ON THE DYNAMICAL PRINCIPLES OF THE MOTION OF VELOCIPEDES.

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(*Concluded from page 153*).

In calculating the whole work done on a given journey the following principles are to be observed :—Calculate by Equation 18 the vertical ascent equivalent to the distance on a level; then, if none of the descending gradients are steeper than the rate of inclination expressed by the co-efficient of resistance, take the actual difference of level of the two ends of the journey, multiply it by the ratio $(1 + b)$, in which the gross weight exceeds the weight of the rider; the product is to be added to or subtracted from the ascent previously computed, according as the difference of level is an ascent or a descent, and the result will be the height of a vertical ladder which is equivalent to the actual journey.

The same mode of calculation would be applicable to all gradients, if the velocipede could safely be allowed to become freely accelerated on steep descents, so as to acquire a store of energy available for surmounting ascents. But if the brake is to be used, so as to prevent acceleration, the calculation is to be modified as follows :—When a descending gradient occurs in which i is greater than f, calculate what the depth of descent would have been in the same distance if i had been equal to f; in other words, multiply the actual depth of descent by $\frac{f}{i}$, and use the product instead of the actual descent in calculating a *virtual* or *effective* value of the difference of level of the ends of the journey. Another way of stating this is as follows :—When a descending gradient i occurs greater than f, multiply the depth of descent on the gradient by $1 - \frac{f}{i}$, and consider the product as an *ascent*, to be combined with the actual difference of level of the ends of the journey, in order to allow for the loss of the energy that might have been acquired by acceleration on the steep descending gradient. In algebraical symbols, let R_0 be the resistance on a level; and let z denote, if positive, the total ascent, and, if negative, the total descent during the journey, modified, if necessary, in the manner already described, to allow for the loss of energy due to the use of the brake on steep descents; then the work done is equivalent to that of raising the weight of the rider vertically upwards to the following height :—

$$\frac{R_0 x + (1 + b) W z}{W} = (1 + b)(f x + z); \quad . \quad . \quad (20)$$

in the first member of which R_0 denotes the resistance on a level. An ascent may be reduced to an *equivalent additional distance*, and a descent (with due deduction for the use of the brake) to an *equivalent saving of distance*, by dividing by f.

24. *Driving Pressure.*—While the velocipede advances through a distance equal to half a revolution of the driving wheel the pressure of the foot of the rider is exerted through a distance equal to twice the crank-arm. Hence the pressure of the foot of the rider must be as many times greater than the total resistance as half the circumference of the driving wheel is greater than twice the crank-arm. In symbols, let c be the crank-arm; d the diameter of the driving wheel, so that πd is its circumference; P the pressure of the foot on the stirrup; then

$$P = \frac{\pi d R}{4 c} = \frac{\pi d}{4 c}(f \pm i)(1 + b) W; \quad . \quad . \quad (21)$$

and the ratio of the pressure required to the weight of the driver is

$$\frac{P}{W} = \frac{\pi d}{4 c}(f \pm i)(1 + b) \quad . \quad . \quad . \quad . \quad (22)$$

Ordinary values of the ratio $\frac{\pi d}{4 c}$ *range from* 4 *to* 8; being often capable of adjustment by shifting the position of the treadles in the cranks. As an example, let us suppose this ratio to be 5; let the roadway be level, and, as before, let $f(1+b) = \frac{1}{40}$. Then we have $\frac{P}{W} = \frac{1}{8}$; or the pressure required is one-eighth of the weight of the rider.

Another calculation which may be made is of the following kind: Assuming that the rider is able to exert a pressure bearing a given ratio to his weight, what rate of ascent will this enable him to surmount? The answer is given by the following equation:

$$i = \frac{4 c P}{(1 + b) \pi d W} - f \quad . \quad . \quad . \quad . \quad . \quad (23)$$

For example, the data being the same as before, let us assume that the rider is able to exert a pressure equal to half his weight, so that $\frac{P}{W} = \frac{1}{2}$; then we have

$$i = \frac{1}{1 \cdot 25 \times 5 \times 2} - 0 \cdot 02 = 0 \cdot 08 - 0 \cdot 02 = 0 \cdot 06 = 1 \text{ in } 16 \text{ nearly.}$$

