

March 11, 1845.

SIR JOHN RENNIE, President, in the Chair.

The ballot for Members, which had been adjourned from the meeting of the 4th instant, was proceeded with, and the following candidates were elected :—

John Hick, as a Member; Captain John Washington, R.N., Robert Wallace Hamilton, William Mitchell, Thomas Fairbairn, James Edward McConnell, Joseph Tregelles Price, Thomas Henry Wyatt, Charles Michael Jopling, David Thomson, Sydney William Smith, and George John Vulliamy, as Associates.

The discussion upon Mr. Guppy's description of the 'Great Britain' being renewed, was extended to such a length as to preclude the reading of any papers during the evening.

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March 18, 1845.

SIR JOHN RENNIE, President, in the Chair.

No. 715. "An account of the Drainage of the Level of Ancholme, Lincolnshire." By Sir John Rennie, Pres. Inst. C. E.

The level of Ancholme consists of a tract of low land, situated on the south side of the river Humber, about 10 miles below its junction with the river Trent, and contains about 50,000 acres of land, of which only about 17,000 acres are subject to taxation.

This district is bounded on the east by an elevated ridge of chalk hills, extending from the Humber, for a distance of nearly 24 miles north and south; about 100,000 acres of the land of this ridge drain into the Ancholme. On the west, there is an inferior ridge of oolite and sandy limestone hills, which divides it from the valley of the Trent; about 50,000 acres of this ridge drain also into the Ancholme. On the south it is bounded by a low ridge of diluvial hills, which divides it from the valley of the Witham, and on the north is situated the river Humber; so that the total quantity of land draining into the Ancholme, may be said to be about 200,000 acres.

The river Ancholme takes its rise, a little to the north of Lincoln, and after a course of about 35 miles, passing through the centre of the above district, discharges itself into the Humber, about a mile to the west of the village of Ferraby. The valley varies from 1 mile to 3 miles in width. At a place called Bishop's Bridge, about 20 miles

from the Humber, and at the southern extremity of the level, the Ancholme is joined by a large brook, called the Rasen, which takes its rise 4 miles north-east of the town of Market Rasen, near the village of Lealby, and brings down considerably more water than the Ancholme.

The streams on the east side of the level, consist of the Kettleby, Kingerby, Cadney, North and South Kelsey, and Thornton becks, or brooks; whilst those on the west side, consist of Bishop Norton, Green and Black dikes, and the Sallownow, Redbourne, and Heblestow drains.

	Cubic Feet.
The streams on the east side produce . . .	48,014,000
Those on the west side . . .	24,500,000
The Ancholme and the Rasen . . .	36,000,000
Sundry small streams . . .	32,000,000
Total in one day's flood . . .	<u>140,514,000</u>

This would cover the whole level about  $2\frac{1}{4}$  inches deep.

This valley, for the most part, lies below the level of high-water-mark of spring tides, in the Humber. Near Ferraby, it is 3 feet under high-water ordinary spring tides; at Brigg, it is 9 feet below; at Black Dike, 15 miles distant from Ferraby, it is 4 feet 6 inches below; and at Glentham Bridge, 18 miles distant, it is level with high-water spring tides. It is probable, that at no very distant period, it was overflowed by the tide, until by the gradual deposit of the alluvial matter, with which the waters of the Humber, and the adjacent coasts abound, it became sufficiently raised above the low-water level, to form a grass or salt marsh, leaving the feeble waters of the Ancholme, to force their devious way to the Humber in the best manner they could; but inasmuch as the Ancholme and its tributaries, bear no proportion to the Humber, the mouth would frequently be blocked up, by the deposit of alluvial matter, and thus the drainage water from the interior would be obstructed, so that, at times, the level would be completely inundated, and even under the most favourable circumstances, would never be properly drained, and necessarily became a vast stagnant marsh, more or less intersected with streams and pools of water, according to the particular state of the season, and the ever varying condition of the adjacent channel of the river Humber, into which it discharges its waters. In that state the tract of land was unfit for tillage, affording but a precarious pasture for cattle, during a few months in the summer, and, in the winter, it became the resort of innumerable flights of wild fowl. This valuable district, however, was not altogether lost sight of, for the great Roman

