en to the transportation of bulky merchandise upon railroads (20 kilometres or 12·42 miles per hour) requires an effort one hundred times greater than the above calculated, or 7205 kilogrammes, and as upon the railroad the effort for this velocity is but 1500 kilogrammes, the proportion between the two routes is completely reversed. The great economy of transportation by the canal supposes implicitly a moderate speed; but in diminishing the velocity to reduce the expense of haulage, we increase the expenses in boating, material, and equipage, which are used a greater length of time; it follows that there must exist in each particular case, a velocity corresponding with the minimum net cost.

(To be Continued.)

On the Results of Trials of Varieties of Iron Permanent Way. By
Mr. F. Fox, M. Inst. C. E.

From Newton's London Journal, March, 1861.

The author stated, that he did not wish to be thought an advocate for the superiority of either of the systems tried over other plans, or of iron over timber for permanent way, under any and all circumstances; his object being merely to record results of actual trials, and the conclusions to which they led.

In 1853, an experimental length of a quarter of a mile (double line) of iron way, on the principle of Mr. I. J. Macdonnell (M. Inst. C. E.,) was laid on the Bristol and Exeter Railway. It consisted of a continuous rolled iron rail bearer, weighing, on an average, $83\frac{1}{2}$ lbs. per lineal yard, and 11 inches in width. The bearers were united by joint or saddle plates 30 inches in length, weighing $50\frac{1}{2}$ lbs. each. The bearers had a rise in the centre of $\frac{9}{16}$ ths of an inch, and a rib or tongue was rolled on the upper side, which fitted approximately into the hollow of the bridge rail. The rails originally laid weighed only $53\frac{3}{4}$ lbs. per yard. Between the rail and the bearer, a thin packing of pine wood was placed, the grain being in the direction of the length of the rail. The rails, the bearers, and the joint plates, were bolted together, the distances between the intermediate bolts being so arranged as to admit of a rail being readily turned by unscrewing the nuts, or of a new rail being put in, without "opening out" the ballast. Transoms, or cross ties of angle iron were placed at average intervals of 12 feet between the two rails, and 24 feet between the two lines. This system differed from the Barlow way, in having the rail or wearing surface separate and easily removable from the bearing surface; but, on the other hand, it considerably exceeded the Barlow rail in weight. After a wear of more than seven years, this length of iron way was in good condition, and bid fair to continue so for some time to come. About one-third of the rails proved defective within the first two years and had been replaced by rails weighing 60 lbs. to the yard. The ballast, which was very indifferent, being a loamy gravel, had been well drained, and thicker packing, laid with the grain transversely to the direction

of the rail, had been introduced. The bearers and joint plates, transoms, and rails, were supplied at £7 per ton delivered, and the cost per single mile of this arrangement, exclusive of the cost of matching and laying, was £1936. The cost of a single mile of the longitudinal timber way, at the same period, taking the rails at the same weight and price, was estimated at £1850. It should be mentioned that iron was then low in price, whilst timber was high. Owing to the undue lightness of the rail, both of these calculations were below the cost of a well constructed permanent way.

As this experiment appeared on the whole to have been successful, it was determined to extend the trial, by laying one mile of double line, on this system, at a further distance from a station, so that all trains should pass over it at full speed. Some modifications were, however, made. The width of the bearer was increased to 12 inches, and its thickness was reduced to $\frac{9}{16}$ ths of an inch, so that its weight was 75 lbs. per lineal yard. At the same time the curvature was slightly increased. The pine packing (creosoted) was thicker, and at the rail joints pieces of hard wood, laid with grain lengthwise, were substituted. The rails weighed 68 lbs. per yard. The contract for the bearers, joint plates, and transoms was taken at £9 10s. per ton, —the cost of rails being £9 8s. 8d. per ton. This length was laid in July, 1857, where the line had not long before been re-ballasted with hard clinker ballast. The cost of a single mile, exclusive of laying, amounted to £2511. One mile of timber way, laid with the same section of rail at the same time, cost about £2254.

As these trials appeared to give a reasonable expectation of the greater durability and diminished cost of maintenance of the iron way, the author felt justified in recommending a further trial, on a more extended scale, and on different districts of the railway. As the rolling and straightening of the curved section of bearer was alleged to be difficult, it was decided to adopt a flat section. The bearing surface was increased to 13 inches, the centre rib was rolled $\frac{1}{2}$ an inch deeper, and the weight was thus brought up to 84 lbs. per yard. Rail joint plates of a similar section to the bearer joint plates were bolted underneath the bearer at every rail joint. Although this addition had been found advantageous, the way was still weaker at the rail joints than at any other part. Additional intermediate bolts were used, so that the upper and lower sections of the way were held together as a girder. The contract for the bearers, joints, and transoms, was taken at £9 12s. per ton, and the rails, being £8 13s. 1d. per ton, the cost per single mile was £2571.

