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M B Mullins: An Historical Sketch of Engineering in Ireland
INLAND NAVIGATION.
The importance attached to the supplying of Dublin with native coal gave rise to many extensive projects for the promotion of that object. The communication between the collieries at Drumglass, near Dungannon, and lough Neagh, was effected by the Tyrone navigation, or Coal Island Canal, leading into the Blackwater river, and from thence by the Maghery Cut into the lough from which the river Bann and the Newry navigation conduct to Carlingford lough.
The Newry Canal extends 3½ miles from the Victoria sea-lock at Doyle's Hole to Newry, and from thence to the navigable part of the Upper Bann river, the whole distance to lough Neagh being 25½ miles Irish, 9 miles being in the bed of the river. The summit is 65 feet above the level of the sea, and 22 feet above lough Neagh, making a total rise and fall of 87 feet in 24 miles, equal to 3⅝ feet of lockage. There are 13 inland locks, varying in size from 63 feet 10 inches by 15 feet 1 inch to 15 feet 3 inches in width, 5 feet to 5 feet 6 inches on sills, in the normal state of the navigation; width of canal, 40 to 45 feet at water line. The summit level is supplied by a feeder from the Cushe river, taken at Tanderagee bridge; there is also the reservoir of lough Shark, about 75 acres area, which is, itself, fed by a stream flowing from Loughbrickland; this, however, is stored up in summer for flax mills when it is most needed for the purposes of the canal. The Bann seldom floods the neighbouring lands since the completion of the lough Neagh drainage. There is, at the entrance of the lough, a bar, having over from 4 to 5 feet of water in summer, but as it shifts with the varying impulses of the current, frequent dredging would be required.
The adoption of different plans, and the rejection of them when partly executed, led to great expense in the execution of the works of this navigation; some short details of the difficulties of which, it is presumed will not be amiss in illustration of the state of the engineering of the period, not belonging to a native school though practised in Ireland. The undertaking was commenced in 1732 between Newry and the river Bann, under the direction of Mr. Richard Cassel, a German Engineer, who was appointed by the Commissioners of the Board of Navigation, and who built the first stone lock erected in Ireland. Mr. Cassel, not having given satisfaction, was replaced by Mr. Steers, a Liverpool Engineer, under whom the canal from Newry to the deep water of the Bann was finished in 1741. The portion between Newry and Fathom Point was not completed until 30 years later.
We learn from a report in 1750, of Mr. Acheson Johnston, Undertaker and Engineer of the Newry Canal, positions then not incompatible, that of the fifteen locks on the canal, twelve were in good order, two of the remaining three were built nine years previously on a French plan, with pipes in the side walls instead of sluice tunnels; these were subject to burst and were out of order. The splays or fronts and tails of the locks were built of brick and were mouldering away, and the waste of water was such, that the levels, full over night, were dry in the morning. The third lock was built of common rough stone, and the water had pooled behind it in several places. A mile and a half of the upper level, next Poyntz Pass, was so narrow that two boats of burthen could not pass each other.

As to the then state of the navigation from lough Neagh through the county of Tyrone towards the coal pits, Mr. Johnston stated that the navigation was continued out of the lough by the Maghery Cut for nearly three miles in the bed of the Blackwater river, and that a canal was carried from thence 3 miles 38 perches to the town of Coal Island, that it had three locks upon it of stone, and that it should be carried further towards the collieries of Drumglass and Stewartstown.

The Maghery Cut was made across the isthmus of that name for the purpose of avoiding the bar at the mouth of the Blackwater, having upon it 1 foot 10 inches of water in summer.

The continuation of the canal, on Mr. Acheson Johnston's plan, having presented some difficulties, Mr. Christoper Myers was appointed to succeed him as director of the works, in 1762. He proposed to make a canal of sufficient size to enable vessels of 100 tons to sail from Newry to the collieries. He began at the colliery basin, but he bad not made much progress when he found that the expense would be so great, that he recommended the giving of it up after having made the experiment, as he called it, of excavating a portion of the line and building a lock 125 feet long and 22 feet wide. The estimated cost of this canal, to extend 2E miles, from the termination of the old canal to the colliery, was £26,000. The intention of making it having been abandoned, Mr. Davis Duckart, an English Engineer, who had been long in the Sardinian service, was appointed. He made a communication between Drumglass and Coal Island, a distance of about three miles, by the formation of four pools, or levels, at different elevations, 4 feet deep and 24 feet wide, for vessels of 12 tons burthen: between each level, was an inclined plane having beams of timber laid down with castors fixed on them. These contrivances, called dry hurries, were intended for small laden vessels to go down with the help of a crane and rope to prevent their running too fast, and also to draw up the empty boats.

This system of narrow canals, inclined planes, and wheeled boats of about 4 feet in width, was recommended by Fulton, as useful in facilitating the navigation of the great rivers and lakes of America, and was intended as an improvement on the plan of the Chinese, who, being ignorant of the contrivance of a lock, use, at the present day, inclined planes, up which their boats are pulled by a great expenditure of manual labour.

In the year 1774, Mr. Jessop was consulted as to the mode of constructing the inclined planes between the different reaches of the canal, and he having had some doubts as to the mode of proceeding, had recourse to the advice of Smeaton, who, in his reply, as given in the second volume of his Reports, observes—*'That, as the bulk of the expense had been incurred in making the reaches of the canal, the experiment of Duckart ought to be carried out in order to test its applicability to other places.'* Smeaton adds—*'If the scheme does not, on trial, answer, a railroad of timber, after the manner of those at Newcastle and Whitehaven, would be preferable in such a situation, either to a canal or a gravelled road, especially as it could be done with a length of two miles, and most of the way down hill, so that the loaded waggons would go down by their own gravity, and the horses would have nothing to do but to draw the empty ones back, which, in a rise of 192 feet in two miles, would be easy work.'* We, at this time, cannot understand how a most expensive and complicated system should be preferred to the simple and effective contrivance of an inclined plane.

Mr. Duckart also proposed and partly executed a subterranean navigable canal, with ventilating shafts to be made to answer as a sough or drain for all the collieries, and to communicate with the old navigation, at a cost of £26,900. A Mr. Hamilton Bury, an Engineer, who had been contractor on the works of the Nore, gave evidence before a Committee of the House of Commons, as we do now-a-days, that the work could be executed for the estimate, but, as also sometimes happens with us, it was not so done, and was, after the expenditure of a considerable sum of money, abandoned about the year 1775.

Mr. Richard Owen having been called on for his professional advice in 1787, found the hurries constructed by Mr. Duckart out of order: he recommended the gradient of the inclines to be lessened, and the beams and rollers to be replaced by a road made of broken stone and gravel. In this state matters remained as long as unchecked dilapidation permitted.

With reference to that portion of the navigation from Newry to Fathom, which, as before stated, was not finished until thirty years after that between Newry and the Bann, a contract was entered into in 1758, for its execution, with Mr. John Golborne, Engineer, of Chester, who, after working at it for a year, abandoned it, and returned to his own country. After Golborne's departure, recourse was had to Mr. Christopher Myers and Mr. Thomas Omer, in conjunction, by whom, what was done by Golborne, was condemned, and considerable sums were laid out by them up to 1763, without, however, producing any desirable result; for, on inquiry before a Committee of the House of Commons, in 1767, it appeared that the work was wholly inoperative.

Mr. Christopher Myers, who, at that period, was architect to His Majesty's Board of works, having been examined, stated that so much of the work as was carried on by him, in 1762 and 1763, was in accordance with the plan approved by the House in 1759, that he had advised 6 feet depth instead of 9 feet, as executed, and that he had offered in the first instance to contract for the whole for £18,000, provided half the amount was then granted, and the remainder in the following session, but as £5,000 only was granted, he refused to be responsible for its completion.

Mr. Thomas Omer, who was a Dutch Engineer, having been examined as to the insufficiency of his plans, excused himself by stating that he knew they would not answer; that he had made them by order of the Navigation Board, and that he proceeded while the money lasted.

