consequence, year follows year, and the very sensible recommendation is unheeded. It is estimated by a naval officer who has given a great deal of attention to this subject that the actual annual loss to the merchant marine of the United States from striking upon these unmarked obstructions is equal to at least ten per cent of the losses from all other causes combined. The cost of building and maintaining the necessary vessel to remove these obstructions would be more than saved in the first year by the prevention of losses to coasting-vessels and transatlantic steamers which are jeopardized by the failure of the government to do its duty in this respect.

EXPLOSIONS IN COAL-MINES.

'A REPORT by W. N. and J. B. Atkinson, inspectors of coal-mines for the north of England,' recently published, is a very valuable contribution to our knowledge of an intensely practical subject, viz., the causes of explosions in coal-mines; and it is simply wonderful, considering how much this question has been investigated during the last hundred years, that some of the most important facts should not have been correctly apprehended or fully appreciated until this late day.

The nature of one cause of explosions, fire-damp or coal-gas, was demonstrated long ago, and guarded against by the invention of the safety-lamp. But that there must be some other cause at least equally potent has long been evident to thoughtful minds, from the fact, that, where the safety-lamp is in general use, explosions are still distressingly frequent and fatal. Thus official statistics for the years 1850 to 1885 show, in the United Kingdom alone, an annual average of fifty-six fatal explosions, the annual loss of life for the same period averaging two hundred and thirty-seven.

The report of the Messrs. Atkinson shows that the dust in coal-mines is now the chief explosive substance, the explosions usually resembling those in the large flouring-mills of Minnesota. This is not a hasty or foregone conclusion on the part of the authors, but it has a broad basis of experience gained by the direct and careful investigation of many important explosions. The discussion is able and thoroughly scientific, for not only is every statement abundantly fortified with facts, but it is made very clear in every case that no other view is tenable.

In all the collieries of the north of England the coal-seams lie at a considerable depth below the surface, with which they are connected by at least two shafts, — a *downcast* for the admission of fresh air, and an *upcast* for the escape of the foul air from the workings. The circulation is usually maintained by a furnace at the bottom of the upcast shaft. The fresh air passes from the downcast by straight roads, from which lateral escape or leakage is prevented, to the working faces, and thence returns by other roads and through the abandoned parts of the colliery, where the coal has been removed and the roof allowed to fall in, to the upcast. The intake airways are usually the oldest parts of the workings, and are also the main avenues for hauling out the coal and for the ingress and egress of men and horses; while the return airways are rarely used for any other purpose than the passage of the foul air.

Fire-damp or light carburetted hydrogen exists in all the coal of this district, and issues constantly from the freshly exposed surfaces in the working places; but the ventilation is usually so efficient, that the gas cannot be detected even along the return airways, and it is very rarely observed on the main intake roads traversed by large volumes of fresh air, their surfaces having long exhausted themselves of gas. Naked lights are often used in the outer portions of the intake roads, and locked safety-lamps, as a rule, in all other parts of the colliery. Observations are cited which show, that, while one volume of fire-damp to fifteen volumes of air is required to make an explosive mixture, in the first half-mile of the intake roads the proportion cannot exceed one volume of fire-damp in fifteen hundred volumes of air. And yet it is exactly in this part of the colliery that the explosions are most frequent and violent.

The coal is largely of a tender or dusty nature; and, although the shafts are usually wet, the working planes are, for the most part, quite dry, and the air especially, although moistened by its passage down the wet shaft, becomes very dry through the rise of temperature due to the fact that the temperature of the ground increases downwards.

The return airways, where the fire-damp is most abundant, are usually quite free from dust, and at the working faces the dust is not often a serious evil. But the principal accumulations of dust are found along the roads through which the coal is hauled, i.e., the intake airways. It is especially abundant where the coal is hauled by engine-power, or at a high rate of speed. The dust is shaken and blown out of the cars by their rapid motion against strong currents of air, and flies as a cloud along the top of the train. The heavier particles fall to the bottom of the roadway, and the lighter particles form a deposit on the upper parts as well as on the floor. This fine dust is not only found on horizontal surfaces, but it exhibits the property of sticking to timber, stone, and coal, something like soot hanging in a chimney, being sometimes from one to two inches thick on vertical and overhanging surfaces. In dusty mines it is often necessary to remove the dust on the floor of the roadway to prevent the tracks from becoming blocked; but the upper dust is not interfered with. Only one pound of dust to one hundred and sixty cubic feet of air is necessary in order to form an inflammable mixture, and this proportion is often largely exceeded on dusty roads.

