

on a bank of fog, and even on the bubbles of a small brook. Professor Necker describes another beautiful phenomenon, the explanation of which must be referred to the same principle; "If the Sun is rising behind a hill covered with trees and brush-wood, a spectator just within the verge of the shadow of the hill will see all the little branches thrown into relief against the sky, not, however, dark and opaque, but glowing with a white brilliancy like silver, even to the depth of several feet below the summit of the hill."

When the suspended aqueous vapour is condensed and descends in the form of rain, it gives rise to the splendid and familiar spectacle of the rainbow. This consists in general of two circular and concentric arcs, separated by a dark interval of about  $8^\circ$  breadth, the outer one being much the fainter of the two, and each exhibiting the prismatic colours, in the inner the violet being on the inside while in the outer the order of colour is reversed. The first person to point out the origin of the bows was Antonius de Dominis, Archbishop of Spalatro, in 1611, A. D.; his explanation was appropriated by DesCartes, but as the true theory of colours was not at that time known, it was left for Newton to give a full account of the phenomenon. It was by him shewn, beyond doubt, that the inner or primary bow is formed by the Sun's rays which reach the spectator's eye at emergence from the rain-drops under the angle of least deviation after one internal reflexion, and in like manner the outer or secondary bow by these emerging after two internal reflexions. So also a tertiary bow would be formed after three such reflexions, surrounding the Sun with an angular radius of  $40^\circ 21'$ , but the light is so much diminished at each successive reflexion as to be too faint to make any impression on the retina, and this bow has consequently never been seen.\* In some instances a coloured arch has been seen between the two bows, and not concentric with them, arising undoubtedly from the reflexion of the lower part of the primary bow which falls below the horizon at the surface of a river or lake. Sometimes, also within the primary and outside the secondary, are seen successive coloured bands, being of a reddish-purple in contact with the violet of the bows, then green, purple, and so on in the order of Newton's rings. Young shewed that these resulted from the interference of rays which undergo the same deviation at angles of incidence a little less and greater than that which furnishes the ray of least deviation. Lastly, Mr. Airy, having observed that the greatest intensity of illumination does not occur exactly in the place indicated by the geometrical construction, has investigated the whole subject as a problem of interferences on the undulatory hypothesis, and his results have been fully verified by the experiments and measurements of Professor Miller, so that the theory of the Rainbow may now be said to be complete.

Similar appearances ought to be produced when the Moon is the illuminating body, but her light is so much fainter than that of the Sun as to render the occurrence even of a primary bow very rare; so far as I am aware, the secondary and supernumerary bows have never been seen.

*To be continued.*

**Railway Accidents; their Cause and Means of Prevention; detailing particularly the various contrivances which are in use, and have been proposed; with the Regulations of some of the principal Lines, by Capt. M. Huish.**

*(Read before the Institution of Civil Engineers.)*

The author first considered those points connected with the road, and the machinery employed upon it, from which loss of

\* This is contrary to the statement of Dr. Lloyd, who says that tertiary rainbows have been observed; he however refers to no particular instance, and I certainly have never heard of one. M. Babinet, an acute observer, was unable under the most favorable circumstances to perceive the faintest trace of one.

life and injury to person and property most generally arose. With regard to the road, or permanent way, from which fewer accidents occurred than from any other cause, its complete effectiveness was the basis of all safety in railway travelling; and for keeping it up, constant vigilance was necessary, especially when any great and sudden change of weather took place, as then the weak points were sure to show themselves. It was a very rare occurrence for trains to run off the line; and when they did so, it was more generally due to obstructions designedly placed on the line than to any neglect of the superintendents or the platelayers. With respect to the rolling stock, it appeared from a return of one thousand cases of engine failures and defects within two years on the London and North-Western Railway, that burst and leaky tubes nearly doubled any other class of failure; and that these, with broken springs and broken valves, amounted to one-third of the whole number; and though they caused no direct danger to the public, yet as producing a temporary or permanent inability of the engine to carry on its train, they might be the remote cause of collision. These and other circumstances had led many persons to suggest various contrivances for communicating between the passengers, the guard, and the engine-driver, almost all of which were identical in principle, consisting of a connecting wire or rope. This plan had been tried and failed. A more feasible and favourite one was that recommended by the Railway Commissioners, which was to continue the foot-boards, so as to form a narrow platform from end to end of the train, but a committee of railway officials had subsequently expressed their unanimous condemnation of the measure. The plan now adopted on the London and North-Western Railway, was, for the guard's van, at the end of the train, to project about a foot beyond the other carriages, so that the guard looking through a window in this projection might notice the waving of a hand or a handkerchief; this was, of course, useless at night. All these causes, however, did not produce a tithe of the accidents which resulted from a want of attention to signals and a neglect of regulations, which of all sources of danger were the most prolific. The Electric Telegraph had greatly facilitated working under variable circumstances, and so beneficial had its effects been, that during the year 1851, out of 7,900,000 passengers, or nearly one-third of the population of England, who had travelled over the London and North-Western Railway, only *one* individual had met with his death (from which casualty the author also suffered) and this was the effect of the gravest disobedience of orders. In the six months during which the Exhibition was open, 775,000 persons were conveyed by excursion trains alone, in 24,000 extra carriages, all centering in a single focus, arriving at irregular hours and in almost unlimited numbers, from more than thirty railways, without the most trifling casualty, or even interruption to the ordinary extensive business of that line. The author thought undue importance had been attached to the question of irregularity in the times of the trains, as an essential element of safety, for with perfect signals and a well disciplined staff no amount of irregularity should lead to danger; but, on the contrary, it should, to a certain extent, by its very uncertainty, induce increased vigilance, and therefore greater safety. Accidents very rarely happened from foreseen circumstances, but generally from a simultaneous conjunction of several causes, and each of these was provided for as it arose. The statistics of railways, and the periodical publication of the Government returns, drew public attention very pointedly to the aggregate of accidents; but it was believed that if due regard was had to comparative results, if the accidents to steamers, or in mines, to omnibus passengers, or even to pedestrians, were as carefully recorded, that then, whether as regarded the ease and celerity of transit, or the facility of conveying numbers, the railway system, even in its present state, would be found to be incomparably safer than any other system in the previous or present history of locomotion.