it follows the inside cavity of the bucket, rises and falls over into the next in succession, and so on. By this system the force of the water is expended on the wheel itself, instead of losing much of its power in rushing along through the wheel-race, as generally occurs in even well made undershot wheels.

M. Poncelet has treated this subject at such length in his able work on water-wheels, that it is not necessary here to enter into further details; but it may be observed, that a practical improvement might be effected, by terminating the lower stone platform of the race somewhat short of the vertical line of the centre of the wheel, as the escape of the water would be facilitated, and the ascending buckets would be more easily relieved of their contents; this is a point of such importance for all wheels, that it must equally apply to this form.

In this Paper, the turbine, with the improvements recently introduced in it by Fourneyron, Zuppinger, Whitelaw, and others, has been entirely omitted. There are many published statements relative to these improvements, but its limited employment in this country, up to the present time, scarcely renders it necessary to refer to it. It is however asserted that as much as ninety to ninety-two per cent., have been obtained from M. Fourneyron's turbine, but that gentleman, in a recent visit to this country, kindly furnished the Author with data taken from several of his machines, which reduce the duty to a mean of seventy-two per cent. M. Zuppinger and Mr. Whitelaw, do not claim a higher duty in their machines, the average being from seventy to seventy-four per cent. upon the theoretical value of the fall.

Mr. Rennie said, Mr. Fairbairn's experience in the construction of water-wheels, was so great, and the general remarks of the Paper were so accurate, that little could be added, and he was grieved to disagree with any point in it; but he could not accord with the statement of few improvements having been introduced since the time of Smeaton. Mr. Rennie must claim some merit for his late Father, who had carefully studied both the theory and practice of water-wheels, and he would not permit Mr. Fairbairn to detract from his own merit, as he was universally acknowledged to be at least one of the most successful constructors of these machines.

The late Mr. Rennie introduced the system of laying the water on to the wheel in a thin stream, not exceeding ten inches in depth. In addition to this, and for the purpose of taking the utmost advantage of the fall, he used the curved moveable shuttle, and at the same time tried various curves for the buckets. It appeared, that Mr. Fairbairn had directed his attention to nearly the same points, as there was great similarity in the machines, he having apparently taken the subject up where Mr. Rennie had left it, and the excellent result appeared in the statements contained in the Paper.

Poncelet's experiments on this subject showed, that in some wheels constructed with curved buckets, but without sole-plates, and receiving the water almost like undershot wheels, an advantage of ten per cent. over the ordinary forms could be attained.

The experiments of the Franklin Institute, made upon large wheels, were perhaps the most valuable. The greatest result obtained was, he believed about sixty per cent., with a velocity of eight feet per second.

As the opinion of Professor Robinson had been quoted, it might not be uninteresting to state, that on one occasion he was consulted by his former pupil, the late Mr. Rennie, as to the best form and dimensions of a water-wheel, and that the result was a complete failure; proving that his practice was not as good as his theory.

Sometime since it was expected, that the turbine would, in a great measure, supersede water-wheels; but, however well they might be adapted for peculiar situations, they had not been generally introduced. Fourneyron brought the idea from Germany, and materially improved upon the construction, until, as he stated, about seventy-five per cent. of power was obtained from them; but Mr. Rennie had never yet seen any turbine perform that amount of duty.

Whitelaw's wheel followed, and was stated to have attained about the same power. These machines, however, were both difficult of construction, and did not appear to make progress among Engineers.

Mr. Fairbairn regretted, that he had not read an account of the improvements of the late Mr. Rennie, both before he had constructed the wheels, and when he wrote the Paper, as he could not have failed to benefit by following in the steps of so worthy a predecessor.

The turbine had been noticed very cursorily in the Paper, because the subject had been nearly exhausted in the excellent Paper by Mr. Lewis Gordon,* and because that machine had really been but little employed in this country, and not very extensively on the Continent. He had constructed one for M. Fourneyron, which had been sent to Italy, and was stated to have done good work. He had

* Vide Minutes of Proceedings Inst. C. E. 1842, vol. ii. p. 92.

also made one for Mr. Whitelaw, which had been erected in Yorkshire, for a fall of one hundred and twenty feet. It was at first two feet in diameter, and made about four hundred revolutions per minute, at which speed about thirty per cent. of the power was obtained; it was then altered to two feet six inches diameter, when about fifty per cent. was arrived at; and he believed that other alterations had still further improved its action. Some practical difficulties always occurred, such, among others, as the means of lubricating the main vertical spindle under water, which, for ordinary cases, tended to induce a preference for good water-wheels.

