numbers, the land of their ancestors.

The government, alarmed at this emigration, was apprehensive that if that race, hardened by the rudest of climates, totally abandoned their native country, no inhabitant of the provinces, more favoured by nature, would be willing to go and fertilize, in their stead, an ungrateful and repulsive land. The greatest efforts were therefore made, at the expence of the State, to better the condition of those Scotch Highlanders who still remained. A number of good roads were cut through the gorges of mountains, where there was no passing before but by rugged and almost pathless tracks; every encouragement and facility were given to the establishment of fishing-stations all along the sea-coasts, and on the borders of the principal lochs or lakes; in short, great perseverance was exerted to import into these deserts the benefits of civilization, by forming schools, propagating the Bible, and the knowledge of the English language, &c.

In order to make known the remains of the ancient spirit of the lairds of the Highlands of Scotland, I shall offer but a single instance, yet it is sufficiently striking and characteristic. In following the line of the Caledonian Canal, along Lake Oich, I crossed the vale or *glen* of *Garry*. I passed first in front of an indifferent house, built near the ruins of an old castle, a remnant

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the laird. Strength decided the lots, and the head of the family said to his wife, on the day of division—"*Wife, give me my dirk; I am going to the allotment of the lands.*"

of the power of the Mac Donells over the surrounding country. Over the door of the new mansion, I saw suspended, as emblems of triumph, heads of deer, and carcases of wild birds: these were the trophies of the *chieftain*, in the annual hunting-matches in which he assembled the Highlanders of his clan, together with the visiters from the neighbouring clans, all clad in kilts and their thighs bare. These hunting-matches last three days. At night they sleep in the forests, and at length they return to the castle to eat the produce of the chase, and quaff their favourite whisky,* to an excess which not unfrequently terminates in savage broils.

In pursuing our route, at some distance from the castle, we arrived at the foot of a monument which made us draw back with horror. Before I give a description of it, the reader must know that, upwards of two hundred years ago, a noble family having made several of its vassals experience some acts of injustice, seven among them joined and destroyed part of the family, or at least every probability indicated them as perpetrators of this deed. Immediately the laird, in whose clan the crime had been committed, sent his satellites with orders, neither more nor less, than to bring to him the seven heads of the offenders. These unfortunate men were found concealed in a cavern, whither they had fled for refuge. There they were beheaded, and their heads were carried to a spring near Glengarry Castle, and washed; when they were thus rendered more fit to be presented, they were carried to the laird who had demanded them.

Over this small spring, on the bank of Loch Oich, now rises a pyramid with four faces, the truncated shaft of which bears seven heads, fixed in a circle on the summit of the pyramid, thus offering on all sides their hideous features. Their hair, bristling on their skulls, is grasped by an enormous hand, holding a dagger or dirk, from which blood is dropping. On the four faces of the pedestal or base of the pyramid is written in French, in English, in Latin, and in Gaelic, the inscription which serves as an explanation to the monument.†

When I visited this spot, there was a dreadful storm, and the rain was falling in torrents; nevertheless, I alighted from my horse, and copied literally the following inscription:

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* A strong liquor, obtained by the distillation of wheat; that of the Highlands is celebrated for its quality, and is an article which occasions a considerable contraband trade.

† This monument was executed by a skilful artist at Edinburgh, and is said to have cost no trifling sum.

AS A *MEMORIAL*
OF THE *AMPLE* AND *SUMMARY*
VENGEANCE,
WHICH IN THE SWIFT COURSE OF
FEUDAL JUSTICE,
INFLICTED BY THE ORDERS OF
THE LORD McDONELL AND AROSS,
OVERTOOK THE PERPETRATORS OF
THE FOUL MURDER
OF
THE KEPPOCH FAMILY,
A BRANCH OF
THE POWERFUL AND ILLUSTRIOUS
CLAN,
OF WHICH HIS LORDSHIP WAS
THE *CHIEF,*
THIS MONUMENT IS ERECTED BY
COLONEL McDONELL, OF GLENGARRY,
XVII. MAC-MHIA-ALAISTER,
HIS SUCCESSOR AND REPRESENTATIVE,
IN THE YEAR OF OUR *LORD,*
1812.
THE HEADS OF THE SEVEN MURDERERS
WERE PRESENTED AT THE FEET OF
THE NOBLE *CHIEF*
IN GLENGARRY CASTLE,
AFTER HAVING BEEN WASHED
IN THIS SPRING,
AND EVER SINCE THAT EVENT,
WHICH TOOK PLACE EARLY IN
THE SIXTEENTH CENTURY,
IT HAS BEEN KNOWN BY
THE NAME OF
"TOBAR-NAN-CEANN,"
OR
THE *WELL* OF THE *HEADS.*

May my feeble voice make known this infamous monument from one end of Europe to the other; and may nations feel what difference exists between arbitrary sentences, the prompt, the haughty exterminations of feudal tyrants, and the constitutional verdicts of our free juries! I return to my subject, from which I have made a little digression, because a deeper interest impelled me to the statement of a fact not known, and too well deserving to be made public.

The Highlands of Scotland are divided into two parts, nearly equal, by a chain of lochs or lakes in a straight line from north-north-east to south-south-west. These are Lochs Ness, Oich, Lochy, Eil, and Linnhe. The great length of these lochs, and their singular position, indicated, by the mere inspection of the local state of the country, an easy communication between the two seas which washed the east and west coasts of Scotland. For that purpose it was sufficient to open, between the first three lochs and the two seas, a canal, the total length of excavation of which does not exceed twenty-two miles; while the distance comprised between the entrance of Inverness Bay (at Fort George) to the outlet of Loch Linnhe, is at least one hundred miles.*

In 1802, the Lords of the Treasury, in order to ascertain, with greater precision, what it would be possible to undertake for the benefit of the Highlands of Scotland, in connexion with other important measures, directed Mr. Thomas Telford to make a general survey of the coasts of Scotland, and central parts of the Highlands. The Report which he, in consequence, drew up, involved a variety of considerations, connected with the improvement of the Highlands, and the employment of the population of these districts, and amongst these, he renewed the proposal made by Mr. James Watt, of opening a canal from Inverness to Fort William, that is, an inland navigation from Loch Beauly and the German Ocean on the eastern coast, to Loch Eil and the Atlantic Ocean on the western coast. Mr. Watt proposed that this canal should be ten feet in depth, or two feet more than the Forth and Clyde Canal, (which was originally called the *Great Canal;*) but Mr. Telford, considering the great command of water from the chain of lochs or lakes on its lines, and that the advancing spirit of maritime adventure had gradually led to an increase in the dimensions of merchant-ships, thought that it would be more advantageous to form a canal capable of affording a passage to the largest class of Baltic traders, and even, in case of need, to thirty-two gun frigates. He therefore proposed to give a depth of twenty feet to the Caledonian Canal.

