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Account of the Under-ground inclined Plane executed at Walkden Moor, in Lancashire, by his Grace the Duke of Bridgewater.

By the Rev. Francis H. Egerton, of Bridgewater House.

From the Transactions of the Society for the Encouragement of Arts, Manufactures, and Commerce. The Gold Medal was voted to his Grace as a Testimony of the high opinion entertained by the Society of his Grace's Execution of this great Work, and of his wonderful exertions in Inland Navigation.

I beg leave to present to the Society an account of the Under-ground inclined Plane, which the Duke of Bridgewater has lately made at Walkden Moor, between Worsley and Bolton, in Lancashire.

To this account I have subjoined two plans, with a table of reference to each

Following, you will find the plan, and the section of this work, with a table of reference for each figure.

At Worsley the Duke of Bridgewater's navigation begins; it goes west to Leigh, and east, to Manchester, where it joins the Rochdale Canal, where it goes through a lock: on the way to Manchester, it turns away in a westerly direction near the bridge of Longford, to join the canal, called Grand Trunk, above Preston Brook: from there, leaving to the north-west in Runcorn, it descends down to the Mersey, by locks and joins the waters of the port of Liverpool.

This open air navigation, which extends in length in all directions, is forty miles on the same level (i) without tunnel or lock. Except the communication locks that are at the ends, joins an underground navigation *in* Worsley, which communicates with the various coal mines, below Walkden Moor. It is these mines which these two canals, are used to supply Manchester, and several other places with this important material.

- (1) *In addition to these 40 miles, about 12 miles of underground canals, the lower level and including 18 miles of the Canal called the Grand Trunk, from the lowest lock that is located between Middlewich and Preston Brook, there are 70 miles of navigable canals, on one level, without a single lock, and 82 feet above the low water sea level. Through this canal, communication is made between the cities of London, Liverpool, Bristol and Hull: by the low lock between Middlewich and Preston Brook, and the Grand Trunk Navigation down to the same level as the Duke of Bridgewater Canal. The channels, or canals, which form the underground navigation, are arranged on two floors or levels.*

The lower level canal is on the same level as the open air navigation. which it joins at Worsley, it consists of several lines in different directions, which follow the various seams of coal, over a length of excavation of more than twelve miles.

The upper canal, is thirty five and a half yards perpendicular height above the lower canal, and it is thirty-eight to sixty-one yards below the surface of the earth, following profile of the land: there is, excavation, more than six miles in length of underground channels for the single level.

The Excavation of each level is ten feet four inches wide, eight feet six inches high; the water depth is three feet seven inches.

Before communication had been established with an inclined plane, the coal was unloaded by hand, from the boats on the upper Canal, and, they descended to the lower Canal, by a well, in barrels, using a machine, and a wheel. It was proposed, by an underground inclined plane, to lower the boats themselves from the upper canal, to the lower canal: Using this mechanism, the operation is now timely without discharge or damage to the coal, with a quarter of the former expense, thus, the boats from the upper canal descend, body and goods, down the inclined plane and navigate from its foot to nearly three miles in a straight line down the lower Canal, to the open air navigation at Worsley. In the past, to repair the boats in the workshop at Walkden Moor, at great inconvenience, and high costs, it was necessary to draw the boats to the surface, now they come by their own means of transport, for repairs at the large boatyard in Worsley.

The place where the slope is built is remarkably willing to receive it. There is a layer of white rock, or sandstone, eight and a third yards deep, with a slope on a one yard in four, extending in the direction most suitable to form the communication between the two levels. This band of rock was excavated in a tunnel rising from the lower reaches by the explosions of gunpowder, and then finished with iron wedges, and pickaxes. It is in this excavation formed through rock, which extends from the lower to the upper level, the Inclined Plane is created. This location in the heart of a rock is very solid, for securing of all the parts at the top, bottom, and sides: an advantage that is not available to any inclined plane above ground, and, which makes it a unique institution, and perhaps impossible to imitate in any other situation.

The path length of the inclined plane is four hundred and fifty-three feet, not including fifty-four feet in length for locks located at the northern end on the upper reaches: the slope is one foot in four, corresponding to the inclination of the dip in the rock.