road, called Ermin-street, from Lincoln to the Humber, ran along the west side of it, and was partially protected, by banks, from the floods and tides of the Humber, as well as from the Ancholme; it does not however appear, at what time these were constructed; but as the Romans had, evidently, considerable knowledge of draining and embanking, as is shown by the remains of the celebrated Carr Dike, which runs from Peterborough to Lincoln, and the great Po Dike near Lynn, it is by no means probable, that they would entirely neglect such an extensive and valuable district, as the Ancholme level; it is not unreasonable, therefore, to suppose, that they improved it considerably; but after they were compelled, by their own internal dissensions, to abandon England, a long interval of neglect and mismanagement supervened, and any works which they might have constructed, went to decay, and were lost sight of; so that the level returned almost to its primitive state of a marsh. The earliest record relative to this level, is stated by Dugdale, to have been in the year 1288; when Edward 1st directed a writ to the sheriff of the county, to inquire, whether it would be beneficial to His Majesty, or any other, if the course of the Ancholme from Bishop's Bridge to the Humber, were re-opened, and cleansed, so as to enable the waters to pass off; whereupon a jury was empaneled, and reported, not only that no damage would result, but that great benefit would be thence derived by the whole county of Lincoln. Accordingly in 1290, the King appointed three Commissioners, to cause the Ancholme to be scoured out, and in 1295 another Commission for a similar purpose was appointed. In the 6th year of Edward II<sup>nd</sup>, the river having again become obstructed, another Commission was appointed, and subsequently various other Commissions were named for the same object in succeeding reigns, viz., the 3rd, 19th, 23rd, 30th, 36th, and 39th of Edward III<sup>rd</sup>; also in the 15th Richard II<sup>nd</sup>, the 4th Henry IV<sup>th</sup>, the 6th Henry V<sup>th</sup>, and the 22nd Edward IV<sup>th</sup>. From this time, until the 2nd of Charles the II<sup>nd</sup>, nothing further appears to have been done, neither does it appear, that this level was properly drained, for on the 31st of March, 1659, a Commission was held at Glantford Brigg, when a tax of 13 shillings and 4-pence was laid upon each acre, for draining the level, and making a sluice, or clough, near the outfall of the said river; which tax was never paid; therefore the level could not be drained; accordingly, another Commission was directed to be held at Brigg, on the 23rd of August following, and in order to effect their object, the Commissioners proposed to contract with several foreigners, (Dutchmen, it is presumed,) for the purpose of draining the fens. Their demands, however, were found to be too high; accordingly Sir John Morrison offered to undertake the drainage of the whole level,

upon certain terms, offering shares in the undertaking, to any person who might be willing to join him. It was then decreed by the Commissioners, that if Sir John Morrison would complete the drainage of the district in 6 years, he should have and enjoy 5827 acres, free of all taxes and charges, from the time the said lands should be drained; but if through the neglect of Sir J. Morrison, the lands should again become badly drained, the owners of the land should be allowed to re-enter into 2000 acres of them, until their other lands were again drained. The owners, having rights to fish in the old river, should have the same in the new river, and any land divided by the new river, should be rendered accessible. On the 14th of Charles II<sup>nd</sup>, another Commission was held, when it was declared, that Sir J. Morrison having completed his bargain, was duly entitled to retain the 5827 acres, and letters patent, bearing the seal of Charles II<sup>nd</sup>, 24th of February, and 15th of His Majesty's reign, were granted to him. Notwithstanding, however, during the wars, the lands were entered upon and the works and sluices went to decay.

The level also must have been in a flourishing state at an early period subsequent to the Romans, for we find in Dugdale, that Thornholm, or Thornham Priory, was founded for canons of the order of St. Austin by King Stephen, and dedicated to the Holy Virgin, in 1493. The priory is situated in the parish of Appleby, about 5 miles N.W. of Brigg. The style is of the florid Gothic peculiar to the period.

Also the priory of Newstede, or Newstead, near Brigg, founded by King Henry II<sup>nd</sup>, 1173, for the canons of the Gilbertine or Semperingham order, and dedicated to the Holy Trinity. Revenue £55 per annum. In the reign of Henry VIII<sup>th</sup>, it was dissolved, and the lands were granted to Robert Heneage; and there is little reason to doubt, but that the monks who possessed all the learning of the times, and were generally alive to improvement, and everything which would augment the revenues of the church, did not lose sight of the valuable tract of the Ancholme level, but that they employed all the resources of the day, to drain and cultivate it, to the utmost extent. There is not, however, any specific record of works executed by them, in that district, except the curious old work called Bishop's Bridge, consisting of two Gothic arches, of 12 feet span, erected at the southern extremity of the level, across the Ancholme, and over which the road between Gainsborough and Market Rasen now passes.