* The idea of connecting this singular chain of lochs or lakes, into a navigation for ships, as has now been done by the construction of the Caledonian Canal, has been in agitation ever since the reign of Charles II.

TRANSLATOR.

The Committee, appointed by Parliament, to give an account of the situation of the Highlands, and of the means of improving them, examined Mr. Telford's plan; and, in order to ascertain still more positively the practicability of its execution, as well as the probable expence of the intended canal, they called before them Messrs. Jessop* and Rennie, two of the most eminent civil engineers at that time in England, besides some of the most experienced maritime surveyors, and merchants in the kingdom. Skilful mariners were likewise examined on points regarding the navigation of the canal and the lochs, as well as the anchorage for large vessels. Returns were also procured from the ports of Dublin, Liverpool, Greenock, Leith, Aberdeen, and Peterhead, concerning the probable advantage of the proposed inland navigation, and to what extent it might be useful to ships habitually sent from the German Ocean into the Atlantic, or *vice versa*.

The Committee, having considered all the evidence laid before them, recommended, in their Report, the execution of the plan proposed by Mr. Telford. In consequence, a Bill was accordingly brought into Parliament in the Session of 1803, for granting to His Majesty the sum of 20,000*l.* towards defraying the expense of the proposed canal; which act received the royal assent in July of the same year. By the act, which thus decided that the canal should be made at the cost of the State, a Board of Commissioners was nominated to superintend the necessary works and expences, who immediately appointed Mr. Thomas Telford to be their engineer, and ordered him to make again an entire survey of the whole line of the canal from Inverness to Fort William. Mr. Jessop was likewise charged to inspect the whole line, and to add thereto his particular estimates, with a view of furnishing to the Commissioners, in this manner, a double certainty in regard to the operations to be undertaken. Trial-pits and borings were accordingly made from shore to shore, at distances not exceeding half a mile, to ascertain the soil. At the same time, Mr. Murdoch Downie, an experienced seaman and maritime surveyor, was employed to make a survey of the chain of lochs upon the intended line of navigation, in order to sound and determine their respective depths and anchorages.

The length of the fresh water lochs or lakes comprised between the different parts of the artificial canal, is thirty-seven miles and a half, and the extent of the canal to be formed and cut is about twenty-one miles and a half, making a total distance of inland navigation from sea to sea of fifty-nine miles.

The width of the canal, at the bottom, is fifty feet, with rising

* Since dead.

slopes of eighteen inches to a foot, which are continued to within two feet below the summit level of the waters. There, a horizontal *benching* is made six feet wide. Then, the slopes resume their direction as in the lower part, and rise to an even height with the ground bordering the canal. The object of the *benching* before-mentioned is:—1. To prevent large vessels from coming too near the edge of the canal, and destroying the slopes near the water-line.* 2. When from natural decay and wear, or from the effect of the navigation of small vessels, some part of the upper slope shall have fallen down, that part stopped by the benching will not choke the bottom of the canal, and it will always be very easy to cleanse a benching which is but six feet beneath the level of the water. It seems to me that this plan deserves to be adopted in the formation of all great canals. The depth of water of the canal is twenty feet. Consequently, the slopes of the sides being given in the ratio of ten to fifteen, from the height to the base, that part of the water which covers the inclined sides, for twenty feet of height, is on each side thirty feet wide, which makes sixty feet for the two sides. Let us add twice six feet, the width of the two benchings, we have then at length for the width of the canal at the upper surface of the waters: fifty feet, added to sixty feet, and twelve feet, or one hundred and twenty-two feet.

The differences of level are to be overcome by twenty-three locks, besides three regulating-locks, which were first intended to be thirty-eight feet in width by one hundred and sixty-two feet in length. But, in order to render the locks fit for the passage of thirty-two gun frigates, their width was increased to forty feet, and their length to one hundred and seventy-two; the depth of water still remaining at twenty feet.

In 1804, the preparatory operations of surveying, sounding, and tracing the intended line being finished, the excavation of the canal was commenced, and the number of workmen having been increased to nine hundred, it became necessary to appoint resident engineers, particularly at the extremities of the line to which the first works were entirely confined. Mr. Matthew Davidson, who had acquired much experience under Mr. Telford, at the works upon the Ellesmere Canal, particularly at the great aqueduct of Pont-y-cyssyllte, in Denbighshire, was appointed to the eastern division, and Mr. John Telford, a relation of the chief engineer, took charge at the western end.

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* It is, besides, a great advantage to compel vessels to pass at some distance from the brink of the water, because the eddy between the brink and the ships is then far less considerable, and injures the bank less, than when the ships almost graze the bank.

We shall give elsewhere a table of the prices of the work, which, perhaps, will be somewhat interesting to French engineers. It is now necessary to enter into greater detail respecting the description of the coast and of the country in the line of the canal.

The east coast of Scotland, after having stretched to the north-north-west, almost in a straight line from St. Andrew's Bay to Peterhead, trends to the west, and follows almost regularly the direction of a parallel of the land from Kinnaird's Head to Burgh Head, situated at the entrance of the Murray Firth.

The form of the Murray Firth is nearly that of an isosceles triangle, with its base resting on the German Ocean, and its summit extending to near Fort George. This fort was built by George II. to overawe the inhabitants of the Highlands of Scotland, northward of the Murray Firth. It is placed on a peninsula, and its fire reaches to the opposite coast. The strait between Fort George and that coast, leads to Inverness Bay, which is spacious and deep. The town and old fort of Inverness, situated near the head of this bay, were built by a military colony, settled by Cromwell, in order to insure the subjection of the Highlands of Scotland to the power of England.

To the north of Inverness, Loch Beauly is joined by a wide channel to Inverness Bay. Near the junction of this loch and bay, on the southern shore of Loch Beauly, is the *eastern entrance* of the Caledonian Canal. In the Scotch language, the towns or burghs situated at the mouth of rivers, commonly bear the name of the river on the bank of which they are built.

Thus, the name of Inverness informs us that this town is situated on the River Ness, and at its mouth. The Ness is a winding river, very considerable in size, and very rapid, which discharges, over sand and flints, the superabundant waters of Loch Ness. This river not being navigable, it was necessary to dig a canal parallel to it, from the entrance we have just mentioned, as far as the northern extremity of Loch Ness. Loch Ness is twenty-two miles in length, from one to two miles in breadth, and, in some parts, one hundred and twenty-nine fathoms in depth; it is all clear of rocks and shoals, and has some well protected bays and anchorage.

Loch Oich, about five miles distant from Loch Ness, discharges its waters by the River Oich, parallel to which it was likewise necessary to dig a canal, as far as the south-west extremity of Loch Ness, at Fort Augustus. A third part of the canal extends, upon the summit level, between Loch Oich and Loch Lochy. The last pours its waters into the Atlantic Ocean, by a large river, still more rapid than either of the others. It was,

therefore, necessary to dig a fourth portion of the canal parallel to the last-mentioned river.