Coal-dust in mines is often referred to as constantly present in the air. This is not so, except to a limited extent. The velocity of the air is rarely sufficient to carry dust any considerable distance. When dust is largely present in the air, it is due to some disturbing cause other than the ordinary movement of the air. The rapid passage of cars against the air-current raises a cloud of dust from them; the passage of men and horses stirs up the bottom dust; the hewer at the working face raises about him a thin cloud of dust; the concussion of a blast, or wave of air caused by a heavy fall of stone, fills the air with dust; but in the absence of some such cause the dust is quiescent, and after its disturbance by any cause it soon settles down again. The fine, soot-like, upper dust is, however, extremely inflammable, even when not disturbed; and after explosions the greatest amount of violence is observed on those roads likely, before the explosion, to contain the most of this kind of dust. After explosions, the dust thrown into the air and ignited is found to be very generally coked.

Not only has there been heretofore a general misconception as to the nature of the explosive substance, but also as to the actual cause of death of the victims. This may occur from *flame, force of the explosion, falls of stone and timber, suffocation by dust, or after-damp;* but the evidence goes to show that the immediate cause of death, in almost all cases, is after-damp, i.e., the gases resulting from the explosion. After-damp produced by the explosion of ordinary fire-damp consists of carbonic-acid gas, nitrogen, and water vapor; and death results from slow suffocation, due mainly to the exhaustion of the oxygen in the air.

But the after-damp from explosions of coal-dust is much more rapidly fatal, and evidently contains some more poisonous constituent. Analysis shows that this is carbonic oxide. Miners frequently work without serious inconvenience in air containing so much carbonic acid as almost to extinguish their lights; but a proportion of carbonic oxide so small as to have no appreciable effect on his light will cause the death of the miner in a few moments, sometimes almost instantly, his light continuing to burn after his death until the oil is exhausted. It has repeatedly happened that miners who were outside of the roads traversed by an explosion, and uninjured by the explosion itself, have been cut off by the after-damp, and have perished in trying to force their way through it to the shaft. In fact, the most serious features of dust-explosions are, that, unlike gas explosions, they occur absolutely without any warning, and mainly near the shafts, thus preventing escape from any part of the mine.

Of six typical explosions occurring in the north of England in the years 1880 to 1885, five occurred in Durham, in dry dusty mines, and were undoubtedly dust-explosions. The total loss of life was three hundred and thirty, or an average of sixty-six for each explosion. The sixth explosion occurred in the Whitehaven colliery, which extends three miles under the sea, and is wet, and free from dust. This was clearly and purely an explosion of fire-damp, and the most extensive of its kind within the experience of the Messrs. Atkinson, and yet only four lives were lost. This mine was not only free from dust, but the explosion was limited to the most remote, deepest, and most poorly ventilated portion of it.

The following conclusions are warranted by the study of these explosions: all the explosions were limited to one plane or level of the colliery, in no case ascending or descending vertically so as to continue the explosion on another plane. The single gas explosion was remote from the shafts, and so cut off from communication with higher or lower workings; while all the dust-explosions extended to or even crossed the downcast shafts, but could not follow the shafts up or down because they are wet and free from dust; and, in general, the flame and violence of the dust-explosions were confined to those roads on which there was much coal-dust, their intensity varied with the amount of dust, and they were often arrested at places where the roads were wet or damp. In no case were the return airways, where gas is always most abundant, seriously affected; and the intake airways also escaped where not used for handling coal. Since the dust is naturally heavy and quiescent, it can only be ignited when some disturbance throws a cloud of it into the air in the presence of a flame. One of the dust-explosions was probably initiated by a small explosion of fire-damp; but all the others were simultaneous with the firing of shots of gunpowder in stone; and it is concluded that the concussion of the shots threw the dust into the air, and the flame of the shots ignited it. Gunpowder is in daily use in the collieries, but usually on the working face, where there is insufficient dust to start an explosion. In every case but one, however, the shots causing the explosions were fired where the miners were enlarging the main roadway, and where the dust had been quietly accumulating for years. The fresh air passing these points at the times of the explosions varied from twenty-three thousand to sixty-one thousand cubic feet per minute, so that any accumulation of fire-damp was impossible. Dust in the air may be ignited by an open light, but not by a safety-lamp. One of the curious features of the dust-explosions is, that they exhibit but little force or violence near the point of origin, but seem to require a distance of from fifty to one hundred yards in which to gain headway. Once initiated, the explosion is self-propagating, and rapidly increases in violence; the normal condition, after an explosion is fairly established, being (1) a wave of air preceding the explosion and filling the air in the roads with coal-dust, (2) flame following instantly into compressed air charged with dust.

