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THE LIVERPOOL DOCK SYSTEM

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THE DEVELOPMENT OF THE LIVERPOOL DOCK SYSTEM

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As far back as the middle of the fourteenth century Liverpool occupied a somewhat important position in whatever maritime trade existed on the western seaboard of the country, and the port was then regarded as one of the best natural harbours along this coast.

The site of the original port was the shallow creek which ran inland from the right bank of the river in a north-easterly direction, commencing at a point about midway along the "deep" on the site of which the Custom House used to stand, and extending along the depression now occupied by Paradise Street, Whitechapel and Byrom Street. Its length was about one mile and judging from its position it must have been well sheltered from the action of the prevailing winds.

The vessels in those early days were few in number and small in size. It is recorded that twelve vessels with a gross burden of 177 tons represented the extent of the shipping belonging to the town in 1540.

From there being no record of wharves or quays, vessels must have loaded and discharged their cargoes either afloat in the river by means of boats, or by grounding on the banks of the creek and making use of carts at low-water.

Towards the end of the seventeenth century there began in Liverpool a great upsurge of industrial and commercial activity, which, once started, was to continue right through the eighteenth century with gathering momentum and on into the nineteenth century with few checks. The interdependence of the economic life of the town and port was a most prominent feature of this phenomenal expansion.

The disadvantages of handling cargoes by lighters while the ships lay at anchor in the river, or the damage that must have occurred to the larger vessels if they were allowed to take the ground in the more sheltered pool, are obvious. Men of energy and enterprise were not lacking and the problem was solved by the Corporation building an enclosed dock with gates to impound the water.

Construction was begun in 1709, and the dock, afterwards known as the Old Dock, opened to shipping in 1715. The design and construction was placed in the hands of Thomas Steers, who came from London for the purpose. It was three and one-half acres in area and designed to afford accommodation for 100 ships, and to have not less than ten feet of water within it at neap tides. The width of the entrance was thirty feet and the sill was placed roughly four feet six inches below mean tide level. As Old Dock Sill, this level is preserved to this day as the datum for constructional work in the port, though for charts and navigational purposes the more convenient

datum, ten feet lower, known as Liverpool Bay Datum is used, as the latter coincides with the low water level of a pretty average equinoctial spring tide, few tides ebbing lower. It is of interest to note that Holden's *Tide Tables*, first published about 1780, were computed from observations made at the entrance of the Old Dock.

There were no quay facilities or sheds such as we associate with docks today; in fact houses were allowed to come down almost to the water's edge.

It has been stated that it was the first commercial enclosed wet dock in the country, but there are records to show that it was preceded by at least ten years by the Howland Great Wet Dock at Rotherhithe on the Thames. The name of this dock was afterwards changed to Greenland Dock, and it is now incorporated in the Surrey Commercial group of the Port of London Authority. The Howland Dock appears to have been rather larger than the Old Dock, having a water area nearer ten acres and capable of accommodating 125 ships. The Howland Dock had been preceded by a small dock at Blackwall built by a shipbuilder in 1661 and mentioned by Pepys; and in 1686 there was a dock of four and one-half acres in existence at Dunkirk, and also one at Portsmouth Dockyard in 1700. Graving docks had been a existence for centuries previously though with crude gates, usually no more than a clay dam. Moreover, lock gates had been introduced on canals in Italy or Holland sometime in the fourteenth or fifteenth century.

Thus there would appear to be very little that was original about the Old Dock, unless it is that it was the first wet dock to be constructed on a site reclaimed from the foreshore of an estuary, or else the first built by a public authority.

Nevertheless, it is interesting to note the dates of other early first docks—Leith 1720, Hull 1778, Bristol 1809 and the first corporately-owned docks at London, the West India Docks 1802.

The approach to the Old Dock was via a narrow gut opening out into a pool of one and a half acres with a small graving dock built on its north side.

The rectangular form of dock was chosen after some argument, there being strong advocates of a long narrow dock, rather like a canal, extending a considerable distance up the Pool. No doubt more alongside accommodation would have been obtained, but with the disadvantage of cutting into the heart of the town, with all the attendant inconveniences such as are experienced between Birkenhead and Wallasey today.

The Old Dock proved a boon to all concerned and its acquisition greatly improved the position of Liverpool as a seaport. Trade expanded so rapidly that before long its capacity was found insufficient to meet the requirements of trade. The Corporation determined on extending the dock accommodation, and in 1753 there were constructed and opened to shipping the Salthouse Dock together with a pier, running out in a westerly direction to low water mark on the north side of the entrance gut, so as to form an open basin for the use of coasting vessels and to act as a breakwater protecting both the entrance to the Old Dock and that of the Salthouse Dock, which was built to the southward and westward of the Old Dock.

Off the open basin, or dry dock, were built three graving docks in 1765.