Of these four hundred and fifty three feet, about two hundred and eighty-two are formed by a double iron way, to allow up and down, two trolleys with one boat loaded and one boat emptied: the path is divided by a brick wall that supports the roof of the excavation, there are openings at intervals, where men can shelter away from boats descending: this double path merges to form one, about one hundred and seventy two feet from the lower reaches.

The total width of the double railway, is nineteen feet, the single railway after the meeting, its width is only ten feet.

These paths for the descent of the boats are lined with iron plates placed on sleepers, sealed in the ground at intervals: the height of the roof over the railway is eight feet.

At the top of the Inclined Plane is a double lock, or rather two locks, one placed next to each other, and cut into the rock: These locks are alternately loaded with boats that come from the upper reaches, and from the lower reaches of empty boats. The length of this part of the excavation is fifty-four feet, the width of twenty feet and a half, and the height, the - above the locks at the northern end of twenty-one feet, in order to place the large wheel brake mechanism. (See fig 2)

The bottom end of the "Southern" inclined plane is six feet nine inches below the surface of the water, where loaded boats the truck are disengaged from the carriage, and are floated onto the lower level canal.

The depth of the locks below the water at the northern end, is four and a half feet, and eight feet at the opposite end.

The wall separating the two locks is three feet thick j is elevated nine inches above the water line of the level.

The diameter of the horizontal cylinder (mainshaft), on which the rope lowers the loaded boats, and the one that lifts the empty boats, is four feet eleven inches, its circumference is five feet five inches: the cable has two inches and a half in diameter, and seven and a half in circumference: it is wrapped with a small cord about an inch in circumference, with a length of nearly one hundred and five yards to prevent the cable wear, what would happen mainly when dragging the bottom, at work, at the meeting point of two paths, and, for the same purpose, set at intervals along the inclined plane, small rollers eight inches in diameter: in addition, there is a long roller of hollow cast Iron of eight and a half inches in diameter, placed across the Western lock, which is parallel to the upper door of the lock, just before the north end of the lock but eighteen inches above the door: its job is to support the cable and prevent it from wobbling.

A strong rope is attached to the cable to secure every boat on its carriage, when ascending or descending. It is indicated kk, fig. Ve: we hear more about its use in the explanation of the board.

In the middle of the horizontal cylinder (mainshaft) above, is the brake wheel, which regulates the speed of the boat loaded down the inclined plane.

This wheel is lined on the side, with iron gear teeth, together forming a wheel (spur-wheel) three hundred and seventy two teeth sprocket (little-wheel) which sets in motion has eleven teeth (see fig. 3) : This gear is supported by two uprights, between which it works, and are secured in the roof and the wall.

Two cranks, 44, fig. 2, on its axis, set in motion the horizontal cylinder dd, Jig. ire, or, No. 1, fig-2

The power of these two cranks together, enables a man, which employs a force equal to a weight of forty pounds, capable of raising two tons on the railroad, and this force, multiplied with the cranks, is enough to advance the loaded boat to the output of a lock, and, returning to the empty boat in the other.

The boats are thus set in motion; the pinion is engaged with the teeth of the big wheel, by means of a slide which removes the pinion so as to release its teeth from those of the wheel (spur-wheel). The weight of four tons, is enough to raise the weight of a ton or so.

The toothed wheel (spur-wheel) that is attached to the brake (brake-wheel) No. 2, fig. 2, is rarely used: it is only used occasionally, only to adjust the tension of the cables, when new, and to secure an empty boat into the lock, when sometimes it may happen that is overloaded with materials such as mortar, timbering, etc., to be used in coal mines in the upper reaches, and it will not rise by itself from the lower levels by a counterweight.

The length of the carriage or cradle is thirty feet, and a width of seven feet four inches: it moves on four wheels solid cast iron, which run on cast iron plates, on each of which there are peaks of iron projecting two inches above the plates, to prevent the carriage running off the track.

The net weight of coal contained in the laden ship, is about twelve tons, the boat weighs nearly four, and the trolley, or cradle, which the boat is placed on about five, when it descends the inclined Plane: in all, nearly twenty one tons (i).

This inclined plane is currently carrying down thirty loaded vessels, with ease, in eight hours, making four boats in a little over an hour.

The boats used in these coal mines are of various sizes and dimensions: some are seven, some eight and a half, and other twelve tons.

