Mr. Joseph Samuda must be permitted to say, that he thought the author of the paper had scarcely entered fairly into the examination of the system, as the statement was made up entirely of the demerits of the plan, without giving it credit for the success, which had already attended its first establishment. Several of the objections were made, evidently without a knowledge of how the apparent difficulties in the application, were proposed to be overcome, or were actually avoided. He would instance only a few points, and leave to others, better qualified than he was, the task of refuting the charge of impossibility.

It was not proposed to use any other than the engines of the main line, for working the sidings, which could be laid in, without at all interfering with the continuity of the main line. Level crossings were quite as practicable as on locomotive lines. There was even an additional security, as by a simple contrivance, consisting of a cylinder and piston connected with the main pipe, the platform, which, when down, formed the protection of the valve, under the crossing, could be raised when the vacuum was being formed, and thus, not only became a signal that a train was about to pass, but also formed a barrier, for preventing anything from traversing at an inopportune moment.

He could not understand the necessity for bringing two trains together, as had been assumed; but if that did occur, a little extra power might be used in that particular instance, in the same way as in an emergency, another locomotive would be added to the ordinary train engine.

As respected the liability to be thrown off the rails by impediments, he must contend, that the position assumed was not supported by facts. On the Dalkey line, there were curves of 130 yards radius, which were constantly traversed at a speed of 35 miles per hour; yet no accident had occurred. It was well known, that locomotive engines were not in the habit of traversing curves of that radius, at such a speed.

He could not agree with the statement of the comparative cost of the two systems. He thought, that the author had underrated the actual cost of locomotive haulage; while he had overrated, not only the cost of that by the atmospheric system, but also the amount of power employed; for instance, with a gross load of 75 tons, not more than two-thirds of the actual power of the engine were employed, as was shown by the indicator diagrams.

In the statement of the cost of construction, Mr. Samuda's experience was equally at variance with the assertions of the author.

As regarded the probable expense of the maintenance of the way, on new atmospheric railways; it must be remembered, that the

Dalkey line was quite new, but it had worked through the winter without any stoppage, either from subsidence, or from slips, and it was kept in order with as little difficulty as the part which was worked by locomotive engines.

It should not be assumed, that the system was not susceptible of modification, to accommodate itself to any amount of traffic. Mr. Samuda must, on the contrary, assert, that any economical arrangements which were practicable with the locomotive system, might be adopted with the atmospheric plan. For instance; if it was found desirable to have trains at long intervals, the obvious plan would be, to substitute, for a powerful engine, a small power, to pump water into a reservoir, which, during the time necessary for forming the vacuum, should exert a considerable power upon a water-wheel. The system was capable of being economically adapted to almost any locality, where there was sufficient traffic to warrant the formation of a railway.

Mr. P. W. Barlow stated, that his object in presenting the paper to the Institution, was not to attack the atmospheric system, but simply to suggest, for the consideration of the members, certain objections with reference to it, which appeared to him proper subjects for discussion.

As to the sidings, he did not contend that it was impossible to apply them, in a mechanical point of view; but that they would lead to great inconvenience, and be inconsistent with practice. It could only be done, (unless the crossing were divided,) by raising the piston above the level of the rails, which would be inconvenient, from want of space under the carriages.

With reference to the comparative advantage of obtaining 10 miles of pipe in one length, it would be desirable in one respect, as permitting a less number of stationary engines, and as saving working expenses; but it would be objectionable, inasmuch as it would increase the loss of time which necessarily occurred, when the trains met on a single line, from the time requisite to exhaust the air out of the pipe to the next station, which would require 20 minutes.

Mr. Pim professed a high respect, not only for the speculative views of the theorist, but also for the examination of the practical man, but he thought the theory of subjects like the present, should not be examined, until after careful observation of the actual practical working of the system, as it was notorious how the results of the soundest theory were modified by a slight alteration in the practical condition of the machine, or system. It was to be regretted, that the author had not made himself better acquainted with the results obtained on the Dalkey line, where any information he required, would have been readily afforded to him. He would then

have seen, that several of his objections did not, in fact, exist. It would suffice to mention a very few.