Canning Dock now occupies the site of the open basin and the entrance channel alongside the pier is now Canning Half-Tide Dock. The land west

of the South Dock, as Salthouse Dock was first known, was laid out as ship-building yards, which existed until Albert Dock was constructed.

This extension of dock accommodation soon proved to be inadequate to cope with the requirements of an expanded and rapidly growing trade and the New Dock and the New Dry Dock at its north end were opened in 1771. These were afterwards renamed Georges Dock and Georges Basin, and soon followed in 1788 by Kings Dock and Queens Basin to the south of Salthouse Dock and by Queens Dock in 1798.

The New Dock, or Georges Dock, was connected with the open basin adjacent to the Old Dock by the original graving dock, but Kings Dock was separated from Salthouse by Dukes Dock built as the terminal of the Bridgewater Canal.

The terms dry dock, graving dock and floating dock appear to have undergone some change since the eighteenth century. On the old plans a dry dock is a basin, open to the river, that dries out at low water; graving dock has the same meaning as today. A floating dock was a wet dock, or float, and not a floating graving dock as today.

Thus before the end of the eighteenth century there were at Liverpool five wet docks and three open basins, the former totalling twenty-seven acres water area, and two-miles length of quay space, the latter having a total area of ten acres of water space and about three-quarters of a mile of lineal quay space.

This early growth of the docks was associated with the development of natural waterways and canals for the inland carriage of goods. The roads in Lancashire and Cheshire were still wretchedly bad.

In 1694 the Mersey had been made navigable as far as Warrington. From there, transport was by cart to Stockport, and by packhorse over the Pennines.

In 1720 the Mersey and Irwell were made navigable as far as Manchester and in 1721 the Weaver was made navigable, bringing the Cheshire salt mines and manufactories into easy communication with Liverpool. Salt played a considerable part in the trade of the port during the eighteenth century.

In 1760 the Douglas navigation made possible water transport from Wigan to Liverpool via the Ribble estuary.

The Sankey Canal from St. Helens to the Mersey at Warrington was cut in 1757 by Henry Berry, the Liverpool dock engineer, and was the first modern English canal, preceding Brindley's Worsley to Manchester canal by several years. The Sankey canal was cut to provide access to St. Helens coal.

At the same time some improvement was taking place in the roads. In 1726 the Liverpool to Prescot road was placed under a turnpike trust on account of the heavy coal traffic. In 1749 it was extended to St. Helens, and in 1753 from Prescot to Warrington, and from St. Helens to Ashton-in-Makerfield. None the less, the roads were still very bad.

In 1773, the Bridgewater Canal was opened from Manchester to Runcorn with Dukes Dock as the Liverpool terminal.

In 1774 the Leeds and Liverpool Canal was opened as far as Wigan, though it was not completed until 1816.

In 1777, the Grand Trunk Canal was opened connecting the Bridgewater Canal near Runcorn to the Trent and in 1799 the Shropshire Union Canal was

extended to Ellesmere Port. Chester Basin, a small inlet between Georges Parade and Canning Dock, had been constructed in 1795 as a terminal for this canal.

About 1785 a small basin just south of Chester Basin and called Manchester Basin was constructed for river craft. In 1818 it was fitted with gates and used by coasters.

By the beginning of the nineteenth century Liverpool was the supply port for the manufacturing districts of Lancashire, Yorkshire and the Midlands.

Between 1772 and 1805 the total tonnage of shipping handled had increased from 170,000 to 670,000, foreign shipping increasing from 20,000 to 280,000.

The improved means of inland carriage, together with the great lead over other ports in the country taken by Liverpool in providing dock accommodation for ships, made the port a centre of commerce having facilities for trade second to none, with the result that the increase of shipping kept pace with that of the dock space.

Trade with India and China was freed of the East India Company's monopolies in the years 1814 and 1833 respectively, resulting in further opportunities of extending commerce, and of which full advantage was taken.

The opening of the Liverpool and Manchester Railway in 1830 marked the beginning of railway transport; it was closely followed by other lines and in 1837 the line was opened to Birmingham; in 1838 to London. In 1840 the Birkenhead and Chester Railway was opened and work started on a line from Liverpool to Lancaster, and in 1846 from Liverpool to Bury.

The railways greatly increased the means of communication and reduced the cost of inland carriage and improved trade generally. The first docks railway goods station was opened at Wapping in 1831, being connected to Edge Hill by a tunnel.

In 1844, one and one-half million tons of merchandise were carried to and from the port by inland and river conveyance exclusive of coal and salt.

The extension of the docks northward was continued at the beginning of the nineteenth century. Princes Dock was started in 1816 and completed in 1821. It was entered from the river by an open tidal basin from the south side of which a lock led to the dock. Whenever circumstances permitted, it was the practice to construct important entrances off open tidal basins with a view to providing shelter for vessels and the lock gates.