As this was by no means a solitary instance of the misapplication of public funds, the management of the Navigation Board fell into disrepute; and that body, which commenced its functions in 1730, under the 3rd Geo. II., was dissolved by the 27th Geo. III. in 1787, and a system of granting aids to private undertakers, in proportion to their subscriptions, was thenceforth adopted under the provisions of that act. The navigations thus transferred were those of Newry, the Boyne, the Barrow, the Shannon, and Tyrone. The company for carrying on the Limerick Navigation had been already incorporated in the year 1767, and the Grand Canal Company in 1772. To these undertakings grants in aid were made from 1789 to 1800, and in the latter year a sum of £500,000 was granted to be applied to the system of navigation

generally, and for the improvement of the Port of Dublin in particular under the supervision of a board of five directors.

The management of a body so numerous and ill-constituted as the old Navigation Board, consisting as it did of eighty-six persons, twenty commissioners having been particularly named for each of the four provinces, with the Chief Governor, the four Archbishops, the Speaker for the time being, at their head, carried with it from the beginning the germ of its own decadence, and in its failure could have suggested no other feeling than that of surprise at its having been accorded an existence of fifty-seven years, during which twenty-three different extensive projects were undertaken, but not a single one brought to completion, with an aggregate expenditure of £600,000. But bad as the administrative part of the management must have been, the executive was still worse, and its details go far to show that there were other causes of failure than that generally received, of a prevalent system of jobbing, an imputation from which to relieve the country, even at this distance of time, is a duty not too late to be performed; the inference from the statement of facts being left to others to draw, keeping in mind that the Engineers employed during the period referred to were not Irish.

About the year 1780 the canal was extended three miles further to Fathom, to accommodate the ordinary run of coasters of about 120 tons, there being 9 feet depth of water on the sill, and 21 feet breadth of lock. In 1789 Mr. Richard Evans, Civil Engineer, reported on the state of the navigation, and gave plans for its improvement, but without having been attended with results, nor does any renewed attention appear to have been given to the subject until the year 1800, on the vesting of the Tyrone Navigation in the newly constituted Board of Inland Navigation, when Sir Thomas Hyde Page made a proposal to extend the canal from Fathom to Rice's Bay, opposite Warren Point, at a cost of £136,000. On entering into possession at the above period the Directors-General found that the works, constructed at a cost of £114,220, had been allowed to fall almost into a state of ruin, and they were obliged to expend £20,730 on the Tyrone Navigation which had been abandoned, and £53,379 on the reconstruction of the Newry Navigation, in deepening the levels and rebuilding most of the locks; £15,043 of the latter expenditure having been received from tolls. Up to 1812 these works were executed under the direction of Mr. Brownrigg, who was the first native Engineer appointed.

The widening of the sea lock at Fathom, and the putting in of a stone platform and sill—the first instance of that mode of construction in Ireland, was subsequently executed at an additional expense of £5,000, under the superintendence of the same Engineer.

In 1828 Mr. Alexander Nimmo having been consulted, reported in favour of deepening the natural channel of the river, so as to secure 14 feet depth at neap tides all the way up to Newry. For this his estimate was £98,568. In 1830 Rennie, Killaly, and Brownrigg agreed generally in their Reports as to the propriety of making a canal from Fathom to the deep water at Doyle's Hole, with a ship lock there, and the deepening of the natural channel at Narrow Water, as recommended by Rennie.

In the year 1831 the Newry Navigation Company was incorporated by Act of Parliament, and they were authorised to levy tolls on condition of their expending not

less than £80,000, in seven years, in keeping the works in repair, and in the extension and improvement of the Navigation, or in default, the works to revert to the Commissioners of Inland Navigation, on payment of their value to the Company. It appears that up to 1848 nearly £50,000 were expended by the Company in deepening and widening the channel of the river from Doyle's Hole to Narrow Water, and from thence to Warren Point, that a steam dredge had been purchased for that purpose, and that a contract had been entered into amounting to £40,000 for extending the canal along the western side of the river, from Fathom to Doyle's Hole, and the erection of a ship lock, all of which have been since executed.

The canal has been extended one mile and a-half from Fathom—the old lock there taken up, and the Victoria lock designed by Sir John Rennie, and superintended by Mr. John Ramsay, Civil Engineer, was opened for traffic in the year 1850, at a point in the river three and a-half miles below Newry, known as Doyle's Hole, where there is 76 feet sounding, affording safe anchorage to vessels waiting for the opening of the lock, which is 220 feet long and 50 feet wide, having 17 feet 9 inches of water on the upper sill into the canal, and 7 feet on the lower sill at low water of spring tides. The masonry is of a very superior description, consisting of massive granite blocks, with some limestone, from the neighbourhood of Carlingford. The whole was erected at a cost of £25,000, including two pair of gates made of mahogany and teak; the estimate of the latter was £3,500.

The new part of the canal is 140 feet wide at water surface, and 80 feet wide for the remainder of the distance to the entrance of the Albert Basin at Newry. which does not admit vessels of more than 14 feet draught, rendering it necessary to lighten them in the canal, where the depth is 17 feet. From Victoria Lock to Warrenpoint Roads, a distance of two and one-third miles, shoals of rock and sand have been removed by blasting and dredging, and river walls constructed, confining, and in some parts enlarging, the tidal scour.

The Belfast Railway competes with the Newry Canal to Portadown, running close alongside in many places; however, the communication by means of lough Neagh with the Ulster, Coal Island, and Lagan Canals, enables this navigation to maintain the struggle. The tonnage register entered sea-wards, on an average of the years 1858 and 1859, was 78,051 tons, and the receipts from ballast and tolls, both sea and inland, amounted averagely to £6,074.

With reference to the attainment of the object which at the outset prompted the undertaking of the Tyrone and Newry Navigations, namely, the supplying of Dublin with coal, it appears that in 1748 a company, consisting of a few wealthy local proprietors, was formed, and a Mr. John Fletcher, an English gentleman of great experience, was brought over, who, on examination, was so convinced of the great capabilities of the Drumglass and Stewartstown collieries that he joined the partnership, and sent miners and artificers from England. He put up a large water engine, worked by a rivulet, and constructed a sough or underground drain, 1,200 yards in length, but these means of unwatering having proved to be inadequate, a sum of £2,000 was granted by Parliament in 1784 to John Staples and James Caulfield, Esquires, for the purpose of erecting a steam engine, obtained from an English manufacturer, who was delayed in fulfilling his agreement by the drought of

the season depriving him of mill power. This was probably the first steam engine introduced into Ireland; and the fact of a factory of that description being wholly dependent on water-power, shows the stage to which that branch of manufacture had at the time arrived in England.

The catalogue of successive failures may be summed up by the report of Mr. Francis Trench, Secretary to the Directors-General in 1812. He informed that Board that the price of coal at the pit was sixteen shillings per ton, and the lessee expected to get them to Dublin for twenty-six or twenty-eight shillings, including the bounty of two shillings per ton. Mr. Trench did not consider it was the interest of the lessee to send them there, as they were of a very indifferent quality, small, swift, and without any of the bituminous quality to make them adhere. He found from actual trial, at a house in the neighbourhood, that a good fire could not be made of them without the addition of turf; at another house they burned English coal, at thirty shillings per ton, which he considered was much cheaper, being better. Having been informed that there was a superior description at Coal Island, he visited that place; the pit was about 60 feet deep, and the seam reported to be six feet, but it could not be raised large; on the whole it was by far the worst coal he ever saw, and in his opinion was not worth working.