The western entrance of the canal is in Loch Eil, near Fort William. From there, ships immediately pass into Loch Linnhe, and thence enter the open sea, at the south end of the Sound of Mull.

We shall successively examine the works of the four parts which it was necessary to excavate by manual labour, in order to form the Caledonian Canal, and, in so doing, follow the order in which they have already been mentioned. The precise spot originally intended for the Eastern sea or tide-lock, was rather to the eastward of the present site; but the ground, upon trial, was found to consist of coarse loose gravel, and not to answer the purposes of a foundation for masonry. The sea-lock of Clachnaharry is about three quarters of a mile to the westward of the much-frequented Ferry of Kessoch. It is placed upwards of four hundred yards from high-water mark, projecting into the sea, where a depth of water equal to about thirty feet will be obtained at high water of spring tides. It became necessary to lay down an immense quantity of earth, in the form of two parallel mounds, extending from the shore where the second canal-lock is placed into Beauly Forth. This was partly taken from the rubble-stone quarry of Clachnaharry, and partly from an adjacent hill, consisting of a kind of indurated clay; it was intended to answer the purposes of a coffer-dam, and consolidate the subsoil or strata of matters deposited from the joint operation of the River and Firth of Beauly. These strata, when bored to the depth of about fifty-four feet, were found to consist of soft bluish clay, or mud, overlaying a whitish clay, similar to the neighbouring hill of Clachnaharry. These mounds of rubbish, extending into the sea, settled and subsided so much, as to require an additional stratum of eleven feet in thickness to restore them to their former level. This suggested the propriety of laying also a quantity of earth between these mounds upon the site of the sea-lock, which in the same manner had the effect of compressing the subsoil, and preparing it for the immense weight of masonry it had to support, which could not have been the case, had it been built with a coffer-dam; the finished work might, in that case, have subsided, as the mounds had done, which would have been productive of the most serious consequences.

When the mass of earth and clay had sufficiently subsided, operations were commenced by excavating the lock-pit in the before-mentioned mound, when the subsoil was found so consolidated, that the excavation had proceeded to a considerable depth, before it was necessary to have recourse to the power of

steam for pumping the water out of the lock-pit. So adhesive was the nature of this prepared ground, that, although piles were driven with great ease into it, yet, after they had remained for a time in the silt, it was neither found practicable to draw them out, nor to drive them further into the ground. When the area of the lock-pit had been dug to a sufficient depth, a course of large stones, two feet in thickness, was laid in the middle for supporting the key-stone of the inverted arch of the lock. This foundation course increased in thickness to five feet towards the springing of the inverted arch, in front of the side-walls, which were built upon it with all possible dispatch, in lengths or compartments of six yards at a time, till the whole was brought to the height of the sill, or to about eight feet, that it might not be unduly exposed to wet and dry. Then the chamber of the lock was formed by the side-walls, which, with the inverted arch, were faced with square masonry, and backed with good rubble-work. The construction of this lock presented great difficulties, which were surmounted by skill and experience, as honourably noticed in the Parliamentary Reports, with reference to all the persons concerned, and particularly to Mr. Davidson, the resident Engineer.

When I visited the Caledonian Canal in 1817, the head of the two piers, forming the sides of the canal, were not entirely faced in front of the entrance or tide-lock: this was the only important operation that remained to be performed in that part. This tide-lock has a lift or rise of eight feet six inches above the mean level of the sea.

The second or Clachnaharry lock, which is barely within high-water mark, has a perpendicular rise of six feet, and forms a division between the sea-lock basin, and the great basin of Muirton, which last-mentioned is of an oblong and rather irregular form; but is well suited to the figure of the ground. It is formed by works of excavation and embankment, and has a very extensive wharf, which will be convenient to the town of Inverness, whence it is but a mile distant. To defend the before-mentioned projecting earthen mounds on each side of the sea-lock, rubble-stones are laid upon the external slopes with such a gentle declivity to the sea, as to sufficiently secure them against the impression of the waves of the Beauly Firth, while the exterior bank of the Muirton basin is defended from its encroachment by a dike of considerable extent.

At the southern extremity of this basin, the road from Inverness to Beauly crosses the line of the canal; and here a handsome turn or swivel-bridge of cast iron has been erected on piers of masonry. There are several other bridges of the same kind on the Caledonian Canal. They are composed of two

pieces or leaves of equal dimensions, each placed upon an opposite abutment of masonry, and move upon a centre similar to those of the West-India and London Docks. The upper part of the bridge is perfectly rectilinear and horizontal.

These bridges combine elegance with lightness. Five ribs of cast iron are united by side-plates, with bolts passing through them. They support a wooden platform, on which carriages pass in the middle, and foot-passengers on the sides, where proper paths are reserved for them. The segment of a very large iron cogged wheel is fixed in the masonry, in such a manner that its centre is on the axis of the moveable part of the bridge. On one side of this moveable part is fixed a vertical pinion, at the lower part of which is a cogged wheel that catches the cogs of the large segment, whilst the head of this pinion bears a hollow cast-iron cap. In this cap, a number of concentric wheels transmit the rotation of a winch to the vertical pinion, and the latter to the cogged wheel that works in the large fixed segment of a circle, so that in turning, as may be required, the winch from right to left, or from left to right, the moveable part of the bridge is opened or shut. The men who work the bridge are placed on it, and are carried away by the motion they give to it. In several of the swivel-bridges which I saw in Great Britain, the men are placed on the shore; and the segment of the large cogged wheel, instead of being fixed in the masonry, is attached to the heel of the bridge, and turns with it. I have a great many other details to give respecting the construction of bridges of this kind; but they would extend to too great a length the present description of the Caledonian Canal.

Just beyond the first swivel-bridge we meet with on the line of the canal, in proceeding to the westward, are the Muirton locks, four in number, and which have each a rise of eight feet. By building them in one connected range, it was necessary to lengthen each a few feet, to give accommodation to the largest vessels; but this method was the most economical, as the head and tail walls, and one pair of gates, are saved. The gates or valves of the lower and upper gates consist of British oak (according to the method generally adopted in this country) these being more liable to accident from ships coming against them than any of the intermediate ones, which are framed of cast iron, in great bars, covered over with strong oak planks, attached to the cast iron work by numerous screw-bolts with nuts.

Lock-gates of cast iron have been for a considerable time in use in England, upon the Chester and Ellesmere Canals. A pair were also constructed on the Carron River, in Scotland, upon a dock for the repair of the ships belonging to the Carron Iron-works Company; but all these gates are of small dimensions, compared

with those of the Caledonian Canal, which measure thirty-feet in height, each leaf being twenty-two feet in breadth, and which have to support a pressure of eight thousand cubic feet of water.