Clarence Dock was opened in 1830 well to the north of Princes and the intervening space filled in by the construction of the Waterloo Dock in 1834 and Victoria and Trafalgar Docks in 1836. Clarence Dock was for the exclusive use of steamships and isolated to minimise the risk of fire. Trafalgar was likewise a steam dock. Waterloo Dock was not either of the Waterloo Docks of today, but had its greater length east and west.

Practically all the north docks at Liverpool have been constructed by reclaiming the ancient foreshore, the only complete exception being Stanley Dock, which is entirely above the original high water mark. The method was to build a wall on the river front more or less along the low water line and to enclose the area of the future dock extension works by a return wall at the extremity carried up to the high water mark. After 1781 it became the practice to site a fort for the defence of the port on the corner between the riverside

wall and the return wall, the first one being constructed to the north of George's Basin.

The method of building the wall at this period was to dump sandstone rubble to form a foundation and build up the courses of sandstone masonry on the rubble, a raft of timber sometimes being laid to help in getting a level bed. Work could only proceed at low water and perhaps a low dam of clay might be used to extend the working period. These foundations have stood fairly well but there have been one or two local failures, in one or two cases resulting in collapse, owing to water seeping under the foundation and washing out the bed material if it was of a silty nature. Some of these older walls exhibit the remarkable phenomenon of rocking very slightly with the rise and fall of the tide. Later, diving bells and dams sheeted with cast-iron piles were used to get down to a rock foundation. The Brunswick river-wall was constructed behind an embankment.

The materials used for the construction of dock and river walls has varied. The walls of the Old Dock are said to have been built mostly of brick with stone copings. Later, sandstone masonry, much of it quarried from Runcorn, was used. The mortar was made from a blue-lias lime obtained from Halkyn in Flintshire. It was delivered in lumps, about the size of coconuts, on the quays close to the mortar mills where it was burnt and ground. The blue-lias lime contained the same substances that form the main ingredients of Portland cement, namely, chalk, or limestone, and clay, though the proportions were not the best. The resulting product gave a weak cement, stronger than ordinary lime mortar but not nearly so strong as Portland cement. In some cases it has degenerated to a slimy paste, probably due to the action of sea-water. Some of the old walls were built with bricks in the heart, made from clay excavated from the dock site.

By the middle of the nineteenth century much granite facing work was done, the stone mostly being quarried from the Board's own quarries in Kirkcudbrightshire. The vast quantities of stone setts required for paving the roadways were also obtained from the same source. Some granite also appears to have been obtained from Cornwall.

The docks were also developed rapidly southwards in the first half of the nineteenth century. The Queens Dock was enlarged in 1816 and a small dock, called the Union Dock, constructed on the south side with a large outer basin. The two were subsequently united and converted into Coburg Dock, which was entered directly from the river.

In 1832 Brunswick Dock was opened south of Coburg Dock. It was intended for the timber trade with a low inclined quay on the east side for hauling up timber unloaded from bow ports. Two graving docks opened out from its south end. The dock absorbed the site of the old tide mill reservoir called Jackson's Dam. The tide mill was erected about 1773 in place of an ordinary water mill whose stream had dried up. The reservoirs were of two sizes, the larger being eight and one-half acres and the smaller one and one-half acres. The mode of operation was as follows: the larger pond was allowed to fill at high water, and then as the tide fell it provided the water to operate the machinery until the next tide rose to meet the now reduced water level.

In the meanwhile the smaller pond had been allowed to empty with the

tide and the gates shut at low water to prevent it filling with the flood. Thus when the larger pond ceased to function, it was possible to continue operating the machinery by letting tidal water run into the smaller pond until the larger was available again after high water.

The mill ceased working in 1827.

Some time before 1840, a private concern had bought land between Brunswick Dock and the Herculaneum Pottery and formed Harrington Dock Company for the construction of docks and warehouses independent of the general dock estate. Two small inlets were constructed, named Harrington Dock and Egerton Dock, but were shortly after purchased by the Dock Committee.

The Old Dock was cleared of shipping in 1826 and filled in, the Custom House being built on the site. The level of the sill was preserved by a nine-inch step on the face of a nearby dock wall. The Dry Dock was enclosed in 1829 becoming Canning Dock, and enlarged in 1842. In 1844 the old entrance gut was enclosed as Canning half-tide, and in 1845 Albert Dock and warehouses opened.

The Albert Dock warehouses appear to be the first of the massive warehouses built on the docks, and are one of the monumental structures of Jesse Hartley, engineer to the dock estate from 1824 to 1860 and well known for the excellence of his work. Jesse Hartley seems to have been a very shrewd engineer. Though he built massively for his day, experience has shown that his judgment was good and by present day standards his works are by no means excessive in size.

The shipbuilding yards moved to west of Queens Dock and Brunswick Graving Docks, where they remained till the turn of the century. The expansion of shipbuilding and ship repairing at Birkenhead and Tranmere follows from the taking over of the Liverpool yards for docks.