At a later period the field was occupied by two companies, and notably by the Hibernian Mining Company in 1829, but as this branch of the subject has been taken up by Sir Richard Griffith, in his Survey of the Tyrone Coal District, it would be more than superfluous to pursue it further here. More details may, at first sight, perhaps, appear to have been entered into with reference to the Tyrone and Newry Navigations than the immediate interest of the subject deserves, but their chequered progress is so illustrative of the empirical character of the engineering of the time, that in an historical point of view a particular notice of the progress of these undertakings, in connection with the professional persons employed, can not be considered out of place, the more so as it has been customary to attribute the failure of every thing in Ireland to native incompetency, or yet worse, to jobbing, whereas the facts show that the unskilfulness was not theirs, and that the spirit of enterprise was marred by the general want of professional knowledge.

LAGAN NAVIGATION.

This navigation extends twenty-eight miles, from lough Neagh to the quays at Belfast, from whence, to the first lock, there are two miles in the tide-way. The summit level, eleven miles in length, is 112 feet 6 inches above the Belfast lough, and 71 feet above lough Neagh. There are twenty-seven locks in all, of which seventeen complete the rise between Belfast and the summit., four of them, in close
proximity, called the Union locks, ascend at a distance of thirteen miles from Belfast, from the river to the summit whence the navigation to the lough is artificial, about three-fourths of the whole length being similarly circumstanced. The summit level is carried over the river Lagan six miles three-quarters from the Union Locks, by an aqueduct of four arches. The chambers of the locks are 65 feet 3 inches long, and 15 feet 6 inches wide, with 6 feet 6 inches depth on the sills in winter. The locks between Belfast and the summit having been built of red sand-stone, became so dilapidated

that large pieces had to be cut out of the side walls, and replaced with fire-brick, but basaltic stone having been used at the lough Neagh side, no such reparation was found necessary. The levels of the respective reaches are maintained by pen weirs, and over-falls constructed on the usual principle the former have from eight to fifteen sluices in each of them respectively. The artificial cuts have a breadth at bottom of 30 feet, and 51 feet 6 inches at water surface, and, except in very dry seasons, barges drawing from 5 to 6 feet pass freely, carrying sixty to seventy tons burthen.

This is one of the many projects commenced under the auspices of our native legislature, defective in design, and consequently attended with ever-recurring impediments during its construction, aggravated by the absence of sufficient means for completion, under unfavourable circumstances. In the year 1753 the Board of Inland Navigation was empowered by the Act 27th Geo. II., c. 3, to make the river Lagan navigable, and to open a passage by water between the town of Belfast and lough Neagh. In order to carry out that object, additional duties were levied by consent of the inhabitants, on certain articles brought for consumption into the district through which the navigation was to extend. The works were commenced soon after the passing of the above-mentioned Act, and were in the year 1763 advanced in their construction so far as to have allowed a boat of forty tons to pass from Belfast to Lisburn, a distance of eleven English miles, open from that period for public traffic.

The following, with reference to this subject, appears in the Reports of the House of Commons for the year 1767. Thomas Omer, Civil Engineer, having been examined, stated that "between Belfast and Lisburn weir, there had been built twelve locks and eight pen locks, upon which were expended about £1,000 each; that it would require one more large pen lock in the tide-way near Belfast, in order to admit of a passage for boats at neap tides, this would cost at least £1,000, and would complete the number of locks necessary between Belfast and Lisburn weir. That the digging yet to be done on the trackways would require £500, so that £1,500 would complete the navigation from Belfast to Lisburn weir for vessels of from forty to fifty tons burthen. That from Lisburn weir to Spencer's bridge, a distance of about six miles, would afford sufficient work from that period to the next session, and would require £3,000 to complete, supposing it to be carried on in the bed of the river."

The Committee resolved that it was their opinion it would require £4,500 to complete the navigation from Lisburn weir to Spencer's bridge, and that the £4,000 granted in the last session had been accounted for.

The works above referred to by Mr. Omer having been completed at an expense of £43,304, arising from tolls and grants, and there being no corporate funds at command, the extension from Spencer's bridge to lough Neagh was carried out under the direction of Mr. Owen, Civil Engineer, at an expense of £60,000, by the munificence of the Donegal family, to whom the navigation belonged until the early part of the present century, when it was purchased by a company of merchants, by whom several necessary improvements were effected, amongst which may be enumerated the making of the artificial cut between the fourth and fifth locks. From this level, also, five tunnels were constructed, opening into the river with valves acting only when the water in the river is low. An additional lock was made in the tide-way

about a mile nearer to Belfast than the previous No. 1 lock, in order to facilitate the passage of boats in neap tides; and the degrading effect of the river on some parts of the canal was remedied by driving piles to support the banks. These improvements were effected between the years 1809 and 1820.

Not less than eight acts of parliament, commencing with the 27th Geo. II., in 1753, and ending with the 6th and 7th Vic., in 1843, conferring powers to raise money to complete this undertaking, were obtained; and yet much that was felt to be desirable remains undone. The money authorised to be borrowed by the act of 1843, has not been raised for the proposed extension of the canal to Belfast, and consequently the difficulty of entering it when the wind blows from a certain point remains unremedied, but lighters can pass freely at all other times of high water at neap tides. The navigation, taken generally, is in fair working order, and the shareholders have been receiving a small dividend for the last few years.

There were two great errors in the original plan of this undertaking, the first being through an idea of economy, making the river with a fall of 80 feet, part of the navigation between Lisburn and Belfast, the rapidity of the current having been a constantly recurring cause of injury to the banks, and interruption to the trade; the second error was the insufficient supply of the head level. For remedying the first, Mr. Robert Whitworth, having been in Ireland in the year 1800, was consulted, and recommended the abandoning of the river as a navigation, and turning it into the bead level for supply, but the valuable milling interests would have been so much injured by the carrying out of his plan, that it was abandoned and palliatives only resorted to.

Mr. Mullins, in his *Treatise on Inland Navigation*, published in 1823, observes that—

'This navigation partakes of the defects of its time, both as to design and cost of execution. Continuing in the beds of rivers, even when running through flat countries little subject to floods, is found generally to be inferior to parallel cuts; but in those rivers subject to a sudden rise in their waters, the idea of making them permanently navigable, at a remunerative cost, is almost hopeless; the tendency they have to raise their beds, the constant shifting of their channels, the wear and casualties to which they are so peculiarly liable, and the consequent cost of maintenance are considerations of such weight, that, if duly appreciated, the improvement of river navigation; except in few instances, would not be undertaken.'

These theories, he continues-

'*Applying almost universally, are realized in our rivers which have been rendered partially navigable by an outlay far more than sufficient to make parallel lines of canals through the districts in which they respectively run; the river courses being in the latter case left free for the performance of such necessary operations as deepening their channels, and the removal of those obstacles which occasion the constant overflowing of their banks for several months in each successive year, to the great deterioration, if not destruction, of thousands of acres of what would otherwise be the best land in the country.'*

Mr. William Chapman, with whom Mr. Mullins had the advantage of frequent communication during his residence in Ireland, makes observations of a somewhat similar nature in his Report, dated 1795, on the proposed canal between Newcastle-on-Tyne and Solway Firth. He rejects the plan of making the river navigable above the tide-way, on account of its liability to floods, and the consequent formation of shoals, owing to the nature of the bottom; and he observes, that flush weirs or any

other means of keeping the channel open in dry seasons, would be attended with great expense; that the river could not be thrown into a succession of still pools, except at an outlay, for the construction of locks, exceeding that of a canal cut through the land; and as to forming a navigation partly composed of a canal, cutting off the sudden bends of the river, and partly of the river itself, it would partake of the inconvenience of making the river the chief line of communication, and would be subject to great interruption and danger from floods. In consequence of this the undertakers should either be content to have their works occasionally overflowed, or they must, at the upstream entrance of every part of the canal, where it leaves the river erect, a guard lock of a height equal to that of the floods. The expense of every such lock, with its accompanying weir, and of the raised trackways along the navigable shore, would be very great. Under these circumstances he decided on an independent canal entirely across the dry land.
The conditions under which the improvement of river navigations should be undertaken, shall be referred to when we come to treat of arterial drainage operations

THE NAVIGATION OF THE NORE.