Subsequent to the work of Sir John Morrison above-mentioned, there is no record of any great works having been carried into effect, although it is probable, that occasional repairs, such as scouring out the drains, and the river, were executed. The drainage however

became so bad that the lands were scarcely tenable. The efforts made were not permanent, and the level relapsed into its former waste and unprofitable state. The district remained in this state, until the year 1769, when an Act of Parliament was passed, appointing fresh Commissioners, who were to be permanent, and additional powers were granted, to levy rates on the lands, for completing the necessary works. By this Act, it was proposed to construct a sluice at Ferraby, across the mouth of the Ancholme, where it joins the Humber. This sluice consisted of three openings, the middle one being 15 feet wide, and the outside ones each 12 feet 6 inches wide. The piers were 7 feet thick, the cills being laid 8 feet above low-water mark in the Humber. It was built of brick, faced with stone, and the openings were covered with circular arches, having wooden draw-doors in the openings on the south side, and the usual self-acting doors on the Humber or sea side. A lock 14 feet 9 inches wide and 70 feet long, was subsequently added on the east side, with its cill laid 18 inches above the cill of the sluice; it was also proposed to straighten and improve the river Ancholme upwards, through the level, nearly as far as Bishop's Bridge, and to tax the land for the purpose of effecting these objects. The above works were accordingly carried into effect, and considerable benefit was derived from them, although the height at which the cill of Ferraby sluice was laid, namely, 8 feet above the level of low-water mark of spring tides, in the Humber, and the partial improvement of the river upwards, prevented the water from getting away during floods, and the drainage of the level was still in a very defective state. The land was therefore unfit for tillage, except during remarkably fine seasons, when a few crops of barley, or oats, were obtained, only in the highest and most favoured parts of the level; indeed even the hay crops were frequently under water, and were gathered in by means of boats.

According to the plan of the level made by Francis Wilkinson and John Fotherby in 1640, and published in Dugdale, it appears, that the Ancholme was straightened, and drains were cut at right angles to the new channel, and another drain from the main river at Horkstow to the high lands near Elsham.

In the year 1801 the late Mr. Rennie was applied to, for his opinion, as to the best plan for improving and completing the drainage and the navigation of the level. He accordingly made a report on the 9th November, 1801, in which, after describing the actual state of the level, he attributes its defective drainage to the deficient capacity of the Ancholme and the subsidiary drains, to carry off the floods, which descend so very suddenly; to the cill of Ferraby sluice having been laid too high; and to there being no catch-water drains, to prevent

the floods, from the adjacent high lands, descending into the level. As a remedy for these evils, he recommended, that the main river Ancholme, should be still further improved, by straightening, deepening, and enlarging its channel; that two new locks should be placed upon it, beyond the lands of the level, so as to preserve the navigation; and with a view to preventing the floods from the high lands, from inundating the level, he proposed, that two drains should be made in the line of the base of the high lands, bordering upon the level, with separate and independent sluices at their junction with the Humber. That on the east side, he proposed to commence with a sluice 22 feet wide, with its cill 4 feet above that at the mouth of the Ancholme, and from thence to proceed to Thomson's Hills across the Caistor canal, intercepting all the brooks in its course west of Kettleby, North and South Kelsey, and Thornton, brooks, to Kingerby brook. The bottom of the drain to be 24 feet wide, diminishing to 16 feet wide, at Kingerby brook. That on the west side, to be continued as far as Black Dike, skirting the bases of the hills, like the other drain, with a bottom width of 10 feet at Black Dike, 15 miles up, and increasing to 16 feet in width at the Humber, into which it should fall through a sluice 12 feet wide. These works he estimated at £63,920. These drains, which Mr. Rennie termed "catch-water drains," involved a very important, and at the same time, novel principle; for it should be understood, that according to the old Dutch plan, of simply cutting a series of straight drains, to some convenient point, where the water could be discharged, and then fixing a sluice upon the main drain, or river, all the high-land and low-land waters were mixed together, and the high-land waters, coming from a higher level, necessarily had a greater fall and velocity, and rushing down upon the low-lands, forced their way to the outfall, quicker than the less rapid waters which fell upon the level, and which were thus left to stagnate there; the sluices being unable to discharge both the high-land as well as the low-land water, during the period, when the tide in the Humber, enabled the doors of the sluices to remain open. It was therefore impossible for the level to be drained by the old system, but by separating the high-land from the low-land waters, by the catch-water drains, as proposed by Mr. Rennie, each body of water would have been effectually discharged, by an independent sluice, into the Humber, without interfering with the other. The catch-water drains were also well adapted to answer the important purpose, of supplying the lands in the level, with fresh water; for it must be remarked, that generally speaking, in the management of extensive districts of low-lands, it is not only necessary to have the means of draining them effectually, but also to have the power of supplying them with fresh