South of the Brunswick shipbuilding yards was a small inlet with gates known as Toxteth Dock, later to be absorbed into a larger dock of the same name, becoming its river entrance.

When the timber trade shifted from Brunswick to Canada Dock a canal-type river craft dock was built on the site of the sloping quay on much the same pattern as the canal dock on the Wallasey side of the East Float surrounded by the Birkenhead grain warehouses. This was filled in at the turn of the century.

In 1855 Wapping Basin was constructed immediately east of Dukes Dock, connecting Salthouse with Wapping Dock, a new dock east of Kings, thus establishing continuity previously broken at Dukes Dock. At the same time Salthouse Dock was enlarged.

Eighteen fifty-eight marked the transfer of the docks to the newly constituted Mersey Docks and Harbour Board, and by 1866 the south docks had further developed. Between Queens Graving Docks and Coburg Dock, Eagle Basin and Trafford Dock had been built for river craft. Owned at first by the Corporation, they were in 1876 bought by the Board.

South of the Coburg Dock was the ferry basin and the dockyard, the latter being the gate-building depot and repair yard of the dock estate.

South of the dockyard was Brunswick half-tide dock, a vestibule to Brunswick Dock and now the Board's floating plant repair dock. Next came

Toxteth Dock, then a stretch of undeveloped land. Next, the small inlets, Harrington and Egerton, and a third belonging to the Bridgewater Trust. Close to these was a landing stage for a south ferry crossing, but it seems not to have prospered.

Then more undeveloped land and finally Herculanum Dock, on the site of the pottery, with two graving docks.

The Herculanum Pottery was opened in 1796, the operatives being brought from Staffordshire with their wives and families. It was closed in 1841 to make way for the dock opened in 1866.

Reverting to the north docks, Clarence Dock was entered from the river through a half-tide dock known as Clarence Basin. Clarence Basin was connected to Trafalgar Dock by a locking basin, in which the side walls opened out wider than the gates to give greater accommodation. On the north side of the half-tide dock was a basin from which the Clarence graving dock opened out, and which was provided with a gridiron.

In 1848, Salisbury, Collingwood, Stanley, Nelson and Bramley-Moore Docks were opened, Stanley Dock being connected with the Leeds and Liverpool canal by a flight of locks and provided with massive warehouses.

Salisbury Dock, like Clarence Basin, appears to have been a half-tide dock from its inception, marking a departure from previous practice.

In 1849 Wellington Dock entered through an outer half-tide dock, was opened. In 1855 a high-level coal railway was built on the east side, for the export of coal. High-level coaling staiths also occupied the east and north sides of Bramley-Moore Dock; that on the east side was afterwards demolished, and the berth is now used for unloading coal for Clarence Dock power station.

Development of the northern system continued unchecked.

Sandon Dock, with six graving docks opening from its north side, was opened in 1851. It was entered through an open basin, and followed by Huskisson Dock entered from the north side of the basin by two locks, one for a large number of small craft and the other for larger ships having a length of 390 ft. and a width of 80 ft.

In 1854 a fort was constructed at the north end of Huskisson Dock to replace one at Clarence, which had superseded that close to the site of Princes Dock. When Canada Dock was built north of Huskisson, the fort was left in an embayment of the river wall, which was not filled in until the fort was eventually removed to Seaforth.

Remarkable confidence in the future was shown at about this time, the land and foreshore being bought right up to Rimrose Brook at the extreme north end of Bootle in 1847. In less than thirty years this step was vindicated and the foreshore was enclosed by a wall more or less along the low water line and the land behind reclaimed as a preliminary to a dock extension scheme of remarkable size. It will be realised that most of the town sewers discharge into the Mersey, crossing the docks on their way to the low water mark. Thus whenever docks have been extended or reconstructed there has frequently been at least one sewer to be catered for.

In 1858 Canada Dock was opened, being more or less rectangular in general outline with a large tongue projecting into it from the north-west corner. The masonry of this tongue contained the 100 ft. wide and 498 ft.

long Canada Lock. This is entered from the river end via Canada Basin, the last of the open outer basins remaining, and now to be extinguished by the new Langton-Canada scheme.

The era of the large paddle steamer had begun about 1840, and, to accommodate these vessels entrances were made first about seventy feet wide, at Wellington, Sandon and Coburg, then eighty feet wide, at Huskisson, and finally 100 ft. at Canada, in 1858. Thus, in the twenty-one years from the opening of Clarence Dock, entrance widths had doubled from 50 ft. to 100 ft. Twenty-three years later no more large paddle steamers were being built, and new entrances were being made sixty-five feet wide.

Canada Lock was ready before Canada Basin and was used for a period as a graving dock. The passing of the large paddle steamer did not render the great width of the lock entirely superfluous, as by the end of the century the demand for entrances of that width had returned.

In 1862 Canada half-tide Dock, since renamed Brocklebank Dock, was constructed on the east side of Canada Basin, being entered directly therefrom by three entrances, the largest sixty feet wide, and giving access to two smallish branch docks, situated on its east side and named North and South Inland Carriers' Docks.