Mr. Whitelaw had asserted, that with a good fall, as much as seventy or seventy-five per cent. of power could be obtained; but M. Fourneyron did not anticipate more than seventy-two per cent.

Mr. Fairbairn had seen abroad a kind of turbine working horizontally, which received the water, through pipes, from a very high fall, into curved buckets, upon the two opposite extremities of its diameter; the velocity was very considerable, and the power gained was stated to be great.

Mr. Croker said, one of the most successful of M. Fourneyron's turbines was erected at St. Blasieu, in the Black Forest, upon a fall of three hundred and fifty feet. The diameter was twelve inches and a half; and when the sluice was open about one-third of an inch, the machine made two thousand two hundred and fifty revolutions per minute, with an expenditure of water not exceeding sixty cubic feet. The supply of water was derived from streams amongst the surrounding hills, and being collected into a reservoir, distant upwards of three-quarters of a league from the turbine, was thence conveyed to it in cast-iron pipes, eighteen inches in diameter. The turbine was used for driving a spinning factory, containing eight thousand water spindles, with the roving frames, carding engines, and all other necessary machinery. The duty of the machine was calculated, from experiment, to be equal to seventy per cent. of the water expended.

Mr. Glynn said, his custom in the construction of water-wheels had been to obtain free egress for the air, by simple openings through the sole-plate, into the interior of the wheel. The contrivance for conveying the air upwards adopted in the wheels which had been described, was a decided improvement, and would tend materially to that regular filling and emptying of the buckets, without which uniformity of motion could not be insured, and for many of the fabrics manufactured by water power that regularity was essential. The ordinary velocity of the wheel was about six feet per second; and with respect to the per centage of power obtained, when the water fell upon the wheel without impulse, and left it without velocity, he conceived that nearly all the power was used.

He admired the details of construction of Mr. Fairbairn's wheels, particularly the arrangement for taking the lift on the loaded side of the wheel, and thus making the axle only the means of retaining the wheel in its place.

Mr. FAIRBAIRN stated, in answer to Captain Moorsom, that he considered the form of the bucket did contribute materially to the regularity of motion. It was important to carry the water down as near to the vertical centre as possible, so as to get the best effect from it, and yet to begin to part with it, as soon as that line was passed. That form was also found to fill better, and waste less water in times of drought, whilst it worked very easily, and without injury from back water in times of flood.

The ventilating wheels were not so essential for very high falls; they would be more expensive, and as the measure of all benefit was the cost, he should not consider them indispensable for high falls with abundance of water.

Mr. BEARDMORE thought, that there was scarcely a situation in Cornwall to which this kind of wheel was applicable, as all the falls were very high. The wheels in that district were chiefly employed for working stampers, or for pumping. In neither case was regularity of action at all necessary; for pumping an exertion of force was essential to raise the heavy plunger rods, and then the wheel might run at any velocity during the other portion of its revolution, and before the next stroke was made, power was accumulated, by the extra filling of these particular buckets, the others possibly not having been more than half filled; the millwright, therefore, gave plenty of bucket room, and ventilation was afforded at the extremities.

Mr. WICKSTEED considered the wheels in Cornwall and those in Lancashire were so differently employed, that no useful comparison could be drawn between them. He thought, however, that no doubt could exist as to the advantages of Mr. Fairbairn's improvements, where steadiness of action, and the economical use of water, were required. He apprehended that some difficulty might occur in times of flood; but the form of the buckets was calculated to meet, to some extent, even that objection. Great attention appeared to be deservedly given to the angle formed by the bucket with the periphery, and he conceived that it was a question of importance, particularly in relation to the amount of strain upon the axis.

Mr. Wicksteed had tried experiments upon large-sized water-wheels, built both on Smeaton's and Rennie's systems, but had not obtained from them more than fifty-six per cent. of power; the velocity was generally about six feet per second.