The leading carriage being tied down to the line, by its connexion with the piston, was sufficient of itself to prevent any tendency to run off the rails, even on the sharpest curves. On one occasion, owing to the carelessness of an attendant, the leading carriage, with the piston, became detached from the train, and travelled up to Dalkey in perfect safety, at a velocity of nearly 70 miles per hour.

There were many omissions in the paper, which savoured somewhat of a strong bias against the atmospheric system. The degree of speed which could be attained, with such safety, was not noticed. There was not a word as to avoiding the chance of collision, when it was notorious, that a collision was utterly and physically impossible. In stating that the dimensions of the tunnels were regulated by the height of the pile of goods on the luggage trains, it did not appear to have struck the author, that it was possible to reduce that height, and, at the same time, to carry as great a load in a more advantageous form. Mr. Pim was of opinion, that the introduction of the atmospheric principle would produce an entire change in railway traffic, as it would be found, that frequent and light trains were more advantageous, both to the railway Company and to the public, than heavy trains at long intervals. The public would very soon have an opportunity of judging practically as to the merits of the system, and his confidence in its advantages was not at all shaken by the statements he had heard in the paper. On the contrary, he had much more confidence in the results, which he felt assured would be attained, by the skill of the two able engineers who were then constructing lines on the atmospheric system.

Mr. P. W. Barlow said, the practical results of the working on the Dalkey line showed, that the tractive power of the stationary engine, as applied by the atmospheric pipe, was about equal to that of an ordinary goods engine used on railways; or the same amount of work could be performed in the same time by one of those engines, and that the consumption of fuel, during the actual motion of the train, was at least equal to that used by the locomotive, which was 40 lbs. per mile; consequently, with the loss from obtaining the vacuum, and constantly keeping up the steam of the stationary engine, no economy in working could be obtained, under any circumstances, unless greater perfection were obtained in the application of the atmospheric principle; and it was doubtful if the Dalkey line, with its advantageous incline and numerous trains, could not be more economically worked by locomotive engines.

Mr. C. H. Gregory said, that without wishing to depreciate Mr.

Barlow's interesting paper, there were some points in it, not noticed by previous speakers, which he would submit, required correction. Mr. Barlow had stated, that in the comparison he had instituted, the atmospheric engine had consumed 40 lbs. of fuel per mile, and that an equal weight was consumed by a locomotive goods engine, under similar circumstances; but it did not appear that any allowance had been made, by him, for the difference in cost, between coal used in the atmospheric and coke in the locomotive system. He thought too, that a comparison between the two systems, ought to include a notice of the great difference between the wear and tear of locomotive and stationary engines, which would be much in favour of the latter. The comparison had been made between the working of the two systems at a slow speed, which he believed was not so favourable to the atmospheric system, where a greater speed would show comparatively greater economy, while it was well known, that high velocities induced a great loss of power in locomotive engines. In illustration of this fact, he alluded to some indications which had been taken by M. Gouin, a French engineer, in the cylinders of locomotive engines at different velocities. In these it was shown, that when the engines were running at slow speed, nearly the whole pressure of the steam had been effective in the cylinders; while, at high speeds, the indications showed a loss in the cylinders alone, amounting to about 50 per cent. of the pressure. This result was in addition to all the acknowledged mechanical defects of locomotive engines at high velocities.

Mr. P. W. Barlow explained, that he did not contend that high velocities could not be obtained on short lines, or between stations; but on long lines, when the trains met, each train must wait, until the air was exhausted out of the next length of pipe, which would reduce the speed, in practice, to 20 miles per hour.

Mr. I. K. Brunel did not appear either as a supporter of the atmospheric system, or as wishing to condemn it; but he thought it due to the inventors, that those who were about to use it should not be entirely silent. The paper appeared to him, rather a list of objections to the plan, than an examination of its comparative value as a method of propulsion; and he must say, that these objections did not seem to be supported by calculation, or by argument. Mr. Brunel was quite prepared to admit, that there were many situations to which the system, in its present state, was inapplicable; but, as a practical man, he clearly perceived the manner of remedying many of the alleged defects; and, without that feeling, he should have had considerable hesitation in recommending its adoption. He thought, also, that many of the presumed deficiencies did not really exist; for instance, upon the atmospheric line, now being established in Devonshire,

there would be numerous stations, in which he anticipated doing all the station work, with as much facility as with locomotives, and even more conveniently.