It had been intended to construct timber ponds, to the north of Canada Basin, to be entered from the river and Canada half-tide Dock, and work appears actually to have started on a small dock just north of the basin to be known as Castle Dock, but the scheme never matured.

Also in 1862, a branch dock was constructed off the south end of Huskisson Dock. Eventually the No. 2, it has been filled in after the *Malakanp* explosion in 1941.

In 1872 a second branch was added at Huskisson Dock and the Canada half-tide lengthened to the north. As the trade in general cargoes expanded, so the timber quays appear to have been taken over and reconstructed for the new trade and new timber quays constructed in the northerly extensions.

The shape of the docks from this time on was varied and the trunk and branch layout generally adopted where practicable in preference to the rectangular design. There are, of course, advantages and disadvantages with the two arrangements. In general the branch dock system gives more berthage per total area, but is less adaptable to changes.

Dock layout and design has been influenced by three major considerations:—

The growth and size of ships.

The introduction of quay cranes.

The use of mechanical plant for handling cargo.

Prior to the first war growth was very rapid and the increasing draught of vessels was a cause for concern. Since the second war, the rate of increase of draught has not been so marked, but vessels are carrying much bigger cargoes requiring more room on the quays for sorting, stacking and delivery.

Replacement of the horse cart by the motor lorry has resulted in more long distance cargoes being handled by road as against rail. Motor vehicles have grown in size and require more room.

Generally wider quays, wider sheds and wider roads are needed. This favours the long rectangular dock, but the frontage is not always available,

and the branch dock system or pier system has to be used. Sometimes a compromise is effected, such as has occurred with the filling in of Huskisson Branch Dock No. 2.

This shows the enormous importance of a very careful examination of the traffic requirements of docks, where very large capital cost is involved, in order to obtain a satisfactory return on the expenditure. However, planning is a continuous process and must meet changes as they arise. To try to plan too far ahead might be dangerous owing to the complexity of the problems and the number of variables.

The stage of development of a port in relation to the growth in size of ships has been an important factor in the problems facing it. Thus if the early days of the port coincided with the rapid growth of the size and numbers of ships, each group of new docks was bigger than its predecessor, and the old docks built for the ocean liners of their day were still big enough for coasters, provided that development was maintained in the right proportions. This process could not go on indefinitely however.

Gradually the emphasis must change from development by new construction to development by reconstruction; in effect from capital expansion to capital replacement. If the need for reconstruction is due only to the increasing size of ships and is not accompanied by increasing total tonnage, there may be very little extra revenue to offset the expenditure unless rates and dues are raised.

Though reconstruction had been undertaken before the inauguration of the Board in 1858 it was about this time that large scale reconstruction and modification were beginning to take place side by side with extension. Later reconstruction was to become predominant and some of the reconstruction schemes have been very extensive indeed.

In 1863 an extensive improvement was commenced at Waterloo Dock and Princes Basin, the latter an open tidal basin with locks into Princes Dock on the south and into Waterloo Dock on the north. The basin was converted to a half-tide dock having river entrances, the sills of which were lower than any then existing. Waterloo Dock, a rectangular dock with its greater length east and west, was replaced by two rectangular docks side by side, with their greater lengths north and south. The westerly one is the present West Waterloo Dock, and the easterly, known at first as the Corn Dock on account of the large corn warehouses surrounding it, is now the East Waterloo Dock.

This work was completed in 1868 and entailed the removal of the Liverpool Observatory, built at Princes Basin in 1844, to its present site on Bidston Hill.

The two landing stages, Georges to the south built in 1847 and Princes to the north built in 1857, were separated by Georges Basin, which gave access to Princes Dock on its north side and Georges Dock on its south.

There was a strong desire for an improvement to be made in the approaches to the stages, the outcome being that Georges Basin was closed, the two stages were joined by inserting a middle section 500 ft. long and a floating roadway built up the site of the basin from the new length of stage. The new landing stage was destroyed by fire in 1874 just before the official opening, but was promptly restored.

These works were really part of a much larger scheme for the improve-

ment of the central river front, but the next step was not taken until some thirty years later, in 1896, when Georges Dock was filled up, and the site turned over to streets and buildings. Water Street and Brunswick Street are carried across the site of Georges Dock, by means of a viaduct.

Meanwhile the lock between Princess Dock and Georges Basin had been converted into a graving dock and the passage between Georges Dock and Canning has become the inlet at the north end of the latter dock. The Princes graving dock has since been converted into a wet dock.

In 1873 the Board applied to Parliament to make the largest and most important extensions to the Liverpool docks that have been undertaken. The docks had been congested for some time but opinions were divided on what should be done. Three schemes were put forward by the engineer, George Fosberry Lyster, namely, extension northward, extension southward and extension eastward across Regent Road in the vicinity of Sandon Dock.