Mr. Scott Russell had rarely seen better designed, or more ably executed machines than these ventilated water-wheels, and he thought the profession was under obligation to Mr. Fairbairn for the improvement he had introduced. He might instance, especially, one point of importance; this was the method of taking off the power, by inside gearing, from the loaded part of the periphery, thus avoiding all risk of straining the wrought-iron tension arms. Attempts had been made to improve upon the system, by taking off the power from the two sides of the wheel; but they had not been successful, as the gearing on both sides did not work well together, and a tremulous motion was communicated, which was very objectionable for spinning mills, where it was important to obtain the utmost regularity of movement. He had heard it remarked, that the yarn spun by water power obtained a higher price in the market, than that produced by steam power.

Mr. Russell had tried some experiments on water-wheels, and found the radial breast-wheels give very good results, with a fall of about fourteen feet, and the sluice and watercourse so arranged as to bring the water on with as little velocity as possible, filling the buckets properly, which, however, could only be accomplished up to a certain speed, without a system of ventilation. In high falls this became even more essential, and, in fact, indispensable.

Mr. Fairbairn explained, that he had tried both methods of taking off the power, and preferred taking it from one side only, as, in addition to the other objections, when the gearing was fixed on both sides, the elasticity of the wrought iron tension arms tended to break the teeth of the pinions. It could therefore only be done when the wheel was perfectly rigid.

Mr. Strutt, of Derby, and the late Mr. Hewes, of Manchester, had made many important improvements in water-wheels, particularly those on the suspension principle, which appeared now to be acknowledged as the most advantageous construction.

Mr. De Bergue said, he had obtained nearly seventy-eight per cent. of power, from a breast wheel, with a good fall, when the periphery was travelling at a velocity of six feet per second.

He had erected several of Poncelet's wheels, and thought well of them, indeed for certain situations he thought they were preferable to any other form, although M. Poncelet had never yet been able to obtain very superior results from wheels erected under his own superintendence.

Mr. De Bergue then exhibited a drawing (Fig. 4,) and explained

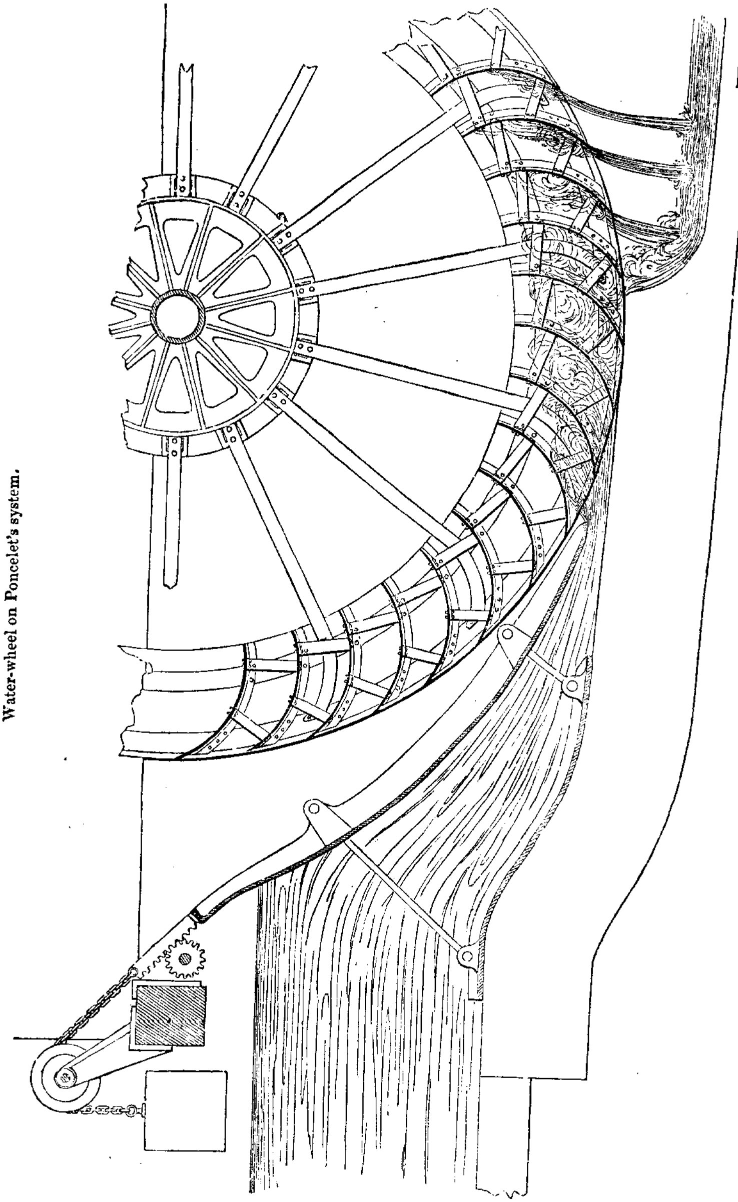

Fig. 4.
Water-wheel on Poncelet's system.

the construction of a wheel on this principle to be erected at the Loubregat, near Montserrat, in Catalonia; one of the same kind having been already erected by him at Gerona, between Barcelona and Bellegarde.