In this undertaking, commenced in 1755, another instance is to be added to the list of failures, as well in the design and construction of the work, as in the ill-considered efforts to supply Dublin with coal, as if the spirit of the day were in accordance with the advice of Dean Swift, to
'Burn everything English but their coal.'
The navigation extending from the city of Kilkenny to Ennisteague, a distance of sixteen miles, had been planned by Mr. Omer, in the bed of the river, and estimated by him at a sum of £10,000; but Mr. Ockenden's plan, in which Mr. Omer concurred, for making a canal about four miles in length, and carrying the navigation in the bed of the river the remainder of the distance to Ennisteague, where there was to be a tide-lock, was adopted at an estimated cost of £22,600. Several locks were built 200 feet in length, 21 feet in breadth, and with from 9 to 10 feet fall; also a rimer or flash lock, intended, in time of flood, to preserve 12 feet head of water; at the entrance of the canal into the river, there were platforms of stonework as overfalls to carry off the waste water, and several weirs. built to turn the water into the canal. Mr. Ockenden died in 1761, Mr. George Smith was appointed to direct the works; he reported that boats had passed through all the locks; that £14,000 had been expended, and that it would take £8,471 to carry the navigation from Ballyredingford to Thomastown, within 4 miles of the proposed termination at Ennisteague.. After an expenditure of £30,000, it was found that the plan was so ill-devised and executed, that the works were unable to resist the force of the floods, and what with the breaches and subsidence, the whole became an irreparable ruin.

LIMERICK NAVIGATION.

The navigation from Limerick to Killaloe, partly still water and partly in the Shannon, is generally known by the above designation; it is twelve miles in length, and the rate of lockage is 83 feet 6 inches in that distance, or nearly 7 feet per mile.

There are eleven locks, none of them alike as to dimensions, and that at Annabeg, although 80 feet long, is not capable of passing a boat exceeding 70 feet in length, owing to the table of the breast gates projecting 10 feet into the chamber. Some of the locks are 16 feet wide, but no boat exceeding 15 feet beam can pass through the whole of them.

The works having been commenced under the direction of Mr. Omer in 1755, were carried on simultaneously with those of the Upper Shannon, between Lanesborough and Carrick, by the Navigation Board, until 1767, when an Act of Parliament was passed incorporating a company of undertakers for making the Shannon navigable from the city of Limerick to lough Derg, above the town of Killaloe; and Mr. William Chapman was appointed their engineer; the works of the Upper Shannon having still remained under the same control as before. From 1767 to 1800 upwards of £25,000 were expended, of which £16,000 were granted by parliament, and a further grant of £6,000 having been applied for in that year as sufficient to complete the works, the Limerick Company were referred by the Government to the Directors-General, who agreed, in 1803, to complete the navigation at the public expense, and to deliver it up to the company on condition of their lowering their tolls as specified. The works were accordingly proceeded with under the direction of Mr. Brownrigg, Principal Engineer to the Board, and when nearly finished, an extraordinary flood, in February, 1809, burst the banks at Erina, carried away the bridge, destroyed the double lock at the same place, and broke through many other parts of the navigation. The cost of repairing these damages formed a considerable portion of the expense incurred, which, up to January, 1812, amounted to £53,609. The injuries done to the navigation having been repaired, the Directors-General in December, 1810, offered to deliver it up to the company, but they refused to receive it, alleging that the works were insufficient, and great differences of opinion having taken place between the Engineer of the Directors -General and Mr. Donnell, who acted for the company, Mr. John Killaly was called in as umpire. The result was, that the company received £17,000 in consideration of relinquishing their rights, and the navigation has since become public property.

The cost of these twelve miles of navigation, of which five and a half are in the bed of the river, computed from 1767 to 1810, was £79,559, to this should be added £17,000 paid for the purchase of the rights of the Limerick Company, making in all £96,558. The sum of £27,000, stated in Mr. Killaly's Report of 1812 to the Directors-General, as necessary to perfect the works, was not laid out, and consequently the navigation was left in a very imperfect state, particularly at O'Brien's bridge and Parteen — the trackways incomplete, and the whole liable to frequent damage from floods, and as to the portion between Killaloe and Banagher, not within the scope of the Act of Incorporation of the Company, large boats could not ply, except in winter, on account of the shoals, nor small boats in summer, for want of towing-paths. The principal benefit derived from the undertaking, at that period, appears to have been the supplying of Limerick with great quantities of turf, English coal having been selling there at fifty shillings per ton.

The original intention of Parliament was to make a communication between the Barrow, the Shannon, and the Boyne, by means of the Grand Canal, as a main trunk, thereby enabling the produce of twenty counties, ten of which lie along the banks of the Shannon, to be carried to the city of Dublin, and with that view the works of the Upper Shannon were commenced simultaneously with those of the Limerick Navigation, and the Grand Canal, in 1755, under the direction of Mr. Thomas Omer, as Engineer. It appears by the evidence, before a Committee of the House of Commons, of a Mr. Edgar, who might have been an assistant to Omer, that in November, 1769, eighty miles of the Shannon had been made navigable between Killaloe and Rooskey. Smeaton states in his Report, dated 1773, that he saw a lock on the Shannon about three miles and a half below Banagher, which had been in use eighteen years. It was built of hammered stone, and stood very well; he understood it was built by Mr. Omer. A Report by Mr. Jessop in 1794, addressed to the Directors of the Grand Canal, into whose hands the control of the Shannon above Killaloe had passed, throws some light on the then state of the navigation. Mr. Jessop referred to the Reports of Mr. Chapman and Mr. Brownrigg, and to the accurate plans in the possession of the Company, supplied by these gentlemen, giving a minute description of the progress already made, rendering it unnecessary for him to do more than to describe the works appearing to be required to make the river navigable as far as practicable to do so with certainty and expedition. The two great objects that in his view called for this improvement were the collieries, in the vicinity of lough Allen, and the cultivation of an extensive country in ten counties bordering on or near the banks of the Shannon. As the coal was found on both sides of lough Allen, and at points widely extended from each other, the strata inclining with a gentle dip, he considered the presumption reasonable that there were many thousand acres embraced in the extent of the mine. Experience had proved that it was easily worked, and that, as much of it could be drained without steam engines, it might be got at an easy expense, and was excellent for smelting iron-stone, of which there were immense quantities of the best quality. Here, then, we have the approval of one of the first English Engineers of the day, of an enterprise famous for its abortiveness, and generally attributed to a want of foresight and knowledge, presumed to be peculiar to this country.

The banks of the Shannon being low, and covered with water many months of the winter, Mr. Jessop recommended trackways to be raised two feet in height above floods, and as these trackways should be made on dry land, it would be necessary to cut a channel through the beds of reeds at the verge of the river, wherever they were more than six perches in width; by this means he considered that forty-one miles would have all the benefit of still-water navigation, the lakes, except lough Forbes, being, of course, excepted.

Beginning at lough Allen, he proposed to get rid of the Arigna river, and the immense quantity of detritus it brought into the Shannon, by turning it into lough Allen, through a cut, already made, and only requiring a weir to retain the gravel. From lough Allen he recommended the navigation to be carried, partly by the river, and partly by cuts, to join the canal, a portion of which was made to Battlebridge. From thence to Carrick, we learn from the same document, that there was no material

obstruction, except a rocky shoal at Port. The river was from thence good to the Jamestown Canal, which was very imperfect through some deep rocky formation, and was, besides, very crooked; after the improvement of this canal to near the lock, he recommended the remainder to be deserted, as the river below passes through a chain of lakes very difficult to navigate, and on these no trackway was practicable, but a canal might be made seven miles in length, to join the Rooskey Canal above the lock, which should be raised to the level of the Jamestown Canal.