Cast-iron gates, however, seem to have been brought into use here rather as a matter of necessity than of choice, from the difficulty of procuring oak of sufficient scantling and size. When these were to be constructed, it was in the height of the last war. The timber it would have been necessary to devote to this purpose is that which is employed for making the beams and keels of ships. The navy then consumed all the timber of this size which England could furnish. For a long time past, Scotland had been stripped of her forests; the continent, through our immediate power or our political influence, was shut against the English. Necessity encouraged the progress of art, and iron was used instead of wood.

To form the heel-posts, which are the principal part, hollow iron cylinders have been cast in a single piece, of as much as from twenty-six to thirty feet high, and eighteen inches in diameter. Their base has the shape of a D, and is composed of a semi-circle, with its diameter a little drawn back parallel to itself, in order to render the surface more considerable, by extending the two extremities of the semi-circle by their tangents. A strong hemispherical gudgeon, of cast iron, which is fitted into the heel of the post, turns in a metal saucer let into the masonry of the lock-sill. A cylindrical cap is fitted to the head of the post. This cap is encircled by a collar of flat iron, more or less confined by nut-screws, and extended on both sides by iron plates, let into the upper facing of the masonry of the sides of the lock. The quadrangular beams, or horizontal rails of the valves or gate-leaves have been replaced by iron bars, the profile of which has in some respects, the shape of a ⊐. On the branch actually vertical of this ⊐ are fixed, by screw-bolts, the planks laid vertically on all these beams, which, by one of their ends, are fastened to the plane face of the heel-post. By the other end, they are fixed to a vertical bar of cast iron, which completes the oblong square of which the metallic framing of each valve is composed. Outside of this vertical bar is applied a lining of wood bevelled like a wedge; so that when the two valves meet, the faces, till then visible, of both linings which are cut obliquely, lay perfectly fair against each other. It was necessary to cover the edges of the gates with wood, in order to avoid the collision of iron against iron, and the fractures which would thence have ensued.

As might naturally be expected, perfection was not immediately attained in the construction of lock-gates of cast iron. The first made were very heavy; the pair of long gates weighed nearly forty-four tons, while a pair of the new ones do not weigh

more than thirty-two. To obtain this great diminution of weight and expence, instead of making the heel-post full on all its faces, the flat face, wherein the horizontal planks are screwed, has been first cast hollow; so that at present this face presents as many rectangular hollow spaces, as there are intervals between the different planks. By this means, it is easy to introduce the screw-bolts from the inside of the pillar through the planks on the outside of which the nuts are screwed; whereas, before this alteration, it was requisite to let a boy down to different heights in the hollow of the post, like a chimney-sweeper in the flue of a chimney, in order to put these bolts into their respective holes. I shall give the complete plan of these gates, with the details of their construction, in my work on the operations in the ports of England. I have few observations to make in regard to the masonry of the locks which I have just described. I have said, in this respect, every thing that appears to me essential to be made known, in speaking of the docks of London and Liverpool.

The masonry of the sea-lock is executed wholly with freestone or sandstone from Redcastle quarry; but the second or Clachnarry lock, and the four locks at Muirton, and the abutments of the Muirton and Bugdt Bridges, are only faced with Redcastle stone, the inner walls or backing being rubble-stone from the more contiguous quarry of Clachnaharry. It is not always possible to apportion the expence of the several compartments of a large work, so as to show the neat cost of each; but it seems probable that these locks, upon an average, exclusively of the sea-lock, will each have cost, when entirely finished, not less than 8000*l.* The locks, originally proposed by Mr. Telford, would, no doubt, have been considerably less expensive, probably not exceeding 5000*l.* as they were meant to have masonry only at the gates; while the space between them was to have been embanked, like the other parts of the canal. But, as this would have made the navigation much more tedious, it was determined to line the lock-chambers with masonry in the usual way, which accounts for the increase of expence.

From Muirton locks to the entrance of the canal into the waters of Loch Ness, the distance is about five miles. In general, the soil is, in this reach, exceedingly bad for canal work, being chiefly composed of sand and coarse gravel. Accordingly, in those places, it has been found necessary to protect, by a proper puddle-lining, the banks and bottom, against the pressure of water in this branch of the canal. On this reach, there is some deep cutting in passing the singular hillock of Tomnahurich; and a considerable embankment also became necessary to the westward of the lands of Bugdt, where the eastern bank of

the canal is actually formed on the bed of the River Ness, under the hill of Torvaine. Here the course of the river has been altered and widened, by cutting away part of its eastern bank for the space of about half a mile. A similar operation, but of smaller extent, became necessary under the hill of Toremore, where the canal banks again trench upon the River Ness. The next work, on this reach, is a regulating-lock and weir for the waters of Loch Ness.

The regulating-lock, for Lochs Doughfour and Ness, can command a rise of six feet six inches, and is situated about half a mile northward from the former Loch, which is connected with Loch Ness by the narrow channel of Bona Ferry. The bad quality of the soil, and the vicinity of the Ness, a considerable and very rapid river, rendered the construction of this lock a very difficult operation. Great labour and perseverance were exerted here, in clearing the lock-pit of water to the depth of about twenty feet under the level of the bed of the river. Connected as the canal is at this end with Lochs Doughfour and Ness, which extend about twenty-four miles to the south-westward, through a range of mountains, and, consequently, forming the drainage of a great extent of country, it is obvious that these extensive locks must receive vast quantities of water during wet and rainy seasons, but especially in time of thaw, when there is much snow on the ground. The effect must be to raise the surface of the water of Loch Ness, which has been known on such occasions, to rise from six to eight feet above its ordinary summer level; considerations which, of course, form the limits of the regulating-lock and weir across the River Ness, connected with this chain of locks.

Another difficult operation, in forming this navigation, was the deepening of Loch Doughfour. This loch, connected with the eastern end of Loch Ness by the narrow pass of Bona Ferry, is about one mile in length, and varies from one hundred to a hundred and fifty fathoms in breadth. From the rapid current at Bona Ferry, it appears that the fall of water, towards the river and the sea, commences here, and, with Loch Doughfour, forms a receptacle for much of the gravel and *debris*, brought down from the face of the adjacent steep mountains on the extensive shores of Loch Ness.