water, during summer, for the want of which, in dry seasons, the low lands suffer as much, as they are injured in winter by the floods. The catch-water drains being laid at a higher level, they would therefore serve to collect and to retain the fresh water, during the summer, so as to admit it into the low-lands, during dry seasons, for the purposes of irrigation, stock, or navigation. The great object to be obtained, in managing a district of low-land, is not merely to get rid of the water during the floods; but to have a perfect command of water during all seasons, in order to provide for the drainage, irrigation, and navigation, all of which are equally important; for without effectual drainage, the lands cannot be cultivated; without irrigation, they cannot be occupied to advantage during dry seasons; and without navigation, the produce cannot be well disposed of; neither can the district import the various necessities, without additional charges, which amount to an additional tax upon the lands occupied. All these grand objects would have been effectually provided for, by Mr. Rennie's plan of catch-water drains, which he was then carrying into effect, on a similar, but more extensive district, called the East, West, and Wildmore Fens near Boston. This work was subsequently completed, and now forms the most perfectly drained district in the empire; and it is only to be regretted, that these principles have not been acted upon to a greater extent in similar localities.

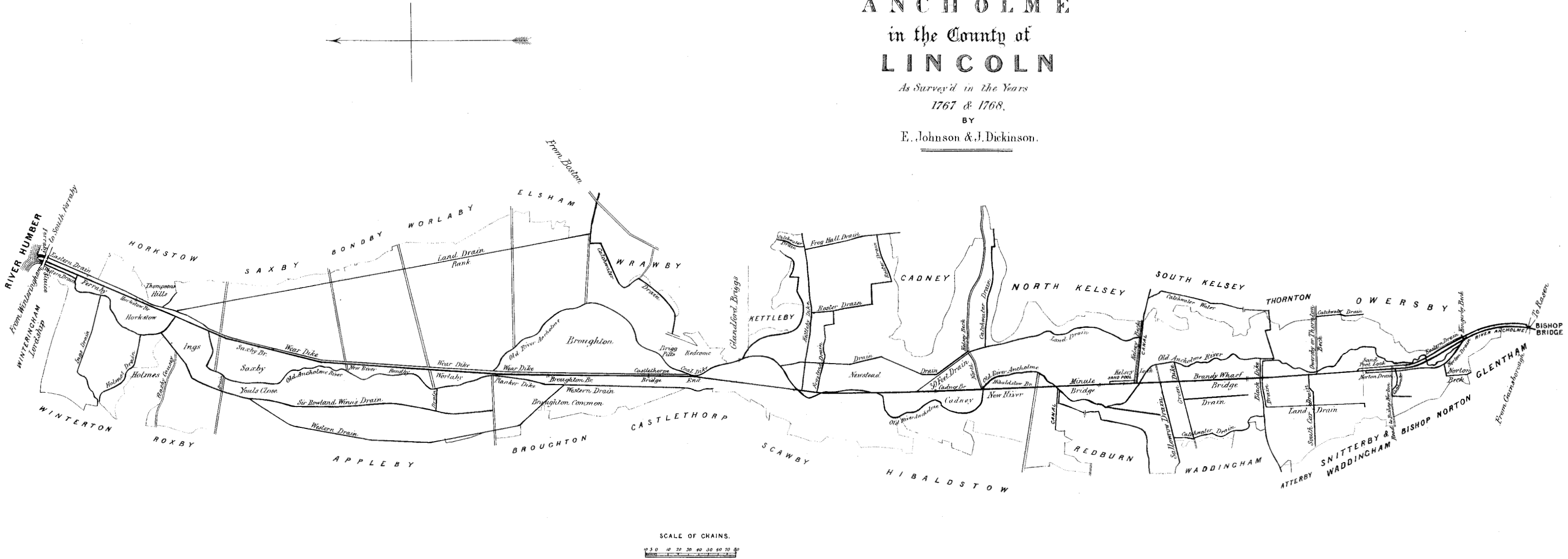
Much has lately been said about the principle of separating drainage from navigation, and it is stated, that the merit of the invention, if such it can be called, is due to others; their claims are not, however, well founded, for the late Mr. Rennie proposed the plan, on the Witham, near Lincoln, in 1803, and the works were finished by Sir John Rennie in 1827. It was necessary, in that case, to preserve the navigation up to Lincoln, and at the same time, to provide for the drainage of an extensive district of low-lands, above the city. This was done, by making two drains parallel to the Witham, called the North and South Delphs, which discharged their waters into the Witham below the locks at Horsley Deep; about 6 miles from Lincoln.

The principle is recognized also, to a certain extent, in the catch-water drains, which were proposed by Sir John Rennie, in 1836, for the improvement of the Whittlesea district; by carrying the main drain under the navigation of the old Nene.