In order to test the comparative strength of the different sections of bearer, of rail and bearer combined as laid, and of the rail and bearer joints with and without joint plates, a series of experiments were made, the results of which were given in tabular form. The distance between the points of support was 5 feet. Of the three sections of bearer only, that of 1853 (the first) showed the least, and the flat section of 1859 the greatest, deflection, under a load of about 5 tons; but in each case the ultimate strength did not exceed 7 tons. Of the three

sections of iron way complete, that of 1853 was the weakest, and the curved section of 1857, with a rail weighing 68 lbs. per yard, rather the strongest. The ultimate strength was reached under loads varying from 19 to 21 tons. An experiment with the flat bearer showed, as was expected, the increased stiffness gained by placing the centre rib downwards, thus practically deepening the girder. The ultimate strength of the timber way was ascertained to be $28\frac{1}{2}$ tons, or 50 per cent. higher than the iron way. It was, therefore, determined still further to increase the section of the iron bearer. In this case the width of the bearer was 12 inches, and it was stiffened by a web underneath, 3 inches deep and $\frac{3}{4}$ of an inch thick (a plan which was claimed by Mr. W. Bridges Adams). The weight was reduced to 76 lbs. per yard, and the contract for this section was taken at £9 per ton. To stiffen the rail joints (which had no plates underneath), and to secure the ends of the rails, an iron plate, having a tongue rolled on it, was used. This section of way has been laid too short a time to warrant any decided expression of opinion of it, as compared with the other sections; but as a length of between 4 and 5 single miles was under trial, it would soon be seen if it possessed any advantages. It was perceptibly stiffer to travel over, and the middle web gave it a firmer hold in the ballast than either of the other sections. The cost of a single mile was £2385. This section was the fourth modification of rolled iron bearer under trial, the entire length being $14\frac{1}{2}$ single miles.

The partial failure of the Macdonnell way on the Bridport railway was then referred to; and it was asserted that it arose from the rails and bearers being too weak, and from a disregard of those appliances which the character of the gradients, curves, ballast, and subsoil rendered more than ordinarily necessary.

In May, 1858, a trial length, of a single half mile, of the cast iron sleeper way of Mr. De Bergue, was laid in immediate continuation of the Macdonnell way, and on the same kind of clinker ballast. Whilst still preferring a continuous rolled iron to any cast iron way, the author felt bound to state that not a single sleeper had been broken, the nuts of the bolts did not work loose, the rails wore very well, and with the exception of a little depression at the fished rail joints, the line kept as good a "top" as could be desired, and was as easily maintained, but it was more rigid. The cost of this arrangement per single mile was £2103, or £300 per mile less than the Macdonnell way of the same period.

The merits and defects of the continuous rolled iron permanent way were thus stated. The defects, or supposed defects, appeared to be:—
 1. The great cost, at present prices, almost precluding its adoption on a railway of limited capital. 2. The difficulty of getting the bearers rolled. 3. The possible increased wear of the rails. 4. The greater "wash" of all but very good ballast, inseparable from all iron ways, resting on or near the surface. And, 5. The difficulty of laying on sharp curves, and of keeping in place when laid. Its presumed merits were:—1. Greater economy in the long run, owing to increased dura-

bility. It was estimated that the cost of renewal of the longitudinal timber way was £45, and of the iron way only £21, per single mile per annum, or less than half, without reckoning the considerable item of labor in the replacement of the timbers. 2. Saving in maintenance, and facility for packing, owing to no "opening out" being required. 3. The safety of the iron way, especially as contrasted with a timber way which had been long laid. 4. The facility of exchanging worn rails. 5. The preservation of correct gauge. 6. The lowness of the crown of the rail above the bearing surface. 7. Saving in the depth of ballast in the case of a new line. And, 8. The equableness of the motion, rendering it probable that less injury would be sustained by the rolling stock.—*Proc. Inst. Civ. Eng.*

MECHANICS, PHYSICS, AND CHEMISTRY.

Translated for the Journal of the Franklin Institute.

Action of Light upon a Mixture of Perchloride of Iron and Tartaric Acid: Application to Photographic Printing. Note of M. POITEVIN.—*Academie des Sciences* (Paris), 21 January, 1861.

A long time since I observed that the salts of the peroxide of iron are reduced to the salts of the protoxide by light, in presence of certain organic substances, such as alcohol, ether, &c. As I was seeking to apply this property to photographic printing, I looked for reducing substances which were not volatile. The salts of the sesquioxide of uranium, which are themselves reduced by light, in presence of organic bodies (such as paper), react upon the per-salts of iron, by means of the protoxide of uranium which is at first formed. Acetate of ammonia, alloxanthine, glycerine, and especially tartaric acid, also furnished very distinct reactions which could be used in photography. Although this reduction is common to all the per-salts of iron, and even to the peroxide, which I also experimented upon, I confine myself to the use of a mixture of the perchloride of iron and tartaric acid, and shall speak of these substances only.

The partial formation of sesquigallate of iron on paper or other substances, for producing photographic pictures on them, is based upon the reduction of the sesquichloride of iron to protochloride, which takes place only at the points submitted to the action of the light.

The application of powdered charcoal or other coloring matters, and vitrifiable bodies, depend on another property, which, I believe, I was the first to observe: it is, that the perchloride of iron and tartaric acid dissolved in certain proportions and applied to a given surface, dried either spontaneously or artificially in the dark, give a uniform coat of a non-crystalline compound which is not hygroscopic, and remains thus so long as it is kept from the light; but which becomes deliquescent in the sun or in diffused light. I shewed, in the parts influenced by the light, the presence of the protochloride of iron which is deliquescent, and of a body of acid reaction which is very greedy of water, and which must have been formed by the reaction of chlorine upon tartaric acid; it is particularly this latter product which plays the most im-