The first two schemes were adopted, and by them the total water space added was 110 acres—eighty-three at the north and twenty-seven at the south end, or forty-four per cent of the area of 252 acres of the whole Liverpool estate in 1873.

The extension northward comprised the construction of the Langton Dock, Branch Dock and Graving Docks and Alexandra Dock, all completed in 1880, and Hornby Dock completed in 1884.

The first stage was the construction of a sea-wall parallel with the low water mark from the north pierhead of Canada Basin to Rimrose Brook, a distance of 6,400 ft. The wall was returned at the north end to complete the enclosure of the foreshore, the waters of Rimrose Brook being conveyed to low water mark in a culvert behind the return wall. At the angle of the two walls Seaforth battery was built, being completed in 1874, and half-way along the wall, the North Wall Light.

The Seaforth battery replaced the Huskisson Fort, the foundations of which are being encountered at the south end of the present Canada Dock which is under reconstruction as part of the Langton-Canada scheme.

The main feature of the northern scheme was the enlargement and deepening of Canada Basin, and the sluicing arrangements to maintain the depth there. The principle of the acutely angled entrance facing upriver was first adopted for the Langton entrances, possibly on account of an unfortunate experience in 1868 when the storm gates of the Canada 100 ft. entrance were carried away.

The basin entrance was widened and splay jetties constructed outside to guide shipping and to house sluices, as the new entrances were to be two feet below low water of spring tides. This was four feet deeper than any other entrance on the Liverpool side of the river. Though the Alfred and Morpeth entrances at Birkenhead had been quite successfully maintained at the new depth some misgivings were felt about the Liverpool side, and extensive sluicing arrangements were decided upon. Profiting by the unfortunate experience of the Great Low Water Basin at Birkenhead, the floor of Canada Basin was concreted over after deepening and sluices laid beneath the floor with upcast outlets through the concrete. The arrangement worked remarkably well.

Langton Dock was designed as a half-tide dock, with two entrances side by side, but each had two pairs of gates, thus forming small locks. This had

the double advantage of providing locks for river craft which could then be locked in and out clear of tide time, and of providing a second pair of gates as a stand-by in case of damage. At some other entrances separate locks were provided for river-craft, but these require extra manning and maintenance.

The south works consisted of the enlargement of Herculaneum Dock to accommodate a new graving dock, and a branch dock parallel with the graving docks to serve as a petroleum dock and a possible connecting link with further southward development. On the east and south sides, chambers fifty feet long by twenty feet wide by nineteen feet high were excavated in the rock for storing petroleum in barrels. Between Herculaneum and Brunswick, two new docks, Harrington and Toxteth were built. The sills of these new docks were made two feet below Bay Datum in view of the success of the Canada Basin deepening, the Herculaneum river entrances being deepened four feet to conform. Owing to the narrowness of the estate just here, Harrington and Toxteth docks have their greater length parallel to the river

The old docks from Georges to Brunswick were no longer deep enough, and to increase their effective depth an impounding pumping station was built at Coburg Dock to maintain the dock level at all times equivalent to that of high water spring tides. This expedient had already been adopted for increasing the depth of water on the sills of the Sandon Graving Docks and at Birkenhead.

To connect the two systems, Union Dock was built between Brunswick and Toxteth docks to function as a locking basin. It was situated to the east of the Brunswick graving docks. The impounding of the south docks ceased in 1909, two years after it was adopted for the north system from Hornby to Bramley-Moore.

Though the Liverpool docks owed their phenomenal growth at this time to railway communications and are well provided with rail tracks on the quays, not much direct loading from ship to rail wagon has ever taken place. This has come about because Liverpool was as much a warehouse port as a transit port and the bulk of the cargoes consisted of mixed merchandise that required sorting on the quays. After the cargoes had been broken down into those destined for Board's warehouses, private warehouses and the railways, the parcels were quite small, and as there were four or five different competing railway companies, it would hardly have paid them to send locomotives down to the quays, where there would be congestion, but it was more convenient in most cases, to collect and deliver from the railway goods stations by horse and cart even those goods for immediate despatch by rail. In fact the dock lines of railway were not started until 1849. Thus even in the days before long distance road transport, Liverpool was in one sense a road port.

At this point it might be well to include some account of the development of the Birkenhead docks, not only because they are part of the Port of Liverpool but also because the experience gained with a sluicing scheme there had its influence, as already mentioned, on the design of the Canada Basin sluices.

Sanction for the enclosure of Wallasey Pool, and construction of docks on its site, was obtained by Act of Parliament in 1844 by the Birkenhead Docks Committee, a body formed specially for the purpose and work was immediately started.

Morpeth and Egerton docks were opened in 1847, access from the river being obtained via Woodside Basin just north of the ferry pier. The east and west Floats were not finally opened until 1861, however, as the Birkenhead Docks Committee were unable to complete the proposed works owing to financial difficulties, being bought out by Liverpool Corporation two years before the Board took over in 1858, and the designs were changed to give deeper water in the Floats, some of the walls already built having to be made bigger.