The propriety of adopting this principle, depends much, upon local circumstances and convenience. Where old navigations exist, it would be both expensive and inconvenient to disturb them, the drainage may therefore be carried on by independent and separate channels; but where an entirely new district is to be drained, if the main drains be made low enough, and catch-water drains are formed, there can be

A PLAN  
of  
the LEVEL of  
ANCHOLME  
in the County of  
LINCOLN

As Survey'd in the Years  
1767 & 1768,  
BY  
E. Johnson & J. Dickinson.



E. Culliford, Lith. H. Howard, St. Strand.



no reason, why the drains should not be made navigable; because it saves the cost of double channels, as well as the expense of keeping them open hereafter.

Returning to the Ancholme, the east catch-water drain, as proposed by Mr. Rennie, was partially carried into effect, as far as the town of Brigg, about 9 miles from the Humber, and a new independent sluice, was constructed, 12 feet wide at the Humber, near the Ferraby sluice; but the west catch-water drain and sluice, were never made. A small wooden lock was erected across the Ancholme, about two miles below Bishop's Bridge and 18 miles from Ferraby, where the level terminates.

A small canal was proposed by Mr. Hall, to commence near Caistor, and to communicate with the Ancholme about 5 miles above Brigg, and was carried into effect by Mr. Robert Dickenson, for a company, in the year 1800.

Things remained in this state, until the year 1826. As the works were by no means complete or kept in good repair, for want of sufficient funds, the drainage became in a short time, very inefficient, the lands were for the most part unfit for tillage, and such crops as could be raised, were frequently lost during the floods. In 1824, the complaints of insufficient drainage became universal. The principal proprietors of the level, the Duke of St. Albans, Lords Yarborough and Monson, Sir M. Cholmondeley, Messrs. Corbett, Wynn, Uppley, Skipworth, and others, determined to apply to Parliament for another Act, to amend their former Acts, to increase and enlarge their powers and to enable them to raise additional funds, for the purpose of carrying into effect the necessary works, required to complete the drainage and the navigation. They accordingly applied to Sir John Rennie for the necessary report, plans and estimates.

His report recommended, that the plans of the catch-water drains, as proposed by the late Mr. Rennie, should be carried out to their full extent.

That the main river Ancholme, should be straightened, widened, deepened, and enlarged, to double its then capacity; that a new sluice should be constructed at Ferraby, with its cill laid 6 feet lower than the old one, together with a new lock 20 feet wide, so as to serve the double purpose, of accommodating larger vessels and of acting as an additional discharge for the drainage waters, during periods of flood.

That all the old bridges should be removed; as during floods they kept back the waters, and formed serious obstructions to the drainage.

That a new lock should be constructed, at a place called Haarlem Hill, about 18 miles above Ferraby sluice.

[1845.]

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That as during floods, the Ancholme and the Rasen, brought down a considerable quantity of sand from the adjacent hills, so as sometimes to block up the main river and the drains, and thus to prevent them from discharging their waters and causing inundation of the adjacent lands; it was further proposed, to construct a large overfall and weir, with an extensive reservoir on the lower side, to catch all the sand and mud, which was brought down from the upper part of the country, and thus to prevent it from falling into the main river. From the reservoir, the mud and sand would be occasionally removed, at a trifling expense. It was also subsequently recommended, that there should be similar overfalls, weirs, and reservoirs, at all the minor streams, and brooks, where they united with the level.

An Act of Parliament for these objects was obtained, in the year 1825; the works were commenced directly and were completed, so far as regarded the navigation of the main river Ancholme, up to Bishop's Bridge, by the 18th of June 1828. This was with difficulty effected on account of the limited time allowed, and it was of the utmost consequence that this period should not be exceeded, because the time specified by the Act, for the completion of the navigation works, expired within three days afterwards; but as no time was specified, in the Act, for the completion of the drainage works, the Commissioners determined to proceed with them, more leisurely. The next important object, was the west catch-water drain; this, it was determined to carry into effect, only as far as Castletorph, about 9 miles above Ferraby, and in order to save expense, it was kept within the level skirting the high lands near Appleby.

The sluice on the west side of Ferraby sluice, consisted of a single opening, 13 feet wide, with its cill laid 1 foot 6 inches below the cill of the old Ferraby sluice. The bottom of the drain, from thence, was to be 13 feet wide, decreasing to 8 feet, at its termination, near Brigg, with slopes  $1\frac{1}{2}$  to 1 and 2 to 1, according to the depth of the cutting and the nature of the soil, with the bottom rising 4 inches per mile. This work was accordingly commenced in the year 1830 and was finished in 1831. It answered the desired object completely, by giving a perfect drainage to the whole of the districts on the western side of the level, as far as Brigg, which had hitherto suffered so severely from the want of it.