This part of the navigation it was, therefore, found necessary to deepen, by artificial means, in some places, to nearly the full depth of the canal. This was done chiefly by a dredging-machine, floated upon a barge, and worked by a steam-engine.* This machine, constructed under the immediate direction of Mr. Wil-

* A description of a dredging-machine has been given in page 4.

liam Hughes, is one of the best proportioned which I have seen, and has proved extremely effectual at Loch Doughfour, where it is calculated to have lifted about ninety thousand tons of gravel in a twelvemonth. The stuff lifted is received from the dredging-machine, as it comes out of the water, in punts or lighters, and carried to a proper place for deposition. In the course of this arduous operation, the roots of large trees have been lifted, weighing several tons, and even an indurated gravelly clay, equalling rock in hardness, has been excavated at the depth of twenty feet under water, by putting iron picks and harpoons in the place of the buckets upon the revolving apparatus. By these different means, the navigation from Lough Doughfour to Loch Ness has been opened to a proper depth. To preserve always such a proper depth of water, a regulating weir or dam is to be placed across the eastern end of Loch Doughfour, where the River Ness properly commences. This operation will check the rapid current at Bona Ferry, and prevent the *debris* from being carried from Loch Ness into Loch Doughfour. The waters of the Ness will then be drawn off from the surface of the loch, and will cease to carry with them quantities of stones and gravel, as at present, and Loch Doughfour will become an excellent place of anchorage for wind-bound ships.

Loch Ness, forming so considerable a part of this navigation, is about twenty-two miles in length, of a pretty uniform breadth, varying from about two miles to one. Its depth of water is from one hundred to one hundred and thirty fathoms, in the middle or deepest parts. The sides of the loch appear to be deep and precipitous, as it suddenly deepens from seventy to eighty fathoms, except in the creeks or bays of Dores, Urquhart, Inver Morrison, Cherry Island, and the western extremity of the loch. In these, the depth of water varies from twelve to twenty fathoms; but even these soundings are so close to the shore, that it has been suggested to lay down mooring-buoys to enable vessels to stop for a time, as it would be quite unsafe, especially for ships of great tonnage, to *let go an anchor*, chiefly from the difficulty of purchasing or lifting it, from such strong holding ground.

In discussing the advantages and the inconveniences of the Caledonian Canal, one of the greatest difficulties was to ascertain how far an expanse of water, so deep as Loch Ness, and inclosed like it between high mountains, might be navigable with safety. The antagonists of the canal object that the winds, whatever may be their general direction in the surrounding country, when they come to be ingulfed in the long and deep valley of Loch Ness, change their direction, and run parallel to the axis of that valley; so that vessels going one way will always have the wind directly contrary, while vessels going the other

way will be driven right before the wind. It was also considered as extremely dangerous for a large ship to ply or turn to windward, or merely even to navigate with a free or leading wind on a sort of canal, the bottom of which is, near the shore, strewed with trunks of trees and rocks, and, more in the offing, of an extreme depth ; while the collateral valleys which open into the great valley of the lochs or lakes, bring down sudden squalls, which tend forcibly to throw vessels on the opposite shore.

These objections seem to have great weight, it is true, but they are exaggerated. In the first place, it is not correct to say, as has been asserted, that from one end to the other of Loch Ness, no safe anchorage can be found. It is sufficient for us to mention that of Urquhart, which is situated at one third of the route on the eastern side ; and there are other anchorages to the westward. With a view to ascertain whether, as has also been asserted, the winds always blow on the loch in the division of its length, a register of the winds, and state of the weather, by the barometer and thermometer, has been kept, since the year 1804 to the present day, at the two extremities and at the centre of the Caledonian Canal, that is, at Clachnaharry, Fort Augustus, and Fort William. These meteorological observations have proved, that the winds are nearly as subject to change in the great vale between Inverness and Fort William, as in other parts of the country.*

But if, in certain times of the year, ships could not or durst not proceed against the wind, or rather in calms, the progress of the maritime arts furnish at the present day the means of obviating that inconvenience, by the means of steam-boats employed for tracking. To conceive all the advantage of this new method of towing, let us suppose that we have a vessel which displaces as much water as the steam-boat, and which, in making the same progress or head-way, experiences the same resistance on the part of the fluid. In this hypothesis, the progress of the steam-boat, as well as the propelling power, being represented by a unit, that power applied to the two vessels will not produce merely a progress or rate of going equal to one and a half, or five-tenths, but a progress sensibly equal to seven-tenths. Therefore, from the effect of towing, not more than three-tenths of the progress of the steam-boat will have been lost. As to the possibility of towing vessels in this way on an extensive sheet of water, the experiments made towards the end of the year 1817, in the Firth of Forth, between Leith and the entrance of the

* From the 7th of April to the 24th of November, 1818, above one hundred and fifty voyages were made upon Loch Ness, without accident or inconvenience.
TRANSLATOR.

Great Canal, leave no doubt in this respect. Those trials are besides the more conclusive, as the Forth communicating in all the breadth of its base with the open sea, has its waters always much more agitated than those can be in Loch Ness.

Let us now proceed to the description of the works of the middle district; for, in speaking of the Caledonian Canal, it is generally divided into three districts; viz. the Clachnaharry or eastern district, comprehending the works from Loch Beauly to Fort Augustus; the middle district, extending from there to the west end of Loch Lochy; and the Corpach or western district, from Loch Lochy to Loch Eil, or the western sea. It is to be observed that the sums annually allowed for this undertaking, and also for local circumstances, do not admit of every part being carried on with equal vigour. The works of the middle district have, therefore, been almost wholly confined to excavating the ground; it being of importance to have the eastern end opened to Loch Ness, and the western division to Loch Lochy, before much was done to the masonry of the central parts, in order to facilitate the transport of materials from the respective seas.

Fort Augustus is composed of four bastions, faced with masonry, and protected by half-moons and covered-ways. It is built upon a little hill that advantageously commands Loch Ness, on the axis of which it is placed; but this fort would be commanded by the surrounding heights, if it were possible for the insurgents to bring, in order to reduce it, cannon across the mountains. The only object of this fort was to overawe the Scotch Highlanders, and formerly it fully answered that purpose. It is no longer necessary at the present day, and the Board of Ordnance ought to put it up for sale by auction. It contains barracks, and spacious and well-built magazines. Some day a bustling manufactory will supply the place of this military scarecrow, occupy the surplus of the population, and spread, through the surrounding country, comfort instead of terror.

When I visited the works of the Caledonian Canal, near Fort Augustus, a great number of men were employed on the entrance-lock of that part of the canal in the south-west extremity of Loch Ness. The nature of the soil is extremely unfavourable, being entirely formed of coarse gravel, so that, in the excavations, the water flows in as if from an infinite number of springs of running water. Nevertheless, in spite of these difficulties, it was necessary to dig to the depth of twenty-four feet below the level of the River Oich, by which the waters of Loch Oich are discharged into Loch Ness, and also twenty-four below the surface in Loch Ness. For clearing the lock-pits and excavated parts of water, three of Watt's steam-engines are em-

ployed, one of which has a pump forty inches, another twenty-one inches, and the third twelve inches, in diameter. The first is estimated equal to the power of thirty-six horses, the second to that of nine, and the third to that of four horses. Thus, the total power, here employed in the drainage, is equivalent to that of forty-nine horses, working day and night.*

In order to render this power sufficient for carrying off the water, the whole space where the entrance-lock is to be constructed, has not been excavated at one time; but the lock-pit has been commenced at the place where the gate nearest to Loch Ness is to be erected. A bed of moss has been put on the rubble-stones at the bottom of the excavation; on this moss have been laid the courses of the foundation, the joints of which have also been coated with moss. The effect of the oozing water being to carry this moss through the lower joints, in order to impel it towards the upper joints, by this means, throughout the whole of the masonry is effected a natural caulking, which must powerfully counteract the passage of the water.