The waters of the rivers Birket and Fender discharged into the head of the pool and had to be diverted by means of an open cut across what is now Bidston golf course and past the railway between Bidston and Birkenhead North stations, and finally through a large culvert two miles long under the streets of Birkenhead to Woodside Basin and the Mersey.

The most prominent feature of the Birkenhead docks was to have been the Great Low Water Basin. The design was changed several times but the primary object remained the same. It was to be an open deep-water harbour, into which vessels might run and remain or be locked at once into the Float. Its depth was to be maintained by a scour of water from the Float run daily. The water was to flow from sluices on each side of the lock at the head of the basin, which was more or less rectangular in form, measuring 1,750 ft. east and west and from 300 to 400 feet north to south; the depth was eleven feet below low water spring tides. On the southern side was a recess 1,000 ft. long by 35 ft. to accommodate a floating landing stage. The sluices had the colossal area of 800 square feet and were intended to give the effect of a subaqueous river quietly flowing along the bottom of the basin and removing any silt deposited by the tide, but not disturbing shipping or scouring out the bottom deeper than the original excavations.

The first sluicing trial was made at low water on 20th January 1864. Unfortunately the dam across the mouth of the basin had burst just as the site was being cleared preparatory to letting the water in in the normal way. The result was that the bottom had accumulated a deposit of about thirty-two inches in seven months since the bursting of the dam.

The condition of the water on leaving the sluices was that of a rushing torrent of white foam, with a boiling and tumbling motion and a speed up to eight miles an hour. The colour of the water changed as a dark brown cloud rose. At 150 feet from the head of the basin a wave was formed twelve to eighteen inches high.

It soon became evident that the running of the water was dangerous. The rapid lowering of the float was objectional; on closing the sluice paddles a wave twelve to fifteen inches high surged through the float. The head works of the basin were being undermined by scour, and the basin had to be cleared of vessels. The power let loose was of immense force, and a feeling arose that some great and sudden calamity, unforeseen and uncontrollable, might at any moment arise. Sluicing in the dark was therefore discontinued.

Yet the effect of the scour over the main portion of the basin was tolerably equal, except at the head, where the bottom was swept below the primary level. At the end of ten months the bottom deposit had been reduced by eighteen inches leading to the conclusion that the primary depth could have been maintained.

It was finally decided to abandon sluicing altogether, owing to the danger of undermining the wall at the head of the basin and so leading to a sub-communication between the water of the Great Float and the low water basin, and owing to its being incompatible with the proper and efficient use of the basin as a dock.

Powers were obtained to close off the river end of the basin and to convert it into a wet-dock, but it was not until 1877 that this was completed and opened as Wallasey Dock.

After the sluicing was abandoned, the basin silted up at the rate of thirty-nine inches per year.

In the meanwhile the Alfred dock and entrances, including the 100 ft. lock, had been opened in 1866, and Morpeth lock, eighty-five feet wide, was opened in 1868 into an altered and enlarged Morpeth dock, the branch dock being constructed a year later by closing off Woodside basin. Though connected to the river by locks, Alfred Dock functions partly as a half-tide dock as well.

Later developments at Birkenhead were the construction of Vittoria dock in 1909, the construction of the Alfred eighty foot entrance lock in place of two smaller entrances in 1928, and Bidston Dock in 1933. The graving docks were constructed in 1864 and 1877.

The new north and south works completed in the 1880's, together with the expedient of impounding the southern central docks, the Birkenhead docks and Sandon Dock, did not suffice to meet the growing needs of trade.

In 1890 work commenced on deepening the Bar, and shortly afterwards possibly the most extensive scheme of reconstruction ever undertaken in the port was commenced. The docks between Canada Basin and Wellington were to a great extent remodelled.

Canada Lock was lengthened by the removal of the storm gates and deepened, the southern part of Canada Basin being deepened to conform.

Canada Dock was enlarged southwards into Huskisson Dock, the west quay straightened and lengthened, and two branch docks and a graving dock constructed on the east side on the site of the timber quays.

A new passage connected Canada and Huskisson Docks.

Huskisson Dock and the north branch dock were deepened, the walls being underpinned, that is concrete was placed beneath the existing masonry to extend it downwards to a deeper foundation.

The six Sandon graving docks were demolished and, opening off the main Huskisson dock, a third branch dock, the present No. 1, constructed in their place.

Sandon Basin and Wellington half-tide Dock were joined and converted into Sandon half-tide dock and the Sandon entrances constructed. The locks into Huskisson Dock were replaced by a new passage and Sandon Dock was altered.