The next work was to fix the cill of the east sluice, 2 feet lower, and to scour out the drain connected with it, as far as Wraby; and also, generally, to enlarge and deepen all the minor side drains, which had great effect in improving the drainage of the east part of the level.

The old river Ancholme was also deepened and enlarged, through

the town of Brigg, to the same depth as the improved straight channel, on the west of the town.

The various works, above mentioned, contributed materially to the improvement of the drainage and the navigation; and the whole level derived the greatest benefit from them, as from being little better than a mere swamp, it was converted into a fine arable district, capable of producing luxuriant crops of corn. Still, however, those lands which were most distant from the outfall, and which were not reached by the catch-water drains, suffered a little during floods; it was therefore determined to remedy this effect, by constructing a new and enlarged sluice and lock, at Ferraby, with its cills laid level with the low-water mark at spring tides, and to deepen the lower part of the river to correspond with it. Unfortunately at that time a dispute arose, as to the amount of rates, which each district should pay; the amount being previously determined by three Assessors, appointed under the Act, according to the advantages which each landowner derived from the works. This unfortunate dispute led to much litigation, which lasted for several years and entailed heavy expenses upon all parties, without producing any benefit; but on the contrary, inflicting serious injury upon the whole level. At length, fortunately, in the year 1841, all parties, tired of litigation, determined to reconcile their differences, and to complete the works, by erecting a capacious new sluice and lock, at Ferraby, and deepening the river to correspond with it. The requisite drawings and specifications were accordingly prepared and the works were ordered to be carried into effect.

The new sluice was proposed to consist of three openings, each 18 feet in width, having their cills 8 feet below the cill of the old Ferraby sluice, or from 2 feet 6 inches to 3 feet below low water of an average spring tide in the Humber.

The lock was to be 20 feet wide in the clear, and 80 feet long, between the gates, so as to give a clear water way of 74 feet, with an additional fall of 8 feet, which would discharge above four times the quantity of water in the same time, that the old sluice could do.

The work, which was directed to be built wholly of the best Yorkshire stone, was commenced in the beginning of March, 1842, by forming two whole-tide coffer-dams of timber, one on the Humber, the other on the Ancholme side, so as to enclose a complete space for the sluice, including also the old sluice, but not the old lock, which was still left open for the navigation. In order to provide for the drainage, in the event of floods, an opening, 16 feet wide, was made through each coffer-dam. Both openings were fitted with lifting doors, working in grooves, to be raised by machinery, whenever it was requisite.

The old lock also served as an additional opening for the drainage. The excavation for the foundations of the new lock and sluice, was made in alluvial silt and clay, in which piles from 24 feet to 28 feet long were driven, at intervals of 3 feet from centre to centre; the piles averaged 12 inches diameter, in the middle, and were of beech, elm, or fir timber, with wrought iron hoops and shoes, of sufficient strength to prevent them from splitting whilst being driven; their heads were then cut off and levelled; the earth was excavated 2 feet deep, below the pile-heads, large blocks of chalk were rammed in soundly between them, and the whole was well grouted with lime and sand. Upon the tops of the pile heads, cap-cills, 12 inches square, of Memel fir, elm, or beech, were then nicely fitted, both in the longitudinal and transverse directions, and were firmly spiked down with jagged spikes; the spaces between the cills were then solidly filled up with brickwork, set and well grouted with the best Roman cement, and the whole was then covered with a flooring of Baltic fir plank, 3 inches thick, closely jointed and well spiked down to the cills below, with jagged wrought iron spikes 9 inches long. This flooring was also well bedded in lime, pozzolana, and sand, in the proportions of two parts of lime, three of sand, and one of pozzolana, well ground together. Upon the top of this platform, inverted arches of stone were laid, of solid masonry, 18 inches deep at the crown. The quoins, where the gates shut against, were 2 feet 6 inches deep, and were made perfectly water-tight. The piers were then carried up of solid masonry, set in pozzolana mortar, with the beds, faces, and joints, finely dressed and set. When the piers were carried up to the requisite height, they were covered with elliptical stone arches to form the roadway.

Each opening of the sluice was provided with double gates; one pair on the land-side, with draw-doors which lifted in a water-tight groove, by means of wrought iron pinions, working in screws attached to vertical rods. These draw-doors were for the purpose of regulating the navigation level, which is 13 feet 8 inches above the cill, and so as to enable a depth of 8 feet 9 inches to be preserved at Brigg, which is 9 miles distant, and 6 feet 6 inches at Haarlem Hill lock, which is 18 miles above the sluice. On the outer, or Humber side, there were also gates to prevent the tide from entering the level. These gates were self-acting, shutting by the force of the tide, and opening by the head of fresh water, as soon as the tide had fallen below the level of the water inside; they rested against stone mitred cills, carried down through the solid invert, and faced with segments of cast iron, run in with lead. At the top, the gates abutted against stone mitred arches, projecting from the face of the other work, immedi-

ately below the elliptical arches which form the roadway. The stones forming these mitred arches, consisted of large blocks finely dressed, and bonded into the main body of the work.