With a pressure equal to his *whole* weight we should have

$$i = 0 \cdot 16 - 0 \cdot 02 = 0 \cdot 14 = 1 \text{ in } 7 \text{ nearly.}$$

25. *Day's Work of the Rider.*—It has been ascertained by experiment that a man of ordinary strength and activity, climbing a vertical ladder, is able to ascend for eight hours per day with an average speed of about half a foot (or 152·4 millimetres) per second; which gives as his day's work the raising of his own weight to a height of 14,400ft., or nearly 4400 metres. This, however, is known to be the most favourable way in which the muscular power of the legs can be exerted, the pressure of the foot being at all times equal to the whole weight of the man. During less favourable modes of exerting the legs, and especially when the pressure of the foot parallel to the direction of motion is much less than the weight of the man, a much smaller amount of daily work is to be expected. Accordingly, we find that the work of a velocipede journey of sixty miles on a level road is equivalent to lifting the rider 7920ft., or only about 0·55 of the day's work of vertical climbing.

Further experiments are necessary before any conclusion can be arrived at as to the utmost daily work to be expected from velocipede riders when the powers of the vehicle have been fully developed. A day's work equal to that of vertical climbing would correspond to a journey of about 110 miles on a smooth level road.

A rough comparison, however, may be drawn between velocipede-riding and walking, in the following way. Suppose we assume that a man who can ride 60 miles per day on a velocipede on a smooth level road is able to walk 30 miles per day. The length of the day's journey in walking will not be lessened to any material extent by the occurrence of any degree of roughness or steepness that is consistent with using the velocipede at all. Hence that degree of roughness or of steepness which *doubles the total resistance* of the velocipede, making it one-twenty-fifth instead of one-fiftieth of the gross weight, or one-twentieth instead of one-fortieth of the weight of the rider, brings down velocipede-riding to an equality with walking; and any greater degree of roughness or of steepness gives walking the advantage.

The same method may be applied to other numerical data. Suppose, for example, that it should be ascertained that a man who can walk 30 miles per day is able to ride 75 miles per day on a velocipede on a smooth and level road; the degree of roughness or of steepness which in this case brings down velocipede-riding to an equality with walking is that which increases the total resistance two and a-half times, making it one-twentieth of the gross weight, or one-sixteenth of that of the rider. W. J. M. R.

Glasgow University, 6th August, 1869.

KNAGG'S PROCESS OF CANE SUGAR MAKING.

IN our impression of November the 8th, 1867, we gave a detailed description, illustrated by woodcuts, of Mr. Knagg's patent process of clarifying cane juice, and subsequent evaporation and granulation; we also mentioned that the whole process had been exhibited in operation at the works of Messrs. Easton, Amos, and Anderson, at Erith in the presence of a large number of gentlemen interested in the sugar trade, and that the opinion formed by all present was extremely favourable to the new process.

We have since watched the colonial papers with some interest, to ascertain if the invention was making head, and if the results obtained under a tropical sun, and subject to all local difficulties, were as favourable as those we ourselves witnessed at Erith, and ventured to anticipate for the apparatus when put into actual use. The first portion of Mr. Knagg's invention, viz., the defecation and clarifying by means of sulphurous acid gas and permanganate of potash, has now been tried in Demerara, Trinidad, Jamaica, and is in process of trial at Brisbane; in every case the most complete success has been achieved. For instance, to quote from the *Trinidad Chronicle* of Feb. 25th, 1868, from a report signed by no less than eleven planters :—

The process is free from complication and efficacious, and within the working power of any man of ordinary capacity. The juice is thoroughly clarified, and enters the coppers so pure that skimming is almost dispensed with—so much so that were it entirely omitted, the sugar would be far cleaner than any amount of manipulation can make it under the ordinary process. The juice is greatly decolourised, entering the copper-wall of the colour of pale brandy and water, and as clear. Again Messrs. Bernard and Messrs. John Spiers and Co., state "the economy and advantage of your process, as far as we can now judge, is as follows :—(1), Two clarifiers being required where four are now used; (2), the liquor after being defecated by the sulphurous gas, comes from the subsiders into the coppers so very clear that the number of boiler men on the wall can be reduced to two; (3), the increased quantity of sugar, from 4 to 6 per cent. on the ordinary process, is obtained by the skimmings being reboiled in the clarifiers; (4), the quality of molasses is much improved, and the density of that drained from some of the sugar made by you (Knaggs) was 40 deg. Beaumé; (5), sameness of quality of sugar whether from plant or ratoon canes, and of whatever density; (6), the tempering of the liquor is made more easy and perfect; (7), the draining of the molasses from the sugar is more rapid; (8), the small outlay required.