From the level of Loch Ness, at Fort Augustus, is to be formed a chain of five locks, each having a rise of eight feet water. The piles, made use of in the foundations, are of two sorts. Some are round, and armed at their lower end with a cone of cast iron; these piles are driven under the side-walls. The others are intended to form a perpendicular row below and in front of the sill; the latter are furnished with a shoe, likewise of cast iron, but shaped like a quadrangular wedge, and broader at its base than it is long at its sharp edge. These piles are driven down by a ram of two hundred weight, which is worked by nine men.

About two miles from Fort Augustus, at Callachie, a sixth lock has been constructed upon a stratum of rock, (of that species called by mineralogists *Grey Wacke*,) which runs across the moor, and, being found very compact, rendered an inverted arch for the lock unnecessary. What is most remarkable is, that this stratum on which the Callachie lock is built, is the only mass of rock to be met with in that part of the valley, and, as it is just large enough for the site of the lock, it was preferred to gravel as a foundation.

The extent of the navigation comprehended in this part of the middle district, that is, from Fort Augustus to the entrance of Loch Oich, is about five miles, throughout which distance a bed must be cut for the canal. The whole height, from the Beauly Firth or the east sea to Loch Oich, the summit level of the canal

* Since this account was written, the locks which were thus incommoded by water, have been successfully constructed. Here, as well as in some other parts of these details, we have corrected the text of M. Dupin. TRANSLATOR.

is ninety-four feet; and as fifty-four feet have been overcome in rising to Loch Ness, it is obvious that about forty-one feet will form the ridge of the lockage of this district; while the fall on the western side to Loch Eil is only ninety feet. This is to be overcome by the chain of five locks at Fort Augustus, and one at Callachie, near three miles westward, already mentioned, independently of the regulating-lock within half-a-mile of Loch Oich.

Considerable progress has been made, from Loch Ness to Loch Oich, in excavating the canal, the greater part of which is now formed and cut to the requisite depth.

The regulating-lock at the entrance of Loch Oich, in the western part of the canal, has not yet been constructed. Loch Oich is, in some parts, too shallow and requires to be deepened; this is done by a very powerful *bucket dredging-machine* worked by a steam-engine. The barge carries two sets of apparatus, and has two bucket-frames, one on each side, to the end that, when the one is under repair, the other may be ready for working, without the labour suffering any interruption. The endless chains are each provided with thirty buckets.

The boats employed to carry away the excavated matters, are somewhat similar to our *Maries-salopes*, or mud-lighters. They carry fifty tons of mud or rubbish, and are made with two holes sloping towards the floor or bottom, for the purpose of lessening the width of the discharging apertures, which are closed by two hinged ports, the one forward, the other aft. These ports open outwards, and therefore as the boat receives its cargo, the increasing pressure of the water, acting in a contrary direction, prevents the ports from being forced open by the weight of the stuff, till it be transferred to the place of its destination, when the chains fixed to ring-bolts in these ports are loosened, and the whole contents drop into the water, unless it should be wanted for embankments, or for ballast. The ports are hove up or let down by chains, which are worked on the deck of the boat, and each of which is carried round a small windlass, the one forward and the other aft, and easily managed, by means of a double winch.

The track in which the bed of the canal has been cut here, lies so close to the river Oich, which empties itself into Loch Ness, that it has been found necessary to change the course of that river in two or three places, as was done in regard to the river Ness. But the Oich is not near so manageable as the Ness, because Loch Ness, owing to its very great extent, is not subject to sudden and considerable rises; for the waters of the river Ness cannot be swelled till the whole surface of Loch Ness is raised. On the contrary, Loch Oich, from its smaller capacity, being only about four miles in length, and a quarter of a mile in breadth, is

liable to vary its level with the greatest irregularity, as it forms the drainage of a great extent of mountainous country, without having a comparatively sufficient space for containing its flood-waters, like Loch Ness.

We at length reach the third district of the canal, that is, from Loch Oich to Loch Locky, a distance of about a mile and a half. The works of this part are executed by Mr. Wilson, a man of much merit, and to whom I am under the greatest obligation for the communications and explanations with which he had the goodness to favour me.* The excavation of the soil between Loch Oich and Loch Lochy has been tedious and expensive, owing to the surface of the ground being about twenty feet above the level of the water in Loch Oich, or the summit level of the canal. The space to be excavated has, of course, been very considerable, as the whole depth exceeds forty feet.

In examining these works of excavation in such deep cutting, I remarked the manner in which the removal of the earth was effected. In proportion as the canal is deepened, the sides are cut according to the slope which they are to have. At certain distances two or three rows of planks are laid down, according to the greatest declivity of these slopes. On the inclined roads, prepared in this manner, are placed small carts with four wheels, two larger towards the hind part, and two smaller towards the fore part. The difference of the diameter of these wheels is such, that, when they rest all four on the inclined plane, the platform of the cart which they support is perfectly horizontal. Two carts belonging to two inclined planes next to each other, are fastened to the two ends of a long rope. This rope, in order to reach from one inclined plane to another, passes through two blocks fixed on the crest of the canal. Its length is such, that when one of the carts is at the bottom of the canal, the other is at the top of the inclined plane. A knot made in the horizontal part of this

* In company with Mr. Wilson, I visited the parallel roads of Glenroy, which are at a little distance from Loch Lochy. There are three kinds of cuts made on the declivity of the mountains, on the two sides of a long valley. The height of these roads, on the one side, perfectly corresponds with the height of the roads on the other side. The second roads are eighty feet below the first, and the third three hundred feet below the second. The Scotch geologists have been for a long time seeking to discover whether these roads were the work of art, or the effect of the waters of a lake which should have had three great effluxes or discharges in succession. I own that the reasons given in favour of one of these opinions seem to me nearly as satisfactory as those given in favour of the other. I confess ingenuously, that after having travelled over these astonishing roads, and considered their situation, I found it impossible to explain the artificial construction of six parallel roads, which lead to nothing, and the natural formation of six parallel roads by the effluxes of a lake, of which I cannot see what did form, or what was likely to form the bar. But, as I am not the author of any system, I have not the miraculous gifts of that faith, which can, at pleasure, place and displace mountains. Let us return to the Caledonian Canal.

rope, serves as the place for putting to one or two horses. The labourers, at the bottom of the canal, bring two loaded wheel-barrows on the platform of the little cart which is below. Those who, on the upper part, disperse along the canal the earth that has been removed, bring back two empty barrows on the platform of the cart that is above. Immediately the driver of the horse sets off with him, and thus performs, with as much ease as dispatch, a labour which four men, according to the common method, would not accomplish but very slowly, and with a great deal of fatigue.