The usual mode of effecting this, is to make a framing of wood, above the gates, against which they abut. The wood, however, is subject to decay, and is not so strong as stone.

After the sluice was considerably advanced, it was considered advisable to make a communication with the west drain, by means of a side cut, in order to give to the district draining by the old west sluice, the advantage of the increased fall of the new sluice. For this purpose it was decided, to separate the western opening of the new sluice from the other openings, by means of a draw-door, which could be raised and lowered at pleasure, either for the purpose of turning the whole of the river Ancholme through the three openings, or only through two, as might be deemed advisable.

Another door, or gate, was constructed on the opening, between the west drain and the river Ancholme, to be raised or lowered according to circumstances. The opening, between the two drains, was formed by an inverted arch, resting upon piles, cills, and planking, in a similar manner to that described for the rest of the work, and the gates, which were nicely balanced, were lifted by means of double purchase crabs, with racks and pinions. Over the opening between the Ancholme and the west drain, a stone arch served for a roadway to communicate with the west bank of the Ancholme.

Thus the principle of the west catch-water drain was still preserved, and the extra width and depth of the new sluice and cill was rendered sufficient to drain the level. The whole of the sluice was covered by elliptical stone arches, 18 feet wide, rising 4 feet 6 inches, and surmounted by a simple cornice and plain block parapet, 3 feet 7 inches high, perfectly level from one end to the other. The lock, which was 20 feet wide in the clear, and 77 feet long, between the points of the gates, with a lift of 10 feet at high water, was provided with four pairs of gates; two pairs of which pointed seawards, and were high enough to exclude the highest tides; the other two pair, pointing landwards, were high enough to regulate the navigation level. These gates were wholly constructed of the best English oak, well fitted together with wrought iron straps and bolts. The lock was filled and emptied by means of side culverts in the piers and abutments, which were constructed of solid and finely-worked masonry, set in pozzolana cement, perfectly impervious to water. They were provided with cast iron sluices, working upon brass faces, and were raised and lowered by wrought iron pinions and screws. The whole of the lock was constructed of solid masonry, of the best description;

Bramley Fall stone being alone used. Rings, holding on bolts, platforms, &c., necessary for carrying on the locking and passing of vessels in the most expeditious and economical manner, were also provided.

The chalk-stone was raised in large masses, from the adjacent hills, and formed excellent backing to the masonry.

The mortar was composed of the best lime, fresh burnt, mixed with three parts of clean sharp fresh-water sand, ground and well mixed up, under a mortar-mill, with as little water as possible, and used fresh. Earle's best Roman cement was used, for grouting up the joints, and  $\frac{1}{4}$ th of Italian pozzolana was ground up with all the mortar used for the exterior, and the backing.

Over the lock, a cast iron swivel-turning bridge, 15 feet wide, and 20 feet span, was placed in the line of the roadway over the sluice.

On the lower or Humber side an extensive wooden apron was constructed, composed of piles, 16 feet in length, driven down, their heads cut off and levelled, and the spaces well rammed in with solid chalk-stone, or "clunch," 3 feet in depth and well grouted; the whole surface was then covered with fir plank 3 inches thick, spiked to whole timber sleepers laid upon the piles, in order to prevent the scour from the sluices injuring the work. Wing walls, also of stone, were carried out to the full extent of the platform above described, so that the sluices were, by this means, enabled to discharge the flood waters in the most effectual manner, without any danger of injury by the scour.

Nearly all the old bridges, which were built chiefly of wood, with several small openings, the piles of which materially obstructed the passage of the water, particularly during floods, were removed, and were replaced by others, spanning the river with one opening.

Commencing at the lower end, a new suspension bridge was built at Horkstow, one mile above the new sluice; the span was 130 feet, with stone piers. At Saxby, three miles higher, a wooden bridge was placed, consisting of a series of circular ribs bolted together, forming an arch 96 feet 6 inches span, with a versed sine, or rise, of 10 feet 4 inches. The roadway, which was also of wood, and curved 2 feet, was supported by a series of diagonal braces resting upon the arch below. Both arches rested against stone abutments. The roadway was 12 feet 4 inches wide, and the whole was very substantial.