Various popular ideas about explosions, such as that they 'face the wind' or travel against the fresh air, favor the coal-dust theory.

Under the head of remedial measures, the authors of the report note that watering the roadways, which has been practised for many years as a mere matter of convenience, is of little avail as a means of preventing explosions, since the upper dust in every instance is left undisturbed. Gunpowder should not be used in dusty places without first thoroughly dampening the dust. The accumulation of dust in the roads may be diminished by reducing the velocity of the air, which can be done by enlarging or doubling the roads; by reducing the speed of the coal-cars; or by wetting or covering the loaded cars. Extensive dust-explosions could be prevented by keeping occasional sections of the roads thoroughly wet.

Since the dryness of the mines is due mainly to their high temperatures, a large volume of air entering at 40°, and raised in its course to 70°, exercising an enormous drying power, the following more drastic remedy is also suggested: to raise the air entering the mine to the temperature of the mine, and saturate it with moisture. It could then exercise no drying power, and the natural moisture of the mine would come into play, changing dry mines to damp mines. The principal objections to this plan are the expense, and the greater discomfort to the miners of working in warm, moist air.

A more recent contribution in the Proceedings of the Yorkshire geologic and polytechnic society, for 1886, recognizes the great importance of coal-dust in colliery explosions, and shows, that, contrary to the generally accepted theory, important explosions are much more likely to occur when the barometer is high than when it is low. The explanation is, that, while a high or rising barometer tends to prevent the escape of gas from the coal, it is also usually accompanied by a dry atmosphere, which renders the coal-dust lighter and more inflammable.

ELECTRIC RAILROADS IN THIS COUNTRY.

AN interesting article on electric railroads in the United States, by T. C. Martin, appeared in a recent issue of the *Railroad gazette*. The progress already made in the application of electric energy as a motive power for street-railroads, as reviewed in Mr. Martin's article, cannot fail to be encouraging to all engaged in the development and exploitation of inventions in that particular field of industry. Nor is it without interest to scientific men and the public generally. One electric road in Baltimore, equipped by the Daft company, has been in successful and profitable operation about two years. A road in Los Angeles, Cal., built by the same company, has been running several months, and is soon to be extended to nearly double its present length. This company is also constructing and equipping electric railroads in Pittsburgh, Penn., and Orange, N.J., and will construct others at Mansfield, O., and Ithaca, N.Y.

The Van Depoele company of Chicago is able to show a good record in the matter of electric-railroad construction. Roads using its system of electric propulsion are running at Port Huron and Detroit, Mich.; Appleton, Wis.; Windsor, Ont.; Scranton, Penn.; and Montgomery, Ala.; which last-named city has eleven miles of road in operation. This company is now constructing roads at Lima, O., and Binghamton, N.Y.

In Denver, Col., there is an electric road, constructed on what is known as the Short-Nesmith system, in which the current conductor runs in an underground tube, contact being effected through a five-eighths inch slot between the rails. This road crosses eight horse-car tracks, five steam-car tracks, and a two-hundred-foot bridge.

A three-mile road in Detroit uses the Fisher system of equipment, and a short line in Pittsburgh is being equipped on the same system. A nine-mile section of road in San Diego, Cal., intended for high speed, will be constructed by a company which has just completed a double-track road in Kansas City. These two are overhead conductor roads. A Philadelphia company, which