The difference of level between Loch Oich and Loch Lochy is at present about twenty feet; but where the latter has been raised twelve feet, the difference will eventually be only eight feet. This requires that one lock should be placed between the two Lochs, which will also act as a regulating-lock to Loch Oich.

In like manner that it was requisite to raise the level of Loch Doughfour towards the eastern extremity of the Caledonian Canal, so also, towards the western district, it became necessary to raise the surface of Loch Lochy. But this latter operation is much more difficult than the former, as the level must be raised twelve feet perpendicular instead of two. It has been thought more expedient to shut up the present course, and excavate a new channel for the river Lochy, the only stream that flows from the Loch, raising the level of its new bed, and thereby rendering the works of the summit level more easy than by works of excavation. By this means, the new course of the river Lochy, about half a mile in length, cut through a piece of flat ground, called Mucomer, forms its confluence with the river Spean. The joint waters of the Lochy and the Spean run with great rapidity, and soon afterwards skirt the south-eastern bank of the canal, where it becomes necessary to make a strong defence against their joint efforts, by arming and fortifying it with rubble-stone. They afterwards form a large river, which is discharged into Loch Eil. From Loch Lochy to Loch Eil, the distance is about eight miles; throughout which the canal is finished. Nevertheless, as there remains some lock-gates to be fixed up, that part of the canal is not yet open to navigation.

The track of the canal, from Loch Lochy to Loch Eil, runs at the bottom of the slope of a chain of mountains, whence descend impetuous torrents, to which it was necessary to give an outlet. This has been done by a number of aqueduct bridges; one, in particular, over the river Loy, consists of a centre arch of twenty feet span, and two side arches of ten feet each, and owing to the width of embankment here, the

arch is no less than two hundred and fifty feet in length. But in this and other cases, the side arches answer the purpose of passages under the canal, and thus save the expence of bridges. Over the Mucomer channel of the river Lochy, a very handsome stone bridge of two arches of fifty feet each has been erected.

The regulating-lock of Loch Lochy presents a singularity which it is proper to notice. From the difficulties attending the land-carriage, instead of employing hollow quoins of hewn stone, for the heel-post of each gate to work in, thick plates of cast-iron have been made use of, having outwardly the same concave and cylindrical form as is given to stone quoins. Afterwards, these iron plates have been let into and secured in common masonry. This new application of cast-iron has succeeded; but it seemed to me, from what I was told by the engineers and contractors charged with the works of the canal, that it was not attended with any decisive advantage. Accordingly, recourse has not been had to the same method in executing the subsequent constructions.

Another very difficult and troublesome part of the canal occurs at East Moy, where, like that of Doughfour Burn, the waters of a torrent are allowed to flow into the canal. But, before they reach it, these waters are retained in large reservoirs, where, losing their velocity, they deposit the gravel and other matters which they carried along or held in suspension. It is afterwards only that the upper part of these waters can enter into the canal, and this is, as is well known, the clearest.

Near the same place, there is a tumbling-bay, or weir, for letting off the superfluous waters of the canal. The waste-gates of this weir are of cast-iron, as well as the frame fixed in the masonry, and the system of bars, cogs, and winches, by which these waste-gates are worked. The execution of this weir altogether appeared to me perfect. I do not speak of the turn or swivel-bridges of cast-iron, which are on the western part of the Caledonian Canal, because they are, in every repect, similar to those which I have already described, but there will be three in number in this district, for which the masonry is prepared.

In our progress towards the western sea-lock of Loch Eil, after passing the aqueduct of the Lower Banavie burn, we reach the famous chain of eight locks, commonly called Neptune's Staircase. This majestic chain of locks was finished, with the exception of the gates, in 1817, and will be completed in less than a year. Their probable cost may be estimated at about 50,000*l*. The locks are forty feet in breadth, and the length from one gate to another, is one hundred and eighty

feet; lastly, the difference of the level of the waters above and below this chain of locks is sixty-four feet, that is, eight feet in each lock. The bottom, forming an inverted arch, gives the whole a very grand appearance, and presents the greatest mass of masonry any where to be met with for the purposes of a canal. The gates are framed of cast-iron, in great bars, covered over with strong oak planks, fastened by screw-bolts with nuts, like those at Muirton; with this difference only, that the latter having been made the first, are not so improved, and weigh heavier. When I visited the Caledonian Canal, several of these gates were in hand; some were still in the building-yard, others were half put up. In this manner I followed the progress of their construction, and I shall carefully describe that operation.

A little beyond the great chain of locks, the canal proceeds to Corpach Moss, where are two other locks, connected with a basin for shipping, measuring two hundred and fifty yards in length by a hundred yards in breadth, which joins the sea-lock, and so communicates with the Western Ocean by two mounds, projecting about three hundred and fifty yards into Loch Eil, and completing the inland navigation of the Caledonian Canal from sea to sea. This sea-lock is placed in a well-sheltered part of Loch Eil, where there is good anchorage. Its site is upon a rock, the outer extremity of which is twenty-one feet below high-water mark of neap-tides. This rock increases in height towards the land, and a large portion of it was, therefore, to be excavated for the chamber, &c. of the lock. To accomplish this it became necessary to clear off the gravel and mud, and construct a water-tight coffer-dam upon the rock, at twenty-one feet under high-water of neap-tides. This arduous task was accomplished very successfully by Mr. John Wilson, the contractor for this part of the canal-works. The lock, with its gates, and the pier-heads, have been completed, and regularly worked, whereby vessels are admitted into the above-mentioned basin.

As we have before noticed, the operations of the canal have been, in the earlier stages, chiefly confined to the eastern and western divisions, so as to render these subservient to the operations of the middle or central division. But the artificers have now been employed, to a greater or less extent, upon the middle part for several seasons; and the probability of the canal being opened from sea to sea, must depend, in a great measure, on the annual extent of the funds to be laid out, and the effect which may thereby be given to the works. Time must also be allowed for proving the banks and puddle-

walls, which, in all similar works, are found to leak in the first instance, and require the banks to be partially opened.

The total expence of the canal is now estimated at 800,000l. or 20,000,000 of francs, independently of the various improvements to be made for the navigation, which experience alone can point out and determine, after the canal is opened.