From the Rooskey Canal the bed of the Shannon to be pursued to a point opposite the Camlin river, which was sufficiently wide and deep, except where a small canal had been cut. From the Camlin river the passage through the Clondragh Canal wanted improvement. At Lanesborough there was a shallow of 300 yards in length, with a fall of 12 inches, partly owing to the obstruction of the eel weirs; to avoid this shallow, a cut was already made with a single pair of gates, this to be converted into a lock. At Athlone the canal wanted deepening and widening. The cut at Shannon bridge, and the canals at Banagher and Cloneenogue required repairs. Below lough Dergh, at Killaloe, there being a fall of 23 feet, the river running over some rocky ground, but generally through gravel, he considered it an object worth inquiring whether this fall might not be wholly or so much reduced as to lower the lake about 18 or 20 feet, thus probably, laying dry from six to eight thousand acres of land, that would more than repay the expense, and might possibly enable a trackway to be made through the lake.

These details have been given to show that a general plan of improvement of this important navigation had been carried out at an early date, although in an imperfect manner, but affording valuable examples whereby to profit in subsequent efforts, by the adoption, amendment, or avoidance of what had been already done.

Neither the trackways nor the departure from the line of the Jamestown Canal were adopted, as recommended by the foregoing Reports, but between the years 1800 and 1812 the Directors-General expended £7,168 on the Upper Shannon, in repairing the locks, canals, and other works originally constructed on the navigation from Lanesborough to Jamestown, a distance of about twenty-six miles, together with a sum of £23,000 in making the Lough Allen Canal, extending three and a half miles from the lough to Battlebridge, where it joins the Shannon; some minor works of general repairs were included in this sum, laid out under the advice of Mr. John Killaly, as Directing Engineer. In addition to the above outlay, the Directors-General, between the years 1806 and 1812, gave the Grand Canal Company a sum of £54,634, for making, completing, and preserving (but with out trackways), the navigation of that part of the river Shannon between the northern extremity of lough Derg and the northern extremity of the canal at Athlone, the same to have six feet depth of water at the least, at all seasons of the year, with such locks, bridges, and wharves as the Directors General should think necessary. These works were completed to the satisfaction of the authorities, but at an expense to the Grand Canal Company of upwards of £30,000 beyond the sum received. It thus appears that on the works extending from Limerick to lough Allen, the outlay commencing from 1767 amounted to £211,350, to this should be added a sum of £114,523 laid out in the

previous twelve years by the Navigation Board, making in all £325,873, up to the year 1812. The expenditure at a more recent date shall be given in its proper place.

RIVER BARROW NAVIGATION.

The river forms the course of this navigation, except in a few instances where short deviations were made. It extends from Athy, in the county of Kildare, to the tide water below the rocks called the Scars, at Saint Mullins, in the county of Carlow, a distance of thirty-four miles, nearly five miles of which are lateral cuts. The works were commenced in 1759, according to the designs of Mr. Thomas Omer, who proposed to make them suitable for vessels of seventy tons at all seasons, the river in its then state not having been navigable at certain times of the year, by vessels carrying more than two or three tons. Seven locks, and the cuts leading to and from them, had been completed up to 1790, under the immediate inspection of Mr. John Semple, as Deputy Engineer. In the above mentioned year, £22,500 having been previously spent under the Navigation Board, the Company was incorporated, and Mr. William Chapman was appointed to direct the works.

The proposal made by the Company to Parliament, was to render the river navigable for boats of fifteen tons in summer, and thirty tons in winter, with towing-paths for the whole length, and to expend for that purpose £40,000 of their own money, on receiving £20,000 from the public purse; but whatever success might have attended the first proposal, it was only partially proceeded with, for during the progress of the works the Company were induced to enlarge their project, for the purpose of enabling boats from Youghal and Dungarvan to pass through the river Barrow and Grand Canal to Dublin, without transhipping, and also to take in coal vessels from British ports; with that view twenty-four new locks were designed, 80 feet long, and 16 feet wide, with 5 feet water on the sills, to admit boats of eighty tons burthen; of these, ten were built, and four of the original locks, of various sizes and of bad construction, were taken down and reconstructed on the modified plan; however, on the withdrawing of the canal bounties on produce carried to Dublin, the progress of the enlarged scheme was stopped, but only for a time, no importance having been apparently attached to the fact that the locks of the Grand Canal, which are not uniform in size, are in no instance more than 70 feet in length, so that Dublin could not be reached by eighty-ton boats without transhipping.

After having expended on the several works £62,881, including the grant of £20,000, the navigation being still incomplete on the enlarged scale proposed, the Company applied for aid to the Directors-General, who agreed to give them £20,000, on condition of their reducing the tolls, and to give a further sum of £27,500, a moiety of £55,000, the estimated cost of completing the navigation, with the necessary locks and lateral cuts, weirs, towing-paths, &c., on the enlarged scale before specified. Those several amounts, together with a sum of £11,620, the half of which was likewise contributed by the Directors- General, had been expended on the works up to February, 1812, when a survey was made of their then state, and an estimate of the cost of completion prepared, amounting to £66,000.

The outlay from 1803 to 1812, including £78,891 granted by the Directors-General, was £149,501, if to this we add the sum of £23,500 expended by the Board of

Navigation previous to the incorporation of the Company, and the sum of 66,000, the amount of the estimate to finish, made in 1812, we shall get a total of £239,001, equal to £7,029 8s. 9d. per mile, at a rate of lockage in that distance of only 5 feet per mile; a considerable portion of which would be absorbed in the declination sufficient to give impetus to the discharge of the waters of the river, and of its tributaries.

The profits in 1812, according to the report submitted to Parliament, were £2,589, or £76 per mile per annum, not including interest on capital subscribed by individuals, or on grants obtained from the Government; but had the peculiarly favourable lie of the country, for a canal the whole way, been taken advantage of, the proprietors could not have failed to obtain a far different result, as well by the economy of construction and maintenance as by the general improvement of the surrounding districts, seeing that the Barrow navigation passes through a country of great natural fertility and high cultivation; that it meets at its outfall the rivers Nore and Suir, by which it communicates with the ports of New Ross and Waterford, and that the towns of Carrick-on-Suir, Clonmel, Ennisteague, and Thomastown, are also accessible to it from one extremity, while the port of Dublin is open to its craft at the other; time alone having been necessary for the development of highly remunerative traffic on a line so favourably circumstanced, if cheaply and judiciously constructed. Boats can not load more than two-thirds of their tonnage in summer.

THE RIVER BOYNE NAVIGATION.

This navigation extends from Drogheda to near Navan, a distance of fifteen and a half miles, and from Drogheda to the sea, four and a half miles. The rise from the tide water to the eighteenth lock is 91 feet 9 inches, being a rate of lockage of 5 feet 10 inches per mile. The undertaking was commenced in 1759, under the direction of The Engineer of that day, Mr. Thomas Omer, and was made navigable for nine miles, as far as Slane. There were also several other works executed in the extension to Trim, which were, however, allowed to fall into ruin. Upon the whole of these a sum of £75,000 of public money was expended up to the year 1789, when the River Boyne Company was incorporated, and the navigation was carried to Navan, under the direction of Mr. Daniel Moncks as Engineer. The bed of the river is for the most part navigable from Drogheda to Stackallen, a distance of 12 miles, the remainder from thence to Navan is a still-water navigation, running parallel with the river by which it is supplied at Navan. The continuation of the line to Trim, Kells and Athboy, a level of upwards of 22 miles of canal without a lock was again commenced by Mr. Moncks, and again abandoned from want of funds The intention having been to proceed from Trim to Dublin, and from the same point, on the other hand, by Kells, Athboy, Virginia, and so on to lough Neagh.

The locks vary in their lengths from 80 to 104 feet, by 15 feet wide, and the breadths of the lateral cuts are as variable as the locks are in their lengths, being from 16 to 25 feet at bottom, and from 30 to 49 feet at top, having from 4 feet to 5 feet 6 inches depth of water, these discrepancies having arisen by cutting through rock in some places, and in others by embankments made in the river. The cost of the fifteen and a half miles of navigation, from the date of incorporation, independently of the before-

mentioned large amount expended up to 1759, was £115,677 I Is. 5d., of which £85,800 was contributed by the Government. The produce of the tolls has been at no time adequate to the cost of maintenance and establishment.