Regardless of the weight of the truck and boat, that of coal going down the inclined plane in boats from the port of twelve tons in eight hours, is therefore, three hundred and sixty tons
360 tons

The weight of the carriage, assumed to five tons, down into the same space of time, shall be one hundred fifty tons, 150 tons.

And the weight of the boat, supposedly four tons, down thirty times in eight hours, shall be one hundred twenty tons, 120 tons.

Total weight down in eight hours = 630.

The weight of the truck and the boat back thirty times in eight hours, will be:

The carriage at five tons, mounted thirty times, = 150 tons.

The boat at four tons mounted thirty times, =120 tons.

Total weight lifted = 270 tons in eight hours.

Thus there will be descending 630 tons.

And ascending 270 tons.

In all: Tons = 900 (i) moved on the inclined plane, in eight hours, not including the unknown quantity of materials assembled by hand for the service of mining the upper reaches.

(I) The English Ton is 2240 English Lbs,

(1) Or, 2,016,000 pounds fourteen ounces

Waters that feed the upper reaches, and replace those lost by the locks from the nets, drinking sources, oozing veins by exploiting the coal, and three tanks which can be used on occasion, and in times of drought, and are sufficient to maintain the level at its height, and provide a constant backup of water to fill the locks, and run the work of the inclined plane.

The inclined plane was started in September, 1795; it was completed and made practicable in the month of October, 1797.

This work, like most other works of the Duke of Bridgewater, was imagined and designed by himself, is the perfection of engineering design of great conception, and well run.

The uniqueness of the place where it is constructed, the boldly original project, deployed in the engineering design and implementation, the speed with which it was executed, simplicity, beauty and harmony of its parts tending to a perfect whole, and especially the perfection to which it is proved that it is currently being achieved in practice, make this work so amazing that no other amazing work, so ably planned and executed successively speaks first of Engineers, the patriotic father of Inland Navigation.

Francois - Henry Egerton.

Plan, and Section, the Inclined Plane Underground.

a b. Slope (dip) of the railroad on the Underground inclined plane, as established in the centre of the rock (see p. 12.1. 8, and following, and page 13 of the Statement) from the point b, the underground Canal until the opening of the open air Canal, the distance is three miles. (See ff, pag. 28).

Z, xx, is part of the upper level, joined to Kxx, the locks of the Inclined Plane.

A. Eastern Lock.

B. Western Lock.

C. Section of a lock: the dotted line indicates the depth, the horizontal black line, below, shows the slope on which the wheels of the carriage move, either by entering with the empty boats, or going out with the boats loaded.

d d. Horizontal cylinder (main-shaft) four feet eleven inches in diameter on which the ropes run to raise and lower the boats: this is where the wheel is fixed (brake-wheel), wheel (spur-wheel) and pinion. (VoyezJ'fig. 2, No. i.)

e. Passage between the upper reaches, and its locks.

f. Boat loaded down the inclined plane on one side and an empty boat up on the other side of the railway.

g. Brick wall, from floor to top of the inclined plane, designed to provide support to the roof again.

hhhh. Openings through the brick wall G, in which a person may withdraw from the path of the boats when they go up or down.

î. Bell placed on the upper reaches, and is used by means of a rope indicated by the dotted line, which descends to the lower reaches, to warn that everything is ready at the bottom, that is to say, the empty vessel is placed on the carriage, and you can let go of the boat loaded from above.

k. Ropes attached to the cables, and stapled to a ring in the southern part of each boat, when they rise or descend, to fix them on the truck, and prevent them from wobbling or slipping. These lines are spliced onto the ends of cables, and go above and between the two flanges, when attached to the iron uprights at each side of the carriage: the moorings through boats in length, and maintained in a motionless manner on the carriages.

l. Ropes attached using clamps on the main cables to O, and the two posts mounted on each side of the truck.

0. Location where cable, rope, and flanges, are linked together. '•

■ i. Space, or, well cut in the sides of the lock A. In this space we have arranged a pit to drain the excess of the locks in the lower reaches, and at the same time drive an air flow through the lower galleries of coal.