The complete apparatus, the trial of which we witnessed at Erith, has as yet only been erected on the Bushy Park estate in Jamaica—but we see by the *Gleaner* of Kingston, Jamaica, July 9th, 1869, that a committee of fifteen planters have reported very favourably, especially of the evaporator, of which they say: "That the evaporator is decidedly the most effectual, economical, and expeditious mode of evaporating cane juice we have seen or heard of, and as a proof we give the following results :—

The cane juice from the clarifiers on entering the evaporator stood at 8½ deg. Beaumé, and in *five minutes* came out at 30 deg. to 35 deg.

We gather from the same paper that Mr. Knagg's invention is attracting considerable attention in the colony, so much so that the Governor and the Commander of the Forces, have honoured a public exhibition of the process with their presence; and there can be no doubt that if Mr. Knagg's invention realises the expectations which those who have seen it in operation entertain, it will have a very important effect upon the prosperity of our sugar-growing colonies, by improving the quality of the produce, and reducing to a minimum the amount of skilled, or, indeed, any labour required. We have selected the present moment for again drawing the attention of our readers to this subject, because we think that, during the existing disturbances in Cuba, our colonies, with proper appliances, may become the first sugar producing communities in the world; but to do so, the islands must not, as the Governor of Jamaica is reported to have remarked, "stick in the mud and do things in the way their grandfathers did them, but copy the energy and scientific skill of those who have succeeded in making the despised beet-root a formidable rival; and we do not see that they can make a better beginning than by adopting the invention of one of their own people."

If these considerations have force in connection with the islands, they apply still more completely in the case of the mainland colonies. Demerara and Berbice, with large vacuum pan estates, and ample supplies of water for working them, should stand paramount in sugar production and in sugars of high quality; but these facilities, great as they are, may be immeasurably improved by the general introduction of an improved clarification, such as the system now under consideration embraces, and notably by the elimination of the present wasteful and quality-destroying copper-wall system, in favour of the steam tray evaporator; indeed, the opinions of practical men in the West Indies are gradually taking this direction, and one of our leading West Indian engineers, in a report to the largest of our sugar growing and manufacturing corporations, says, while advocating the employment of steam, as opposed to direct fire evaporation, "rigid economy as well as the march of improvement demand the abandonment of the open Taiche system." Language can scarcely be more forcible.

The attempt at superseding the copper wall by the concretor tray, excellent as have been the results by comparison, is but an evasion of the difficulties so long endured, inasmuch as one system of direct fire heat is but exchanged for another; and although by rapid tray evaporation a useful product is obtained, it still embraces the saccharine principles in combination with the impurities of every kind, and can only be dealt with by the refiner in order to bring it into a state fit for use. The same authority above-mentioned, speaking on this head, says :—

I cannot convince myself, even admitting that the concretor does all that its most enthusiastic supporters claim for it, that it can supersede the "vacuum pan." The making of "usine," or "vacuum pan sugar," direct from the cane juice, cannot be called refining, though the product may be equal to refined sugar; we propose, by the aid of charcoal—and this item of expenditure will probably be less here than in Europe, because the refiner has to operate on a spoiled material while we deal with uninjured juice—and the "triple effect," or other approved process (alluding to the patent system) to convert our pure juice at once into sugar of a quality equal to that from the refinery, which will compete in the same market with it; besides this the refiner's profit, as well as the profits destroyed by spoiling first and then refining, is secured by this system.

Nothing can be stronger than this; and the system of machinery involved offers every inducement to the production of Muscavado and other high class sugars of such colour and quantity as would command the best prices, short of bringing them into the classes where our present somewhat anomalous Customs' restrictions would operate to their prejudice.

WORKING MEN'S CLUB AND INSTITUTE UNION. —VISIT TO CROSSNESS.

