"A New Principle in Mechanical Locomotion"

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The article begins:

> "Owing to the immense variety of our stone deposits, and their wide distribution, it is generally found that it does not pay to work a quarry unless it is close to railroad transportation. A large proportion of our quarries have switches running from the main track of a railroad directly to the pit whence the stone is taken, so that the output can be loaded directly into the cars with the minimum of handling and expense. Occasionally it is found, however, that certain quarries will pay for operation when there are few facilities for transportation. There may be anywhere from one to ten miles that the stone has to be hauled before a shipping point is reached. This cuts very deep into the margin of profit. One granite quarry in the South that occurs to mind gets out a high grade of monumental stock. This has to be hauled six miles to a railroad, and formerly mule teams were used for the purpose. The company has recently installed a traction engine with excellent results…."

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A NEW PRINCIPLE IN MECHANICAL LOCOMOTION.

OWING to the immense variety of our stone deposits, and their wide distribution, it is generally found that it does not pay to work a quarry unless it is close to railroad transportation. A large proportion of our quarries have switches running from the main track of a railroad directly to the pit whence the stone is taken, so that the output can be loaded directly into the cars with the minimum of handling and expense. Occasionally it is found, however, that certain quarries will pay for operation when there are few facilities for transportation. There may be anywhere from one to ten miles that the stone has to be hauled before a shipping point is reached. This cuts very deep into the margin of profit. One granite quarry in the South that occurs to mind gets out a high grade of monumental stock. This has to be hauled six miles to a railroad, and formerly mule teams were used for the purpose. The company has recently installed a traction engine with excellent results. By means of this appliance two trips a day can be made, conveying 15 tons at a time. With the present demand for the stone, the construction of a railroad of this length would be utterly out of the question, and yet the quarry is operating with good profits under existing conditions.

With long hauls by teams or traction engines the question of good roads becomes a vital matter. As a rule, where the railroads are few in number the turnpikes are poor, and often have to be kept in repair by the quarry owners. Sometimes this introduces a most vexing complication. Towns and boroughs are often short sighted, and they may almost kill an industry by taxation. One quarry that has been prosperous for years is now almost forced out of existence by the narrow-minded and bigoted local officials. They have kept piling up the road taxes against the quarry until in some years they have reached as much as $600. All efforts to have permanent hard roads constructed have been futile, although the quarry owners offered a site for a crusher, and to donate to the town all the stone that would be needed for

road building. In England traction engines are widely used by quarries, brick yards and similar industries. There the roads are good, and there is no difficulty in handling large loads. But there is one drawback. Constant disputes arise between the local authorities and the users of traction engines as to the damage to roads by what is known as "extraordinary traffic."

In the effort to do away with these suits for damages for road injury and to provide an engine that would have greater traction over ordinary roads, there has been perfected an appliance known as the Pedrail. This is a traction engine that has, instead of the ordinary wheel with corrugated or spiked tire, a succession of what may be termed huge feet attached by flexible joints to the periphery of the wheel. An account of this new engine, which is claimed to be a revolution in mechanical locomotion, was given in a paper by Prof. H. S. Hele-Shaw, F. R. S., recently read at Liverpool. Prof. Hele-Shaw began by a consideration of various methods of animal locomotion, and then said: "If we attempt to translate an animal mechanism into a mechanical device, it is easy to imitate the general princple of action by having a number of spokes radiating from the centre upon whch the weight is carried. To make this movement mechanical and continuous, the simplest method is to carry the spokes round in a circle. Suppose we increase the number of spokes indefinitely, we get a circular disc, and substitute for a jerky and irregular movement the continuous motion of a rolling wheel.