He did not anticipate any difficulty in transmitting special trains and expresses, but, on the contrary, he believed that the impossibility of collision would induce peculiar facility in that respect.

He thought, that instead of the stoppages reducing the average speed below that of locomotives, say to 20 miles per hour, double that speed would be certainly attained.

He could not agree, that because the system had hitherto only been practised on a short line, it was inapplicable to long lines; calculations proved the reverse, and it would be only just to await the result of the practical working of the lines, now in course of execution.

He was of opinion, that by the use of large boilers, fixed on the most approved plan, by husbanding the power, working the steam expansively, and using the present known improvements in stationary engines, the system would prove as economical, as it was free from danger.

Mr. Cubitt, *V. P.*, thought, that any assertions as to the capabilities or powers of the system, were, in its present state, very inconclusive, and scarcely fair, and the best manner of confuting the positions of the paper was to have a line at work, which would, he hoped, be accomplished without much delay. He must, however, be permitted to say, that the mechanical difficulties of the level crossings, sidings, &c., were met by simple mechanical means. The real questions were the first outlay, and the cost of working, and they could only be decided by actual experience.

Mr. John Scott Russell was neither a prejudiced adversary, nor a headlong advocate, of the atmospheric system. He agreed in the opinion already expressed, that any discussion on points which were soon to be submitted to the test of experience, was of comparatively small value. One important service, however, had been already rendered by the discussion, in having elicited the statements of two eminent engineers, who were then engaged in carrying out the practical application of the atmospheric principle on a large scale. They had stated, that all those difficulties, which had been mentioned in the paper, had been foreseen by them, and had been conquered. This fact was important, for it was most desirable, that any opposition to the atmospheric system should be based on right grounds, and not upon mere prejudice. The paper had pointed out, with much ingenuity, the minor practical difficulties in the way of the execution and the use of the atmospheric railway; but these he did not at all regard as objections to the system, but merely as the statement of pro-

blems, of which the ingenuity of the promoters, in constructing the works, had to invent the solution. Now he thought it only fair to say, that seeing the atmospheric system in the hands of such mechanics as Mr. Cubitt and Mr. Brunel, he had no hesitation in expressing his conviction, that they must have seen their way clearly to sound practical solutions, for all their mechanical difficulties, or they never would have risked their reputation on the construction of such lines. Although he was himself much inferior to them as a mechanic, he could see his way clearly, to the solution of many of the difficulties stated in the ingenious paper of Mr. Barlow, and he had such faith in the powers of invention of the engineers of this country, and in the mechanical skill and powers of execution of the workmen, that he had no doubt if the atmospheric system was sound at heart, and in its principle, all these minor evils would disappear.

On the faith, therefore, of the talent of these engineers, he would give the system credit for all that their skill could devise, and he had no doubt they would overcome the mechanical difficulties of practical execution. But there remained the great question of the value of the system, as a general system of traction, applicable on all railways, and capable of superseding the locomotive engine. It was on this general ground, that the question must be decided, and here the result, he thought, was perfectly clear. The atmospheric system was merely one among many modifications of stationary power. As such, while it possessed the advantages, it must encounter all the evils of the stationary system, and on this broad ground, that the stationary system was neither so economical, nor so convenient, as the locomotive system, he rejected the proposition of the inventors, who wished to substitute stationary atmospheric, for locomotive engine power, generally, on railroads. But in justice to the system, and to those who had adopted it, he ought to say, that he had no doubt, that in cases where stationary power was desirable, there were circumstances which might render the atmospheric system peculiarly appropriate. Selecting, for instance, a line where there were many or sharp curves, or many inclines of variable and steep gradients, and where also the trains were numerous, uniform in magnitude and number; such a case was most favourable to stationary power, and to the atmospheric system especially. He thought it would have been wiser, if the inventors of the system had brought it forward as an expedient of this kind, suited to these circumstances, rather than as a revolutionary system, proposing to displace locomotives on all the great railways of the country. In that case, they would have received the support of many, who now could not accord with their views. In that modified application he would be happy to see it successful, and

he thought the wiser promoters of the system were of his opinion, for it was in peculiar circumstances, of the nature he had indicated, that they were about to introduce it. He should be glad to learn from those engineers who were about to introduce the system, whether they would assure him, that in the application of the system, there was no loss incurred in the use of the air as the means of applying the power. He conceived there must be a mechanical loss of power, in the process of first rarifying the air and afterwards condensing it.