2. Valves for the flow of water in the well i.

3. Valve to let water from the lock B, through a funnel, represented by dotted lines in the lock A, in the well, No. i.

7.7. Gates of the lock gates to let water from the upper levels, to fill the locks.

8.8. Two north lock gates: for each lock that turn on trunnions, and swing to open, or close.

io. io. Valve doors at the end of each lock, which are raised or lowered it by a crank, pinion and a rack.

S. Stop gate, on the upper level, used to park the boats, and to retain water when the lock gates are in need of repair.

T. Where boats leave the railway to enter the path to the right and left, following signs that trucks must take: to this end, there is a circular piece of cast iron moving on a pivot that steers the carriage and moves with it.

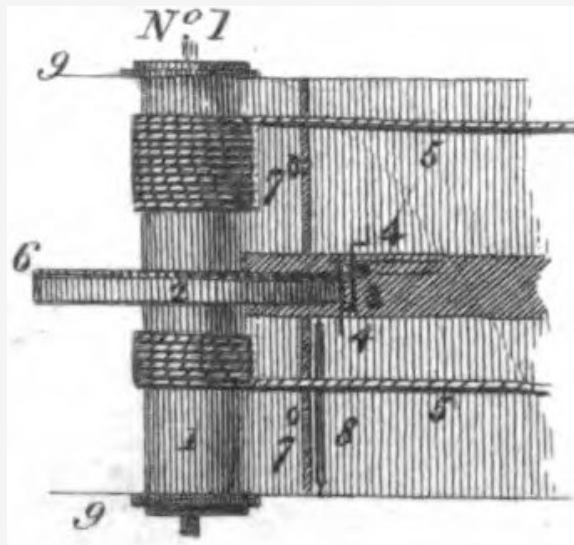


Fig. 2.

Horizontal cylinder (main shaft) on which the cables run, indicated by the No. 1.

2. Wheel (brake-wheel) with spur gear teeth on the side of the cast iron wheel (spur-wheel).

3. Pinion (nut-wheel) seen disengaged, but it meshes with a slide in the segment of the wheel 2, when it comes to raising the empty boat into the lock: this pinion is supported by two uprights, from roof, to the wall.

4.4. Cranks that rotate the pinion and the wheel (spur-wheel).

5. 5. Cables, or hawsers, attached to the boats, they are wrapped with rope to prevent them from wearing.

6. Cast iron cogwheel (spur-wheel) bolted to the rims of the large wheel 2: the solid part of the wheel 2 is placed a brake assembled by bolts of iron, so that pressing the lever end the worker can decrease the speed of the boats descent.

7.7. Sluicing of upper doors for the introduction of water into the locks.

8. A hollow cast iron rolls used to prevent oscillation of the cables.

9. Flanges attached to the ends of the cylinders, amounting to three inches, to prevent the cables from slipping by shaking, or other accidents, out of the cylinder, and falling on to the pins.

We will see the following discussion, what causes and what incidents have resulted in the inclined plane, I just do an accurate description.

It wasn't anything more than eventual work, a following accessory to the works that one did every year, progressively to the Canal.

It can not be regarded as an object that point had to focus attention in preference to any other, the Duke had already run many most distinguished works, some of which offered such great difficulties, that the execution seemed impossible.

It appeared to himself that the Inclined Plane thus did not require anything more than a certain capital, and care in its construction and its mechanism:, and became, of course, part of the work that was being done every year for this navigation;

Francis Egerton, then Duke of Bridgewater, had spent several hundred thousand pounds to establish its navigation, and it was therefore used for the different work of its Canal, a large number of people of merit and talents in all kinds, and all classes.

Even when the Canal was fully completed in all its various extensions, the Duke went every year to pay, weekly, twelve hundred pounds, which were distributed to the different workmen employed in the succeeding three departments: the Navigation , the Mines and the areas of Cheshire and Lancashire, with only its areas were **corrigus** this navigation, and who reported that five to seven thousand pounds per year income inconsiderable in comparison with that that produced his other hereditary dominions in Northamptonshire, Yorkshire, Shropshire, Hertfordshire, Buckinghamshire, and the counties of Durham, Middlesex, etc..

His Grace continued therefore to employ a large number of people whose talents and merit differed in description, were extremely valuable for each kind of works in which they were occupied: but the sum of twelve hundred pounds, payments he paid to them every Saturday was not included in the other amounts he soldait each year the salaries of his employees.