The reconstruction work in the north docks did not cease there, but was continued with the construction of the Canada branch dock No. 3 in 1906, the underpinning of walls and deepening of parts of Canada Dock, the deepening of the Canada-Brocklebank Passage; the underpinning of the walls and deepening of Brocklebank Dock and the filling-in of the entrances from Canada Basin; the conversion of South Carriers Dock into Brocklebank

Graving Dock; the construction of the Brocklebank branch dock and a reinforced concrete wharf in continuation of its north wall; the widening and deepening of the Langton-Brocklebank Passage and the deepening of the Langton-Alexandra East Passage. Well over two miles of wall were underpinned.

The Brocklebank Graving Dock was provided with steel gates, the first in the Port, and still having the largest span, 141 ft. 8 ins. between centres of pivots.

Concurrently with these improvements in the north docks extensive improvements were in hand in the south system.

Kings Dock was replaced by two branch docks, Kings No. 1 and No. 2, branching off Wapping Dock. Two branch docks and a graving dock were constructed on the west side of Queens Dock in place of the Queens half-tide and Graving Docks the shipbuilding yards, and Eagle Basin and Trafford Dock.

This explains why the main docks here are on the landward side with the branches to the River, which is the opposite to the branch dock arrangement in the north docks.

Brunswick Dock was deepened, and was lengthened at the south end by the demolition of the graving docks and the elimination of Union Dock; the east and west quays were improved by the filling in of the river craft dock and of the passage to the Brunswick half-tide; and the present Brunswick deep-water entrances were constructed with sills at nine feet below Bay Datum. The entrances were constructed on the site of the shipbuilding yards already mentioned.

All four passages between Wapping and Toxteth docks were deepened to seven feet below Bay Datum and widened to 100 ft., and a cut dredged across the east end of Coburg Dock.

The amount of new and reconstruction work done by the Board from its inauguration in 1858 to the years just before the 1914-18 War was phenomenal. In the thirty-six years from 1861 to 1897 during which George Fosberry Lyster was engineer-in-chief, work to the value of approximately £20,000,000 was done. His son, Anthony George Lyster, was mainly responsible for the very extensive reconstruction works just described.

It seems appropriate here to mention the Overhead Railway. As the line of docks extended the insufficiency of the old slow-running horse omnibuses, which used the line of docks railway, became sorely apparent. The idea had been first mooted in 1852 and in 1877 G. F. Lyster prepared a scheme followed by others for an elevated railway. The last plan he prepared was for an electric overhead railway in much the same form as that actually constructed. However, the Board finally decided that, as they were primarily a dock authority, they ought not to undertake the responsibility of administering a passenger railway. An arrangement was therefore made with a company who undertook the work and carried it out by their own engineers, Sir Douglas Fox and J. H. Greathead.

Immediately following the great reconstruction schemes came another great new construction, that of the Gladstone system. The graving dock was constructed first, just outside the north return wall on the line of the former Rimrose Brook, well to the north of Hornby Dock and isolated from it.

Opened in 1913, it was of remarkable size and still holds its place today as one of the largest graving docks of the world. One thousand and fifty feet long with a 120 ft. wide entrance and a sill fifteen ft. below Bay Datum, it is just large enough for the *Queens*, though with very little clearance for safety. It opened directly to the sea by a fairway marked with dolphins and was provided with a sliding caisson, which could hold back the water on either side so that it could be used as a graving dock or wet dock as required.

The river entrance, wet dock and branches, and the Hornby lock were opened in 1927. The entrance 1,070 ft. long, 130 ft. wide with sills 20 ft. below Bay Datum is the largest lock in the country.

Though provision has been made for an auxiliary lock on the west side of the existing entrance, and for a passage to connect to an even larger system to the north, present policy does not favour development by new construction but by modernisation.

From 1929 to 1949 the alterations were mainly in the central docks. They included the conversion of Clarence Dock to a power station site, the replacement of the old Clarence half-tide and Trafalgar lock by a wet dock in 1931 and the opening of the new Waterloo river entrance in 1949 as the first deep-water lock for the coastal trade. Princes Dock quays have been improved and the graving dock converted into a wet dock.

At the end of 1949 the Langton-Canada Improvement Scheme was started. Under this scheme the Canada Basin and the locks off it are replaced by a lock comparable with that at Gladstone though a little shorter. The west sides of Langton, Brocklebank and Canada docks are being reconstructed to give more quay space and the Canada-Brocklebank Passage widened and deepened, while the Langton-Brocklebank Passage and adjacent tongues will be demolished.

Though this scheme is not so extensive as those at the turn of the century, the problems are no less difficult, partly owing to the lack of land space but also because difficulties and costs increase with every foot of depth, and depth today is a necessity.

To plan the development of a great dock system is seen to call for a combination of foresight, adaptability and boldness, as the works laid down will outlive the vessels of the day and will see changes and innovations in the types and quantities of cargoes and in the methods of handling them.

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(Since reading his paper, Mr. Stephenson has been elected a full member of the Institute of Civil Engineers, and the Society takes this opportunity of congratulating him.)