"This simple explanation indicates the relation (from a mechanical point of view) between the action of walking and the rolllng of a wheel, and it enables us to appreciate the relative advantages and disadvantages of both methods of locomotion. With the wheel, the whole surface to be moved over becomes in turn a point of support, and unless the surface is both hard and smooth, the resistance which the wheel experiences is always appreciable and may be very considerable. The wheel can only act without appreciable resistance when it makes contact with the smallest possible amount of surface. When it moves on soft ground, the motion is not one of true rolling at all, but an amount of slipping takes place which bears a definite ratio to the depth of the rut left by the wheel, and may in extreme cases be so great as to render it impossible for the wheel to turn at all.

"When obstacles are met with the wheel strikes against them, and unless the obstacles themselves are crushed the wheel—if its rim is hard—must rise bodily over them. It is the fact that it can pass over the small obstacles on the road surface, without being bodily deflected, that has largely contributed to the successful action of that marvellous invention, the pneumatic tire.

"We will dismiss the consideration of the pneumatic tire with the remark that it must still be regarded as a luxury, and, indeed, an expensive luxury, for any but the lightest load, such as the bicycle or very light vehicles, and that all attempts to use it, or any modification of it for carrying heavy loads—or even moderate loads economically—have hitherto been an absolute and complete failure, and I doubt if the most sanguine believer in the pneumatic tire has any hope that it is the solution of the problem of dealing with the transport of merchandise.

"The wheel is, indeed, only working under efficient conditions when its

periphery is hard and it rolls upon a hard smooth surface. It is this fact which has led during the last century from small beginnings of wooden ways, "staith" ways (as they were called), and metal plate ways, up to the present development of the railway systems of the world, and the modern growth of the tramway system, of which the last ten years have seen so remarkable an extension.

"The wheel on the road has an enormously greater resistance than the wheel on the rail, and, taking the average resistance given by various authorities, it may be said that on railways the resistance is, roughly, from 8 to 10 lb. per ton, while on the ordinary turnpike road the resistance varies from 50 to 500 lb. per ton.

"This extraordinary difference in traction makes us pause to consider why it is that railways are not universally employed, and may suggest the question, 'Will not tramways, in spite of their inferiority to the railway, having a resistance of from 30 to 35 lb. per ton, become universal instead of roads?' And the answer is at once obvious. On the rail, the movement is absolutely limited to what may be called one dimension of space, that is, the direction or path in which the rail is laid; and the same may be said of the tramcar. On the road the vehicle has not merely the surface of the road itself, but can, if necessary, proceed in any direction where there are no obstacles; such, for instance, as over the surface of a field. A cart on wheels has not, it is true, the possibilities of locomotion which an animal on legs has of traversing every portion of the earth's surface, even of scaling the most precipitous mountain, and moving over the roughest and most uneven surface, as illustrated by the rocky moraine of a glacier or the broken hummocks of an arctic ice field, but an ordinary vehicle has a range of movement which is utterly beyond the possibility of any railway or tramway system. Hence it is that with the development of railways and tramways, and the marvellously increased powers of mechanical locomotion which have come with the railway system, the demand for improved means of road locomotion and of facilities for locomotion from mines and for agricultural purposes has become determined and persistent during the last few years, and an immense amount of mechanical skill and ingenuity—not to say immense sums of money—have been spent to develop our roadways, and have been devoted to the invention and construction of improved mechanical appliances for travelling upon them.

"An intimate and close study of road locomotion and the properties of the wheel for many years has convinced me (as it has doubtless convinced many others) that the wheel itself has reached its utmost limits of carrying power, both in regard to weight and speed, upon the ordinary roads, however well the roads may be constructed or however perfectly the wheel may be made. I say this with the absolute conviction that the wheel will always play a most important part in road as well as in railway locomotion, and while I do not venture to say it is impossible, I cannot picture the possibility of any contrivance taking the place of the wheel and the pneumatic tire in circumstances where the road surface is good and the conditions suitable.