Everyone who wanted to get a job looked in preference to those presented by the Navigation was in the country, establishing the largest and most renowned: it is still the best. The Duke was the only and sole owner, while they were companies that managed all the other waterways in the country. We were struck by that of the Duke: he had in his favour, his rank, power, wealth, long habits in all that pertained to this kind of navigation in a word, he had, a good reputation.

This advantage allowed him, in a sense, the choice of all that was available, and certainly after the works for his navigation was completed, he was able to sort and choose among those that he had already used.

Those who remained with him, were, in fact, the cleverest, most intelligent and the most skilful, it would have been possible to find. You could not see without admiration these commendable people for their skill and intelligence, who formed, the Worsley workshop, a meeting of workers

in all types of all trades, and all the arts, especially remarkable for the overall ease and speed of everyone's work in the project.

His Grace avoided as much as he could, to not change anyone: many of them had been thirty years in his service: and some very, longer: a large number that were used immediately he began the continuation of the work of the Navigation, originally planned by the Father: Scroop Egerton, Duke of Bridgewater, who died in 1744-5, had obtained in 1782, the tenth year of the reign of George II, an Act of Parliament, whereby "He was authorized to "establish a navigable canal from Worsley to Manchester. "*"

We tried all means to be able to give employees, Assistant Stewards, and the best workers, all the facilities that could accommodate some particularly their ease.

In all the work, they used stone, when it was possible to use it, and it drew great - conveniently the various careers that were, at intervals along and near the Canal, who now, thirty-five miles long on land, and twenty-four miles - below, in the various branches of the Underground Navigation, which leads to different veins of coal.

However, five million bricks are manufactured every year, (which was the average calculation) for the service, not - only three different departments, Navigation Canal, Mines, and Fields, when could not even use the stone, but still, to build houses for the employees, the Under - Stage managers, clerks, and good workers, and, again, we had to allocate attention to each of these houses a certain portion of land for a garden.

Francis Egerton, Duke of Bridgewater, had a great talent to discern and to choose the most clever and most appropriate to the service, he, too, an engaging manner which tied all those he employed, and was, indeed, very remarkable: never compromising his dignity, it seemed, so to speak, he charmed them, while it's electrified. Finally, all those in his service regarded him as their Lord, their protector, and even as their Father.

In the course of several years, the first Clerk of Mines, as well as key workers, or the Canal Boatmen dating back underground, had experienced the disadvantage of the lack of direct communication between the upper reaches and the lower reaches. Their work had major delays and incurred substantial losses, and considerable expense.

They knew that there was in the mountains a layer of rock in place, not only the quality of the stone, but also by its slope, in a peculiarly favorable to a communication by means of an inclined plane, between the upper levels and the lower level; this plan, once executed, would remove all obstacles, and provide all the benefits they sought.

They talked for a time "long enough, about this Inclined Plane", they often suggested the project to the Duke, which was only postponed, because there were more pressing work, and necessary which had to precede the execution: however, the project of the Inclined Plane was not abandoned, and it was to be executed at one time or another.

The employees had projected their plans: Finally, the Duke resolved to carry them out. He saw them all, gave his orders, and the inclined plane was completed without delay.

I'm sure the dimensions I have given are perfectly exact because the Commission, the principal attendants of the work, and the Chief Miner have given me, as I gave the order and, during the summer that I had fun in drawing up this paper, I returned three times, to the underground canal to where the slope is set: I would, however, not take this action if I hadn't had a determined motive as to be most accurate in this presentation, because every time I went up the Canal I occasioned some losses, stopping work in the mines for some time, from which we withdraw ten thousand barrels of coal per week, and interrupting, necessarily, all navigation, all traffic and all kinds of work, or to make preparations for my arrival, or during the time I stayed in the underground canal, delays and suspension of work whose owner's interests were bound to be felt, and how the public felt much loss and inconvenience, in an institution formed on a plane as large, as extensive and also useful.

FRANÇOIS - HENRI EGERTON.
Paris, le 2 Avril, 1812.

Fig. 2.

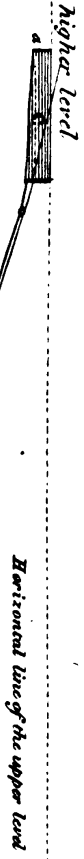


Fig. 1.