THE GRAND CANAL

This canal, including the Liffey line and the branches to Athy, Miltown, Blackwood (leading to the reservoir), Ballyteague and Edenderry, may be taken at one hundred Irish miles in length. The rise from its communication with the Liffey, near Ringsend, to the summit is 278 feet, the fall from thence to the Barrow, at Athy, is 97 feet, and to the Shannon, near Banagher, 162 feet, making of total rise and fall 537 feet, which divided by the length will give $5^1/_3$ feet per mile for its lockage.

The works were commenced in 1755, under the direction of Mr Thomas Omer as Engineer. It ascends seventeen miles by four double, and fourteen single locks, to the summit level, from whence, at a distance of twenty-one and a half Irish miles from Dublin, it divides into two branches; descending by one 103 feet in twenty-two and a-quarter miles to the Barrow, at Athy, and through two double and nine single locks, with one ascending single lock of 8 feet 6 inches at Monasterevan; by the other descending 163 feet 11 inches in forty-one miles to the Shannon, through one double and seventeen single locks.

Twelve miles in length, commencing two miles from Dublin, were partly executed, and locks built for flat-bottomed barges 175 tons burthen, to be navigated by ten men and six horses, after the Dutch fashion, and calculated to pass from the city to the Shannon in eight days; the locks were 136 feet long between the gates, the upper gates six feet high, and the lower 19 feet, the breadth of the canal at water surface 32 feet, with lye-bys at such distances as to be within sight from one to the other. Mr. Omer, in his examination before a Committee of the House of Commons in 1761, stated that as far as he had gone he was within the estimate, except in the cost of experiments made to ascertain with certainty the practicability of the line, and that he was willing to contract for the finishing of the whole. The cost of these experiments and surveys in which Omer and his son, and Mr. Cooley (the designer of the wings of the Four Courts), were engaged, amounted to £ 48,106 4s. 9d., as appeared by the evidence of the Accountant of the Navigation Board, before a Committee of the House of Commons.

In 1763 Mr. Omer reported that four locks, several bridges, tunnels, and lock-houses had been built, the excavation completed, except in the deep rock cuttings, and that he had opened ten miles through the bog of Allen. Doubts having arisen as to the practicability of making the canal through the bog, which had subsided in some places 3 feet, and it having been reported that there were capital errors in the levels, the works were stopped, and Major Vallancey and Mr. Trail were called on to examine and report as to what was proper to be done, the latter at the instance of the Corpo ration of Dublin, who had a considerable interest in the under taking, and had agreed with the Company for the supply of the city with water. These Engineers differed widely in almost every part of their respective surveys and reports, and as observed by Philips, in his *History of Inland Navigation*, Trail assigned good reasons for his opinions; of this, however, there is no opportunity of judging, neither of the

documents referred to being forthcoming, but Mr. Trail's Report to a Committee of the House of Commons in 1769 is still extant, in which he states that he had carefully surveyed the line pro posed and partly executed, from the city of Dublin to the Blackwood river, a distance of twenty-one miles, present ing the greatest difficulties of the whole line, and that he had no doubt, from what he had seen, of the practicability of making a navigable canal for vessels of 170 tons burthen to the Bog of Allen, and from thence to the river Shannon; and as to the mistakes in the levels of the locks and other works, to which his attention had been drawn, he was of opinion they would, in a great measure, turn out to the advantage of the works, which could be finished for a sum of £34,513, as far as the Blackwood river in the bog of Allen.

On the incorporation of the Company in 1772, the works were modified, and the locks made for vessels of 40 tons burthen, under the direction of Mr. Trail, who for a considerable time kept the execution in his own hands, without any contract having been entered into, he receiving 5 per cent. on the expenditure, a mode of proceeding which turned out so unsatisfactory that the original capital was expended before the canal was made navigable to the point of partition near Robertstown, from which it was considered advisable to make the off branch in the first instance to the Barrow, as being the district from whence a return was soonest to be expected. With the view to economy, the Company entered into a con tract with Mr. Trail for the completion, by him, of the canal between Dublin and Sallins, the direction of the other works being still in his hands as Engineer. Upon the termination of the period allowed for the completion of the contract entered into with him, it was found that the banks had not been raised to a sufficient height or breadth, and that the masonry had been very badly executed. Mr. Trail (who was afterwards knighted in connection with the Corporation of Dublin), was dismissed, and General Tarrant was appointed in his place. The sides of the locks built by Sir John Trail, under his contract, twelve in number, fell in on the water being suddenly let off, in order to test them. The opening of the canal to Sallins was by that means delayed for three years, and a very large sum of money lost to the Company.

In 1773 Smeaton having been called on, made a personal inspection of the line, and on that occasion introduced his pupil, William Jessop, to make surveys in conjunction with Trail, in order to ascertain whether a permanent canal could be made through the bog of Allen, and to lay out the best course for making junctions with the Barrow and the Shannon, from the point of partition near Robertstown. Smeaton having made a careful inspection, and taken more than a year to consider the subject, gave his opinion in detail, as recorded in the second volume of his Reports, not unfavourably to passing through the bog, where the ground, as he states in this case, could be selected, and deep cutting and banking avoided — an expectation which was far from being realized,

Under General Tarrant's direction the large locks occupying the sites of the 9th, 10th, 11th, and 12th, were taken down, and others substituted throughout, to admit boats of sixty tons burthen, and the canal was widened to 42 feet breadth at water surface, and 18 feet bottom. On that scale the navigation was carried by that Engineer to Tullamore, in the King's County, in the year 1800, and from thence to the junction

with the Shannon, within one mile of Banagher, was completed in the year 1806, by Mr. John Killaly.

Jessop, in conjunction with William Chapman, laid out the line between Robertstown and Tullamore about the year 1785, but its completion was postponed, owing to the company having directed their means to what was considered a more important object, namely, the construction of the Ringsend docks, and the canal of communication, both of which were planned by Jessop, and approved of by Chapman. The dock was commenced in 1791; it occupies an area of 25 statute acres, has 16 feet depth of water, and communicates with the Liffey by three parallel locks, where one would have been sufficient. There are also three excellent graving docks, of different dimensions. The cost of this work was £122,148, of which £20,000 was granted by Parliament. The semicircular canal of communication is three miles in length, and was estimated at £30,000, its actual cost, however, was £56,958, exclusive of interest of money borrowed for its construction; it enters the Grand Canal immediately below the first lock, which, with the lock next it, were built by Trail in a superior manner, under an agreement of five per cent. on the expenditure, but the cost having amounted to £5,000, the company were induced to let the remainder to him by contract as far as Sallins, with the results already described.

In 1788 it was proposed by Mr. John Brownrigg, Civil Engineer, to unite the Grand Canal with the Liffey by a descent of locks immediately from the James's-street harbour. The estimate,with graving docks for canal boats, was £22,000, and, having been revised by Mr. John Kilally, was reduced to £20,000, but this plan, which would have suited every purpose of an inland navigation company, by enabling their boats to reach the shipping in the river, was rejected for the more magnificent plan of Jessop, whose design was intended to accommodate six hundred ships, the number of which, at any one time, has never since, probably, amounted to more than about a dozen, so true is it that facilities do not necessarily create a trade. The harbour for packet boats, and the hotel at Portobello, designed by Colbourne, were portions of the same scheme, serving, long before the time of railway competition, only as monuments of ill-considered outlay.

Brownrigg was subsequently appointed Engineer to the Directors General of Inland Navigation, and Killaly to the Grand Canal Company, both having been the first Irish Engineers employed in their own country, of whom we have any account.