"I ask you to consider for a moment in what way the wheel falls hopelessly short of mechanical action of an animal's foot. In the first place it must never

be forgotten that the animal does not turn upon its foot. The foot is placed upon the ground, but the turning takes place upon that beautiful structure, the ankle. This structure is exquisitely suited to its work, being flexible and having a ball and socket joint perfectly lubricated so as to afford the very minimum of resistance. This enables the foot to be placed upon the ground and kept there, so as to ensure the minimum of rubbing action with the surface; whereas, as we have seen, the wheel is only adapted to turn on the surface of the ground itself.

"Secondly, whereas the wheel can never be put down upon an obstacle, but strikes it sideways in such a way as to cause bodily resistance of the movement, the foot can be brought down upon an obstacle and the body elevated over it gradually with the least possible amount of shock.

"Now, these advantages of animal mechanisms are so apparent that a large number of walking machines have been invented. These walking machines, however, have hitherto failed from a want of the due appreciation of the complex nature of the problem, and because they have not combined satisfactorily the adapting of the movement of an animal—which is intermittent—with the continuous movement afforded by the properties of the wheel, and the answer to the question which I have asked must be given emphatically in the negative.

"The Pedrail indicates by its name that it is a rail carried upon feet, and the principle of its action may be explained in a few words. It is simply this: Instead of having a permanent rail carried for the whole of its length on permanent feet, viz., sleepers, and wheels running upon this rail, the process is inverted. The feet are (as in the case of the railway) placed upon the ground, but instead of the rails being carried upon the feet, these feet support wheels, and the wheels thus supported act as bearers for a short length of rail attached to the moving carriage.

"The fundamental idea itself is not a new one. You may see in many timber yards that the logs are moved about by being pushed over supports which carry wheels, and by shifting these supports from place to place, the heaviest logs of timber can be rolled upon the wheels to any required part of the yard. The Pedrail invention, however, does more than this. The feet and wheels which they support are attached to the moving carriage itself, so that by an automatic process the feet are carried round after the rail is moved over them, and placed again in front of the machine, thus affording a continuous track of wheels upon which the supporting rails can be carried in any direction in which the vehicle is steered.

"Briefly, the invention might be described as replacing the wheels of an ordinary traction engine by revolving frames, carrying sliding spokes, each spoke having at its end a circular foot, and on the spoke itself, at a little distance above the foot, a small wheel or roller. In connection with each series of revolving spokes a fixed frame is attached to the side of the traction engine. This fixed frame somewhat resembles in form an inverted heart. When the axles revolve, the spokes are carried round and place in turn upon the ground the feet. At the same time the wheels which run round in contact with the heart-shaped frame, when brought underneath it (that is, under what may be described as the broader portion of the heart), act in turn as sup-

ports for the heart-shaped frame to glide over. Hence, the engine is itself supported in turn through the wheels by the spokes which happen at the time to be resting with their feet upon the ground.

"The Pedrail consists of two main parts, one of which is a railway, which is fastened to the axle box and does not revolve, and the other part is a kind of circular box carrying sliding spokes, rollers, and feet, in such a manner that the rollers and feet are placed in succession on the ground, and the rail runs over them.

"The foot itself is a marvel of ingenuity, since this foot must have all the flexibility of the human ankle; but more than this, when the vehicle is being turned the attachment to the foot must have freedom in every direction to slide about within it. This is effected by a sliding box combined with a ball-and-socket joint. We now come to the means provided for walking over obstacles, and here we find that the heart-shaped frame is itself a structure capable of oscillating, so as to enable the vehicle to positively walk over obstacles which would absolutely block the path of any wheeled vehicle.

"The action of the Pedrail on the road is very remarkable. Whereas the ordinary traction engines destroy roads to such an extent that they have been forbidden in many parts of this country, and also in various parts of the world, and heavy motor wagons and traction engines have been severely taxed by local authorities, and made to contribute to the repair of the roads, the Pedrail positively improves the road over which it walks. This has been proved by actual experiment, and it is more than probable, from the remarks of an eminent municipal engineer, that the Pedrail is destined to entirely replace the road roller for repairing roads, as the action of stamping or ramming is much better than rolling for this purpose."