The diameter was sixteen feet eight inches, and the width was thirty feet, which with a fall of six feet six inches, passed one hundred and twenty thousand cubic feet of water per minute, when the periphery travelled at a velocity of eleven to twelve feet per second. An ordinary breast-wheel would require to be ninety feet wide, to use advantageously that quantity of water. It was found, that the velocity of the periphery should be about fifty-five per cent. of that of the water flowing through the sluice, and upon these data the power of the wheel would be about one hundred and eighty H.P.

The buckets were of a curved form, and made of wrought iron, one-eighth of an inch thick, and it would be observed, that there was a larger number of buckets than usual, and that the water came upon them at a tangent, through an orifice of such a form and dimensions, as to allow the buckets to fill easily, at the rapid speed at which the periphery passed before the sluice. This great primary velocity was very important, as it caused a considerable saving in the gearing of the mill.

The main shaft was formed by a hollow cylinder of cast iron, four feet six inches in diameter, in short lengths, bolted together, and the arms were of wrought iron, made very light, and of the same form as those of the paddle-wheel of a steamer, and placed very close together. The strain was brought entirely upon the main shaft, and the weight of the wheel was thus reduced to about thirty tons, which was very little for so powerful a machine.

The sluice was formed of cast-iron plates, with planed joints, bolted through the flanches, to form one large shuttle, of the entire breadth of the wheel, and its motion was regulated by radial tie rods, between the stone apron and the back of the sluice, which could thus be raised with great facility by racks and pinions, and be regulated by the ordinary governor, the weight of the sluice being in a great degree supported by the water flowing beneath it, on to the wheel. It moved very accurately between the side walls of the pen-trough, and cup-leathers at each side prevented any waste of water.

This kind of wheel was less affected by back water, than any other form, and the water acted upon it with its full power of velocity, without any impediment from the air in entering, as there was no sole-plate; the buckets were, therefore, filled and emptied with great facility.

Mr. De Bergue was satisfied, that this was the best kind of wheel for all falls under eight feet in height, and though the principle differed essentially from that generally taken as the basis of construction of water-wheels, he was inclined to prefer it to any other system.

February 6, 1849.

JOSHUA FIELD, President, in the Chair.

No. 795.—"Description of the Abattoirs of Paris."—By Richard Boxall Grantham, M. Inst. C. E.*

AMONGST the various measures which must be speedily adopted for the sanitary improvement of large towns, one of the most important is that of public slaughter-houses; it therefore becomes necessary, that their construction and management should be carefully studied; but as so few attempts have hitherto been made to introduce them into this country, at least with any degree of arrangement, examples must be sought for on the Continent, where they are almost universally adopted.

The abattoirs of Paris are perhaps, on the whole, the best specimens of establishments of this class, and their administration and statistics present some very remarkable features which deserve examination, previous to commencing similar constructions in Great Britain.

The butcher's trade in Paris is conducted on a peculiar system, and, like almost every other business, is under the control, or surveillance of the police, or the Municipal authorities; indeed, the extent to which this is carried, would here be deemed a great interference with the liberty of the subject, and would not be tolerated. Apart from this, there are many excellent regulations, which, whilst they prevent the unpleasant operations of that trade from becoming a nuisance, or being prejudicial to the health of the public, facilitate the computation of the fluctuations in the prices of food, enabling the masses to be provided for with certainty, and furnishing data for most interesting and instructive returns for the statist. At the same time they afford the means of controlling a class of men, who, from the very nature of their occupations, have become strangers to all the finer feelings. The abattoirs are prominent parts of this system, and it is conceived, that under a modified

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* The discussion on this Paper extended over portions of two evenings, but an abstract of the whole is given consecutively.