Three other bridges, of corresponding construction, were placed at Cadney, 76 feet span, and 9 feet 3 inches in rise; at Hibaldstow, 74 feet span, and 9 feet rise; and at Minutes Farm, 74 feet span, and 8 feet 9 inches rise. At Bondby there was another bridge also of

wood, but of a different construction, being framed in the form of a truss, the outer part being 7 feet deep in the middle.

At Brigg another bridge was built, consisting of a single stone arch, the segment of a circle, whose radius was 63 feet span, and the versed sine, or rise, was 11 feet. At Brandy Wharf was a cast iron bridge of a single arch, the segment of a circle, 55 feet span, with a versed sine, or rise, of 5 feet; with stone wing walls and abutments. The bridges of the west catch-water drain varied from 15 feet to 26 feet span, all of semi-elliptical arches, with a rise one-fourth of the span, and built of brickwork.

The whole of these works, which were completed on the 22nd of May, 1807, were opened, with considerable ceremony, by the Duke of St. Albans, the Earl of Yarborough, Mr. Uppley, the Chairman, Mr. Skipworth, Mr. Corbett, and a large body of the Commissioners.

Thus, after a lapse of 43 years, since the late Mr. Rennie's report, and 556 years since the drainage commenced, these works have been finally completed, and the whole of this valuable and extensive district, now receives the benefit of a perfect, natural drainage, without the adventitious aid of mechanical power. The sure principles of drainage,—catch-water drains for the highland waters, and improved rivers and drains for the lowland or fen waters,—have been established, and the whole of the Ancholme level is now converted into a rich arable district, capable of producing the finest crops of every kind.

The whole of the works have been completed under the direction of Sir John Rennie, the principal engineer, assisted by the able co-operation of Mr. Adam Smith (M. Inst. C. E.), the resident engineer, whose great experience, unwearied zeal, and perseverance, accompanied by no ordinary ability, entitle him to great praise. The late indefatigable clerk, Mr. Nicholson, and his successor, Mr. Hett, deserve also particular mention.

Now that the navigation has been completed, up to Bishop's Bridge, it would be extremely desirable, to extend it as far as Witham. This project has been some time in agitation, and a plan was prepared for it in 1829. The distance from Bishop's Bridge, to the Witham, at Barling's Eau,  $6\frac{1}{2}$  miles below Lincoln, is 14 miles. This work might be accomplished without a lock, except at the entrance to the Witham, and would cost about £90,000. The advantages of this measure, both to the drainage and the navigation, would be very great, not only for the valuable agricultural district, of 13 miles in length, through which it would pass, and which is, at present, wholly unprovided with any adequate means of transporting its produce, or receiving back manure and other valuable necessaries,

but it would also confer considerable benefit upon the districts in the Ancholme, and the Witham, by opening a ready and economical communication between Hull, Brigg, Lincoln, Boston, and Barton, far superior to what they at present enjoy, and would not only confer the greatest advantages upon all those places, but would produce a profitable return for the capital expended in carrying it into effect.

The paper is illustrated by ten drawings (Nos. 3713 to 3722), comprising a general plan of the level of Ancholme, with elevations and sections of the various stone, iron and timber bridges in the district and also of the Ferraby sluice.

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Mr. J. OLDHAM bore testimony to the success of the works of the Ancholme drainage, in the beneficial effects they had produced in the district, and mentioned particularly, the construction of the new sluice at Ferraby, a minute description of which, he suggested, would form an interesting communication for the Institution.

Sir JOHN RENNIE, *President*, said, it would be observed, that in the paper, he had brought prominently forward, some leading principles of drainage, which he thought were very important.

These were, 1st, The formation of 'catch-water' drains, which separated the highland from the lowland waters, and conveyed each to independent sluices, at the lowest practicable outfalls. This system was, he believed, first practised by the late Mr. Rennie, about the year 1801, in the Witham drainage.

2nd, The straightening, deepening, and general improvement of the main river, separating, as much as possible, the navigation from the drainage; and—

3rd, The formation of over-fall weirs and reservoirs, for arresting the sand and mud, and preventing the drains from being choked.

The advantages of these plans must be evident, particularly for a flat district, surrounded by high lands. He was of opinion, that the defects, complained of in the Bedford level, might be attributed, in a great degree, to the neglect of these principles, and the continuance of the old Dutch plan, of simply cutting a series of straight drains to the nearest point in the river, without sufficient regard to the outfall, where only as much of the water was discharged, as was allowed by the time the sluice gates could be permitted, on account of the tide, to remain open. This plan alone was, he believed, still pursued in Holland. The attempts to drain the Pontine Marshes, under Pius VII., had been conducted on that principle, and even M. Prony, who was sent to Italy by Napoléon, for the purpose of reporting on the drainage of those marshes, made no other suggestion.

It had been asserted, that the Carr Dyke, which was constructed