THE council of the Working Men's Club and Institute Union wisely determined some time since to arrange a series of visits by the members of the Union to public buildings and important architectural and engineering works completed or in progress. Several of these visits have already come off—to the Holborn Valley Improvement, St. Thomas's Hospital, Blackfriars Bridge, the Metropolitan Embankment, and other places. The most recent visit of the series—which took place a few days ago—was to the metropolitan sewage outfall at Crossness. The visit was intended to have included an inspection of the northern outfall at Barking Creek also, but from some hitch in the arrangements the visitors were unable to land at Barking, and the northern sewage system of the metropolis may be left out of consideration in our account of the visit.

The council of the Union look forward hopefully to the results of these visits as likely to exercise an important influence in connection with the technical education of the working men who may join the excursion. The policy of the council is to obtain for each visit the services of a "guide, philosopher, and friend" to the excursionists, who may be able and willing to explain intelligently the plan and character of the works visited. In the visit to Crossness Mr. Edward Hall, F.S.A., was the guide and expositor. On the evening prior to the visit—Friday last—Mr. Hall delivered a lecture, abundantly illustrated with diagrams, by favour of Mr. Bazalgette, on the metropolitan sewage system, in the Lecture Hall of the Society of Arts in the Adelphi, the lecture being specially intended for the information of those who intended to join the excursion. From Mr. Hall's lecture on the Friday evening, the conversational discussion in the steamer in going down the river on Saturday afternoon, and our own inquiries and inspection, we compile the following account of the works and the visit.

The lecture on Friday evening was numerously attended. It is proverbially dangerous to judge from appearances, and unsafe to conclude from them confidently. We venture to think, notwithstanding, that if the audience at the lecture and the visitors to Crossness on the following afternoon were, for the greater part, conventional "working men," they must have been the very *élite* of their order. The steamboat Black Prince, specially chartered for the occasion, left the Temple Pier on Saturday afternoon at three o'clock, so well filled as to leave very little room for the excursionists who had the option of joining at Blackwall.

The first point in passing down the Thames demanding special attention is the sewage pumping station at Deptford, often described. At Deptford it is curious that the sewage, as it arrives from the Surrey side of the metropolis—and it is the same elsewhere—is comparatively inoffensive as regards smell. The visitor might naturally expect to find at the bottom of the well from which the sewage is lifted a fetid, turgid, viscous stream, repulsive alike to the senses of sight and smell; but, instead of that, he finds only a quantity of dirty water, not apparently very thick, and although not sending forth a perfume quite of the otto of roses or eau de cologne character, passibly bearable. A man employed at the bottom of the well is hooking up the insoluble matters likely to interfere with the working of the machinery. The leading article that his gripe fetches up is human hair, as discharged from the barbers' shops; shavings, and pieces of leather and cloth of various kinds also turn up, but the hair usually bulks quite as largely as any other description of material. The sewage having thus performed its ten mile journey, is lifted at Deptford 20ft., that it may flow on for seven miles and 2240ft. to Crossness, where it has to be again pumped up for discharge into the Thames. Although the sewage as it arrives at the bottom of this lift at Deptford is comparatively inoffensive, it is curious that when it reaches the upper level to which it is pumped it has a very distinctly pronounced smell of naphtha, probably from the bursting of globules and the exhalation of their gases from the agitation of the sewage. In the course of the great main between Deptford pumping station and Crossness, there is a reach of 5000ft. of tunnelling under the town of Woolwich, the sewage is conveyed through 39,200ft. of 11ft. 6in. barrel sewer. At Crossness the sewage is lifted from the level at which it arrives to the reservoir. This tremendous receptacle our readers will recollect is about 572ft. long by 528ft. wide, and when full is about 17ft. deep, which makes the lift about 35ft., but the reservoir is rarely more than half full, and the work of the four engines at Crossness is not much in excess, as regards height of lift, to those at Deptford. There is of course an increased quantity to lift at the outfall from the deliveries to the main in Greenwich, Charlton, and Woolwich. At Crossness the strata upon which the works are constructed is to a depth of 30ft. at the bottom, grey sub-angular flint gravel, next river sand, and above these, blue clay, peat, brown silty clay, and vegetable soil. In some of the trial shafts the peat was as much as 11ft. in depth.

The machinery at Deptford and at Crossness, the laying out and condition of the premises and grounds at the sewage stations, are highly creditable to the engineers who have laid out the works, to the mechanical engineers who have provided the engines, to the supervisors who keep the works and grounds in order, and also indicate in the splendour as well as vastness of this apparatus for