The cost of construction of the Grand Canal, according to an account taken from papers on the Inland Navigation of Ireland, printed by order of the House of Commons, July 1812, amounted to £966,364, including a sum of £122,148, the cost of the docks, and deducting that amount, gives £8,442 as the rate per mile in actual expenditure on the works; according to the above statement, without any other aid from Parliament than a sum of £93,258, and not reckoning a sum of £73,646, uselessly expended previous to the incorporation of the Company, nor the large debt, amounting to not less than £116,750, created in paying dividends out of loans, in anticipation of profits, and in working the Castlecomer and Doonane Collieries at a loss, in accordance with the received opinion of the day—that it was practicable to compete in the Dublin market with English coal.

Amongst those who distinguished themselves in the promotion of the best interests of the Company, in which they were seconded with a strong patriotic feeling by the country at large, may be mentioned the names of Lord Harberton, Sir John Macartney, and Mr. Richard Griffith, who was Chairman of the Board of Directors, and a member of the Irish Parliament.

The following observations, made by Philips, with reference to the Grand Canal, in his work on Inland Navigation, is worthy of quotation for its appositeness. In concluding the notice of this undertaking, he observes:— *"The failure of this great work, which at first might have been so easily completed at a moderate expense, may justly be attributed to the want of an accurate and well digested plan and survey, for it does not appear that there were any material difficulties in the whole line, but what might have been overcome with great ease had the work been properly conducted by an able and experienced Engineer, since neither money nor a proper attention to its being laid out judiciously was wanting, as may be seen by the 'resolves' of the Company of Proprietors,"* which he subjoined, *"to show how careful they were to be properly supplied in time, and prevent the work standing still for materials and utensils."*

The often quoted opinion of an unprofessional English tourist, Arthur Young, to the effect that this undertaking was, from the beginning, a mere job, can not be allowed to weigh against the testimony of Philips, whose judgment has been confirmed by the facts here adduced, proving the incompetency at least of some of the Engineers to whom the works were at the outset intrusted.

ROYAL CANAL.

The Royal Canal extends from the river Liffey, at Dublin, to the Shannon, at Tarmonbarry, a distance of seventy-two Irish miles; it has its summit at an elevation of 322 feet above the former, and 191 feet above the latter, its rate of lockage being $7^1/_8$ feet per mile. The Company of undertakers, with a capital of £20,000, was incorporated in 1789, and Mr. Richard Evans was appointed their Engineer. The works having been carried out as far as Newcastle, twenty-two miles from Dublin, at an expense of £315,204 of which £70,556 had been granted by Parliament; the Company, in the year 1801, represented to the Directors-General their inability to proceed unless assisted by part of the grant of £ 500,000 before referred to. In consequence of this application, they obtained a sum of £95,866 in consideration of their completing the Canal to Thomastown at their own expense, the cost being estimated at £ 63,136, and from thence, by means of the grant, to Coolnahay, a distance of forty-six miles from Dublin, with a cut from Mullingar to lough Owel, also on condition of their erecting a sea lock and turning bridge at the Liffey, making docks adjoining thereto, and finishing an aqueduct and boat harbour at the Broadstone, of which Mr. Millar was the Engineer, and in further consideration of lowering their tolls to certain specified rates. The sum granted being the cost estimated by the Company for the construction of the works above enumerated, but instead of that amount, together with the sum of £63,136 before mentioned, being sufficient for the proposed under takings, the expenditure in completing them amounted to £304,920, as proved before the Directors-General, and exceeding the estimates by £145,000, while the income arising from the low scale of tolls on which

they were dependent to pay the interest on their debt, and finally to liquidate it, did not amount to more than 4½ per cent. on the sum granted.

The canal having been carried to Coolnahay, within twenty five miles of the Shannon, it appears that in December, 1810, the debt of the Company amounted to £862,000, the interest and annuities to £49,824, two years of which were then in arrear, and their permanent expenditure, including all charges, exceeded their revenue by £45,693. To get out of this difficulty a new Company was formed in 1812, leaving nothing to the original proprietors, but hopeful calculations which were never realized. The line was completed from Coolnahay to the Shannon, in the year 1817, at the public expense for a sum of £200,000, making in all £ 1,421,954, or £ 19,749 per mile, the cost to the two proprietors and to the nation. The rate of profit for many years after the completion, may be taken averagely at £ 120 per mile, per annum, or 3/5 per cent. on the capital expended; a result not to be wondered at, seeing that at 35 miles distance from Dublin, —after having overcome 322 feet of lockage and other works of great difficulty, such as the excavation through the quarries of Carpenterstown, the embankment and acqueduct across the Ryewater, which cost upwards of £30,000 and the cutting through the bog of Cappagh,—the Royal Canal is but eight miles distant from the Grand Canal, and at many intermediate places not more than four miles, so that these two great canals for half their length westward are performing little more than the work of one, and hence the unproductiveness of both; whereas had the western branch of the Grand Canal entered the Shannon at Athlone, equidistant with Banagher from Tullamore, it would have commanded the trade of the middle, lower, and upper Shannon, and thus have rendered the subsequent project of the Royal Canal obviously hopeless, by taking a great portion of its expected income.

The Grand Canal Company opposed this line with all the influence they were able to bring to bear at the many opportunities which occurred during its faltering progress, but in vain, and thus these two great undertakings have remained to our day, as monuments of unsuccessful enterprise, rather than as beacons to warn their successors; for on the same ground we see the same error committed, with less injurious, but still serious ill consequences, by the two great Railway Companies; as if the *genius loci* still exercised a malign influence, and that needless sacrifices must continue to be inconsiderately made; and now that the two canals have ceased to be a necessity for transit, and must be looked on as principally useful in supplying the city with water, they are, by a vicissitude of circumstances, about to be abandoned, and a new source adopted, involving great difficulty and expense; upon what matured consideration of so important a matter, I have not, as yet, had an opportunity of judging; but, if time permit, I shall return to this subject, as one which should not be passed over before concluding this paper.

There is throughout the whole of the navigations here described, not only an entire want of uniformity in the size of the locks of the same line, but, as might thence be expected, between locks of different lines, though having a means of connection; as for instance, the Royal Canal boats cannot navigate the Grand Canal, nor those of the latter the Royal Canal, nor could either, from their construction, navigate the Shannon; so that all goods forwarded by either Canal, from Dublin to Limerick, and

vice versa, and to Jamestown, and the Arigna district, in the other direction, should be tran shipped into Shannon built boats, where the Canals join that river; or be transported by a class of vessels of inferior tonnage, which was the practice adopted by traders on both Canals previous to the introduction of steam tugs. The locks of the Barrow as compared with those of the Grand Canal, and the different portions of the inland communication between Newry and Belfast, present the same anomalies. Nor can England boast of exemption in this respect, for whether we look to the navigation of the Thames, the Severn, the Mersey, or the Humber, we find similar incongruities pervading the lines of canal and their ramifications, by which these great commercial rivers are united; as for instance, the river Avon, which entering the Severn at Kings road, is navigated by vessels of forty to fifty tons burthen, and fourteen feet on the beam, to Bath, and onwards by the Kennet and Avon Canal to Leamington, where it unites with the Wilts and Berks Canal, which can only be navigated by boats of twenty to twenty-five tons burthen, and but seven feet on the beam. This canal is about fifty-two miles in length, and falls into the Thames at Abington. The junction of the Severn with the Mersey by the Ellesmere and Chester Canals, is similarly defective, and the junction of the latter river with the Humber, by the Duke of Bridgewater's Canal, the Grand Trunk Canal, and the river Trent navigation, are in a like predicament. Nor were the English canals, either as to cost of construction or management of the affairs of the companies, in a much better position generally, than those of Ireland, except in situations where the peculiar advantages of mineral traffic compensated for the prevalent errors of the day, and, consequently, a large proportion of them were attended with ill success in a commercial point of view, as was amply testified by the low market value of the shares, long before the depression caused by railway competition. It would be here out of place, to enumerate the many instances of unfavourable results, but for example sake, and similarity to what took place amongst ourselves, the Clyde and Forth Canal, commenced by Smeaton and finished by Whitworth, may be mentioned; of it Philips observes that, *"it was a series of blunders and unnecessary expense, in which the public spirited proprietors were equally involved, with those whose selfish views had been so very detrimental throughout"*; and Mr. Thomas Gray, in his work advocating the Railway System in 1825, says of the Caledonian Canal, which was not excavated within six feet of its specified depth, that *"the waste of public money had been quite as great upon it, as on those public works in Ireland, of which so much has been said, although there has been less jobbing and abuse in the outlay of the money."*

Up to the year 1755, the improvement of the natural beds of rivers was the only inland mode of navigation occupying public attention in England; but in that year the proprietors of the Sankey Navigation in Lancashire (who had obtained an Act for making that river navigable from the Mersey to near St. Helen's) determined to make a separate cut, which was effected in 1760; and, in the same year, the conversion of the Worsley Brook scheme, by James Brindley, into the famed Bridgewater Canal, was attended with so much success, that enterprises of that description occupied a large share of public attention until the introduction of railways in 1829, at which time 2,471 miles of still water navigation had been brought into operation in a period of 70 years, while not more than 400 miles existed in Ireland, where the first effort had been made, in 1755, in the commencement of the Grand Canal.