Mr. PIM said, that it was not for him to enter into an analysis of the theory of the atmospheric system, but his belief in its correctness was in a great degree confirmed by the investigation of Dr. Robinson of Armagh, who had arrived at diametrically opposite results from Mr. Russell.

He could, however, judge of the practical results; and when comparing the actual speed and cost of propulsion on the Dublin and Kingstown railway, with that of the Kingstown and Dalkey line, the result was decidedly in favour of the latter; on the former, with locomotive engines, $\frac{3}{4}$ mile with a rise of 13 feet, was traversed in 4 minutes; while on the latter, with the atmospheric system, 1 mile with a rise of $71\frac{1}{3}$ feet and several sharp curves, was passed over in a little more than 3 minutes: the consumption of steam in the Dalkey engine was, at the same time, much less than in a locomotive.

Mr. CUBITT, *V.P.*, thought, that it was not incumbent on the advocates of the system to show, that it was perfect as a mechanical power. It sufficed to show, that it was superior to fixed engines and ropes, which had been attempted to be substituted for locomotives, not only on account of their cost of steam and fuel whilst travelling, but also because of their excessive wear and tear.

If, as had been asserted by a great railway authority, the power required to move the engine and tender, equalled that requisite for drawing fifteen passenger carriages, which was more than an average train, it would follow, that it would cost more to move the engine and tender, than the average of all the passenger trains. If therefore the traffic could be conveyed by the atmospheric system at a less expense, a great point would be gained.

Mr. J. SCOTT RUSSELL gathered from what Mr. Pim had said, that it appeared from Dr. Robinson's calculations, that the power expended and the power usefully applied, were theoretically precisely equal. Mr. Russell had not arrived at the same conclusion, and he would desire to ascertain, whether the engineers intending to use the system and who had doubtless examined the subject carefully, agreed with Dr. Robinson's view, or entertained a more modified opinion of it.

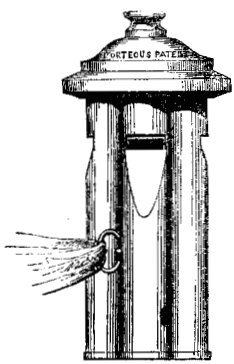
Mr. J. SAMUDA could not admit Mr. Russell's view of the loss of

power. He contended, on the contrary, that the power primarily expended in forming the vacuum, was returned during the passage of the train. When the air-pumps were working at 15 inches of mercury, with a pressure of $4\frac{1}{2}$ lbs. per square inch on the piston of the steam cylinder, a power was attained in the pipe, equal to $7\frac{1}{2}$ lbs. per square inch upon the travelling piston.

Mr. I. K. BRUNEL contended also, that a loss of power to the extent that had been stated, could not be proved, when a certain amount of work was performed, with the expenditure of a certain power. He would admit, that some loss might arise from the absorption of heat, during the process of rarefying the air in the main, but he could not concur in the position assumed by Mr. Russell.

PORTEOUS' SIGNAL WHISTLE FOR RAILWAYS.

Mr. PORTEOUS exhibited an instrument introduced by him for the purpose of giving signals on railways, and for other purposes.



The instrument consists of three, or more, metallic tubular whistles, combined under one mouth-piece, and having their tones so arranged, that by the introduction of one discordant note, an extremely shrill vibrating sound is produced, which strikes forcibly on the ear, and can be heard at a great distance. Its peculiar discordance, enables it to be readily distinguished from any ordinary whistle, however powerful, and from any common sound. Its tone somewhat resembles that of the steam whistle used on locomotive engines, and on that account it is found very useful for persons employed on railways.

They have been made of all sizes, and are adapted not only for railway purposes, but for park and gamekeepers,* the police, and for any position where a prompt signal is required.

They appeared, from the testimony of several members, to have been generally approved upon the railways where they had been introduced.

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* Messrs. Swaine and Isaac, 185, Piccadilly, who are the sole wholesale agents, have adapted them generally for sporting purposes, for which they have the patronage of H.R.H. Prince Albert.