To render the access to the canal from seaward more safe, and give every facility to the navigation, there will require to be beacons fixed, and buoys moored in various parts, and even a light-house erected in the Murray Firth, to mark the entrance of the canal from the German Ocean; a light-house will also be required as a direction for the Sound, between the Islands of Mull and Kerrara, on the side of the Atlantic.

But, in order to give to the Caledonian Canal all the advantages of which it is susceptible, another canal must be cut to connect *West* Loch Eil with Loch Shiel, so as to form a passage to the Western Ocean in the direction of the districts of Ardnamurchan and Moidart. This new work does not seem likely to be attended with much expence, considering the small extent of the cuts which it will be necessary to execute.

The ships coming out by the western extremity of the Caledonian Canal, will be able, at pleasure, to direct their course to the north-west, or to the south-west, according as they shall pass through the one or the other outlet.

Mr. Stevenson, in speaking of the objections which have been made against the Caledonian Canal, relatively to the greatness of its dimensions, presents an observation, which appears to me extremely just.

"The question of the ultimate advantage of this work," says he, "has been matter of much discussion. But, we believe, this may at once be restricted to the consideration of the propriety of the excess of dimensions above fifteen or sixteen feet, so as to admit almost the largest class of merchant-ships, using the Baltic and North-sea trade. Now, we think that it was proper that it should be constructed upon a scale calculated to meet the increasing dimensions of merchant-vessels. For, when the Forth and Clyde Canal was determined, in the year 1768, to be of the depth of eight feet, and the locks in proportion to measure seventy-four feet in length, and nineteen in breadth, it was termed the 'GREAT CANAL,' and it is worthy of remark, that its uncommon size, for that day, was considered unnecessary and useless to the trade of the country. The reverse of all this, however, has been found by experience, and if its dimensions could now be enlarged, and its depth increased to the rise of the tides of the Firth

of Forth, or to the depth of sixteen feet, the benefit of that navigation to the country would be incalculably greater. The Commissioners of the Caledonian Canal," adds he, " certainly acted wisely, in keeping its dimensions large, as this will be of great service in navigating vessels even of a middling size; the force applicable to the trackage of ships being found to be in proportion to the quantity of fluid compared to the bulk of the vessel. Although the inducement for frigates and the smaller class of ships of war passing through this navigation does not appear very obvious, yet cases may occur when this may be found advisable; and as there is an abundant supply of water for the wants of any supposable lockage, it was certainly proper that, in a national work, such an event should be provided for."

Besides, it must be admitted that, when there is plenty of water, it is always more advantageous to navigate on wide canals, both for the facility of the trackage, and because the resistance and the eddy of the water being less, the banks of the canal are less quickly destroyed.

Some difficulties may, no doubt, be presented by the navigation of some of the lakes; but, nevertheless, they seem to me exaggerated. They appear by no means so formidable as the dangers, delays, and disappointments, experienced in sailing round the Orkneys in the winter season, or in stormy weather. The British ship-owners and seamen are enterprising, active, and endowed with extraordinary perseverance; hence, I am persuaded, that they will find means to conquer any obstacles to be met with in this new and valuable navigation, which, we understand, will be opened, from sea to sea, in the year 1820.

Lines on the CALEDONIAN CANAL, *introduced by* M. DUPIN.

J'ai vu, dans les déserts de la Calédonie,
Un canal des deux mers, fruit hardi du génie;
J'ai vu des lacs profonds bordés de rocs affreux,
Qui portent jusqu' au ciel leurs sommets sourcilleux.
Pour briser ces prisons de l'onde mugissante,
Que de siècles ont vu la fureur impuissante !
Pour réunir ces lacs, ô triomphe des arts !
On creuse un lit aux eaux entre ces fiers remparts!
C'est au sein du désert que l'homme opiniâtre
Vient combattre et dompter la nature marâtre.
Il ne voit que le ronce en d'arides guérêts
Où jadis s'élevait de nobles forêts.
Du chêne, en vain cherché pour cet immense ouvrage,
Un fer imitateur prend la forme et l'usage.

Huit bassins, enchaînés par neuf portes de fer,
Semblent les creux paliers des grottes de l'enfer.
Mais le nocher, fidèle au dieu de sa fortune,
Leur donna le beau nom D'ESCALIER DE NEPTUNE.
Oui, Neptune lui-même, avec tous ses vassaux,
A la file guidant huit superbes vaisseaux
Dans les flancs spacieux de ces marches humides,
Va descendre au palais de ses mers Atlantides.
Ainsi la cour des dieux embellit les confins
Dont le barbare aspect repoussa les Romains.

Imitation of the above, by the MODERN BARD OF CALEDONIA.

Far in the desert Scottish bounds I saw
Art's proudest triumph over Nature's law;
Where, distant shores and oceans to combine,
Her daring hand has traced a liquid line,
Uniting lakes, around whose verges rise
Mountains which hide their heads in misty skies;
Each, bound within such adamantine chain,
For ages lash'd its lonely shores in vain,
Till, through their barriers, skill and labour led
The willing waves along a level bed.
Thus, e'en within her wildest fastness, man
Subdued his step-dame Nature's churlish plan.
The barren wilds, divested of their shade,
No trees could yield the giant-work to aid.
To mould the gates the skilful artist hied,
And iron frames the want of oak supplied.
Form'd of such stern material, portals nine,
In basins eight, the sever'd waves confine;
Locking each portion in its separate cell,
Whose gloomy grots might seem the gates of hell.
But better-augured name the passage bears,
Call'd by the hardy pilot NEPTUNE'S STAIRS.
There might the Sea-God and his vassals meet,
And gratulate the fair descending fleet,
When down those wat'ry stairs were seen to glide
Eight gallant sail that sought th' Atlantic tide.
Commerce and Art the floating wonder hail'd,
And triumph'd where the Roman arms had fail'd.

Directions to the Binder.

The transverse Section of the BREAKWATER, to face page 57.

The Sketch of PLYMOUTH SOUND, at the end.


SKETCH of PLYMOUTH SOUND,
with the
Breakwater.
The Tamer
Plymouth
Dock
Lines
Dock
Yard
&
Town
Mountwise
HAMOAZE
Mill Prison
Mill
Bay
Plymouth
Town
Sutton Pool
Deadmans
Bay
CATWATER
Oreavn
Quarries
Mount Batten
Devils Point
Firestone Bay
St Nicholas
Island
Mount
Edgecumbe
Ravens Point
Redden Pt
Punstone Point
SOUND
Staddon Point
Borisand
Bay
Kingsand
Cawsand
Cawsand
Bay
Breakwater
St Carlos
Rocks
Panther
Map
Shovel Rocks
Andurn Point
West Nap
Tinker
Penlee Point
Rame Point
PLYMOUTH