of these curves, received its spiral action from a nut fixed in the centre of a revolving disc, which communicated motion to a screw, carbonic paper being used for obtaining an impression of the path of the disc.

March 11, 1851.

WILLIAM CUBITT, President, in the Chair.

No. 846.—“Description of the Mode of Working an Incline of 1 in 27½, on the Oldham Branch of the Lancashire and Yorkshire Railway.”¹ By Captain JOHN MILLIGAN LAWS, R.N., Assoc. Inst. C.E.

THE mode of working this incline, by a combination of locomotive power and gravity, has been attended with the most perfect success, and what was at first considered a formidable physical difficulty, has been overcome by a simple and inexpensive contrivance.

The branch of the original Manchester and Leeds Railway, upon which the incline is situated, diverges from the main line, about five miles and a-half from Manchester; it was projected by the late Mr. George Stephenson, and constructed under the superintendence of Mr. Thomas L. Gooch, (M. Inst. C.E.) It was originally proposed to work the incline by a horizontal wheel, rope, and pulleys, with a locomotive engine at each end of the rope, so that one train might descend the incline, while the other ascended it. Before the line was opened, however, it occurred to the Author, that such a mode of working, if not altogether inapplicable, from the many contingencies which must arise, in consequence of the trains in different directions having to depend upon meeting one another at this spot, would still be very expensive in locomotive power, and that a balance weight might, with great advantage, be substituted for the descending locomotive, particularly as there was a working coal-pit at the head of the incline, which might be put in connection with it, and render, what would otherwise have been an objectionable cost, a positive source of revenue. To obviate any deficiency in the supply of coal waggons at the required time, and to make the running of the trains perfectly independent of any such contingency, a number of ballast waggons were filled with sand, which, with a heavy break van, together equal in weight to an ordinary train, were kept as a permanent balance; and by appropriating one line for it, and the

¹ The discussion on this Paper was continued over portions of two evenings, but an abstract of the whole is given consecutively.

other for the traffic, every purpose has been completely answered. The length of the single line is only one mile and a quarter, and as there is an electric telegraph, little, or no inconvenience has arisen, particularly as it is found, that an ordinary train may descend the incline, with perfect safety, at a speed of from five miles to thirty miles per hour, with no other retarding force than that of the locomotive and ordinary breaks; so that in the event of a goods, or passenger train passing, when the balance is at the head of the incline, ready to assist an ascending train, there is no necessity to await its arrival. It is necessary to mention this fact, because a prevailing idea existed, that there would be great danger in descending so steep an inclination, and evidence to that effect was given in Parliament on the Bill; but the experience of seven years' daily practice has proved this opinion to be erroneous, although almost every contingency which could be suggested, has occurred. The rope has broken several times, yet no difficulty was experienced in checking the speed, and stopping the trains:—the balance weight has been permitted, by carelessness, to run down by itself, without break, or breaksmen, without any train being attached on the ascending line;—yet all that happened was injury to the balance waggon, and the tearing of the pulleys on the up-line, by the hook at the end of the rope catching them. This accident occurred soon after the line was opened, when everything was imperfect, and there was no self-acting scotch at the head of the incline to secure the balance. Frequently, during the year, trains pass up and down at intervals of only a quarter of an hour, and carry as many as six hundred, or seven hundred passengers in each train. There is also a considerable goods traffic on the ascending line and coal traffic on the descending line; arrangements existing by which they can be worked perfectly independent of each other, if it be considered desirable. It is found to be more convenient for the sidings and station, as well as more generally economical, to work the coal traffic on the descending line behind the break waggons, and detach it at the foot of the incline; thence it is worked, in the ordinary manner, by locomotive power. The ordinary passenger trains ascend and descend the incline at speeds varying from twenty miles to twenty-five miles per hour, the mode being to stop at the foot of the incline to attach the rope, then to back the engine, so as to draw the weight of the balance train off the scotch at the top; when the steam is put on, and the balance descends, the train of course ascends, the power of the locomotive regulating the speed, and as perfectly controlling it, as if on an easy gradient. On the arrival of the carriages at the top the rope is unhooked, and the train proceeds onwards by means of the engine power as usual.

Several circumstances which have been noticed in the working of this incline seem to show, that gravity and impetus, in combination with locomotive power, have not received all the attention, in the construction of railways, which they merit. By experiments made on this incline of 1 in $27\frac{1}{2}$, to test the power of the locomotive, it has been found, that an ordinary coupled engine, with wheels 4 feet 6 inches in diameter, cylinders 14 inches in diameter, and length of stroke of 18 inches, could just pass the curve, with a carriage weighing 4 tons, the tender with water weighing $2\frac{1}{2}$ tons, and 18 cwt. of coke, (making a total weight of engine, tender, water, coke and carriage, of $26\frac{1}{2}$ tons): whereas the same engine, coming on the foot of the incline with a load of 36 tons, in addition to that of the engine and tender, at a speed of 40 miles per hour, would ascend 500 yards, at an average speed of 23 miles per hour, and rapidly come to a stand after passing that distance. These facts lead the Author to believe, that the natural undulations of the country may be followed more closely than has been usual, and that considerable expense in works, and claims for damage to property may be avoided, by deviating to a greater extent from a uniform gradient, in certain positions, such as passing canals, rivers, roads, and streets.

This Branch Line has afforded, during seven years' constant work, an opportunity of testing the merits of R. S. Newall and Co.'s wire rope, which has been in use throughout that period. Each rope, which is more than $1\frac{1}{2}$ mile long and $3\frac{1}{2}$ inches in circumference, weighs 126 cwt., and costs £316, lasts, on an average, two years and four months. The difference of wear of the two lines of rails appears to have been extremely small, as the difference of weight does not, in any instance, exceed 5 oz. per yard, whilst the average loss of weight in seven years amounts to near 2 lbs. per yard, but this is due more to atmospheric action, than to any other cause. The rails weighed, originally, 56 lbs. per yard, and they are rather more than one-third worn: on the train line they are crushed, or laminated, to some extent, by the weight of the engine, whilst on the balance line this is scarcely perceptible.

Captain LAWS said, that his primary object, in presenting this Paper, was the fulfilment of the engagement he had entered into on his election; and his second was, to draw the attention of Engineers, generally, to this important question, in order that the best mode of working inclined planes might be ascertained, and the situations to which they were applicable might be determined.