To come to works of the same description, but of a more modern date. The extension of the Royal Canal from Coolnahay to Tarmonbarry, on the Shannon, 32 miles in length, was commenced in 1814, and completed at the latter end of 1817, at a cost of £6,280 per mile, towards which Parliament granted a sum of £200,000. There are 21 locks, 47 bridges, and a large aqueduct over the river Inny.

The rate of wages, owing to the war prices of food, was then twice what it was in 1830, when Mr. Mullins stated in his evidence before a Committee of the House of Commons in that year, on the condition of the poor in Ireland, that the works could have been then executed at half the cost, owing to the fall in wages — namely, from 10s. or 12s. to 5s. or 6s. per week, for labourers. Timber, which, in 1830, could be had for £4 15s., had risen during the war to £18, per ton; and many other articles of general consumption in a similar proportion.

THE BALLINASLOE CANAL

This undertaking, extending 15 statute miles, from the Shannon to Ballinasloe, was commenced in 1825, and opened in 1830, at a cost of £3,226 per mile. Its course lay through flow or soft bog, of what might be considered the most difficult kind to make a canal through, averaging from 26 feet to 46 feet in depth, and bounded by large rivers, the Shannon and the Suck; but, by a judicious mode of drainage, and avoiding the dictum of Smeaton, *"not to go deep into it,"* the work was perfected in a cheap and permanent manner. The bog subsided fully 20 feet, on an average; in many places 25 feet, and in some few places, where the bog was very soft, to the actual level of bottom. The particulars of the method adopted are given in detail in the 4th Vol. of the *Transactions of the Institution*, in connection with the paper on the origin and reclamation of peat-bog.

That portion of the Grand Canal which passes through the town of Edenderry, in the King's County, furnishes a striking instance of the ill consequences of not attending to deep drainage, for that which was expected to be an unusually cheap reach of canal in shallow cutting, ended—after several years of unremitting labour, and enormous expense,—in the formation of a bank on either side 45 feet in height, for a distance of 80 perches; so that the canal, with the carrying up of its sides and bottom to the required level, containing 6 feet of water, was in the centre of a high artificial embankment, having a base of fully 400 feet. Indeed, the difficulties were so great, that it was more than once contemplated to abandon the line, and make a new cut.

THE ULSTER CANAL.

This canal connects lough Neagh and lough Erne. It commences in the county of Armagh, near Charlemont, on the river Blackwater, which is navigable for a distance of 11 miles up to that point, and enters the south-eastern extremity of upper lough Erne, at Edergul, in the county of Fermanagh, winding, in its course, along the fertile valleys of the Blackwater and Finn rivers, and passing the towns of Benburb, Caledon, Middleton, Monaghan, and Clones. The length of the canal is 48 miles. There are 26 single locks, each 56 feet long in the chamber, 12 feet wide, and about 8 feet rise. Nineteen of these locks are on the eastern or lough Neagh side of the

summit, and the remainder on the western side, the difference between the levels of the loughs being about 103 feet. The intended depth of water on the lock sills was 5½ feet.

Although the advantages of this canal must have been obvious at an early date, as an important link in the inland navigation of the country, it does not appear that any practical measures were adopted to carry out such a project, until towards the close of the first quarter of the present century, when Mr. John Killaly made the necessary surveys, and pre pared plans and estimates, upon which an application was made to Parliament, in the year 1825, and an Act obtained, namely "The 6th Geo. IV., cap. 193," incorporating the Company.

The difficulty of raising the amount of the estimate, £160,000, equal to £3,478 per mile, gave rise to great delay in commencing the works, and the death of Mr. Killaly, in 1832, led to the seeking of other professional advice, when Mr. Thomas Telford and Sir William Cubit were called in. Under their direction, the works—previously designed on a scale corresponding with the canals already in connection with lough Neagh and the river Shannon-were modified, and the width and length of the locks reduced, so that the trade boats commonly used in those navigations cannot pass; and thus, that which was intended to diminish the outlay, has proved to be very injurious to the prosperity of the undertaking, as, indeed, ought to have been anticipated, for no considerations of economy could have justified, on ordinarily intelligible principles, such modifications of a canal so circumstanced, in excluding boats entering lough Neagh from other quarters.

The summit level is supplied near the town of Monaghan by the Quigg-lough reservoir, which is a natural lake, rendered capable, by embankments, of ponding up about 14½ feet depth of water, to be delivered into the canal by a regulating sluice and feeder-channel; but although this reservoir receives the surplus water from the river Blackwater at Ballinode, when the mills in the neighbourhood do not require it, the supply to the canal is far from being sufficient; and the consequence is, that during at least three months of the dry season of each year, the summit level is impassible for trade boats. In Mr. Killaly's design, the section of the canal was calculated to contain three feet in depth of water beyond the standard navigable height, being intended as a reservoir to draw upon when circumstances would require.

The Company, notwithstanding the sacrifices made of efficiency to economy, had to contend with the usual financial difficulties of such projects in this country, and having been finally unable to raise the necessary funds, by subscription, to complete the works, they were obliged to have recourse to amendments of their acts, to borrow money for that purpose from the Loan Commissioners, in whose hands the navigation is now vested to repay the debt, the Company having failed to meet their engagements

By the Act of Incorporation, the time of completion was limited to July, 1829. By the 9th Geo. IV., c. 96, it was extended to the 20th June, 1833; and by the lst and 2nd Wm. IV., there was a further extension to the 24th June, 1837,

Since the canal came under the control of the Loan Comissioners, it has been let on lease at an annual rent, and is at present held by the Dundalk Steam Navigation Com pany, but owing to the uniform deficiency of water, at certain seasons, the peculiar

scale of the works, and railway competition, the traffic is at present very small indeed; if, however, the water supply were improved — the works put into an efficient state of repair, and the carrying trade conducted with care and regularity, there is no reason to doubt that a sufficient return would be realized to meet all current charges and leave a fair profit on the expenditure required for improvements and repairs.

Having brought the narrative down to our own time — in giving an outline of the history of the canals which supplied the first great schools of practical engineering in this country, as well as in England — I trust that it may not be considered irrelevant to state, that one of our own late Vice-Presidents, Mr. Mullins, who was an Assistant Engineer to Mr. Evans in the execution of the Royal Canal, having found the field preoccupied, almost to the exclusion of Irishmen, looked out for a combination to enable him to embark extensively in the execution of public works, and in the early part of the present century commenced with his partners, Messrs. Henry and M'Mahon, a career which, associated with engineering, will lose nothing by comparison with the most successful period of the profession in this or possibly other in any country.

Mr. M'Mahon, on the termination of the partnership, be came Engineer to the Drainage Department of the Board of Works in the year 1843, and continued to fulfil the duties of that office during the most active period of their extensive operations. The drainages of lough Neagh, lough Corrib, and the upper Brosna river were the principal works of which he gave plans and specifications.