IV. The curves again disappear at about the same time; but to judge from the time of greatest steadiness before the disturbance commenced at Nicolaiew, it appears to have reached Strassburg first. The last small increase at 14·87h. and 14·95h. is, on the contrary, earlier at Nicolaiew than at Strassburg, but this might be an independent disturbance. After the strongest motion, the light-point resumes its steadiness much sooner at Strassburg than at Nicolaiew.

It is evident that the case is, on the whole, not favourable to an hypothesis which first occurred to me, that all four disturbances might have been caused by four successive waves emanating from a single centre and a single shock, and circulating round the earth. The fact that II. and IV. are more considerable than I. and III. does not appear of much importance, for it is proved by many examples that the intensity of a disturbance is not alone dependent from the distance from the centre; but, if the hypothesis were right, disturbances III. and IV. ought probably to be much smaller. Besides, the velocity of about 100 km. per minute would be a very small value compared to those determined on other occasions.

I reject this hypothesis, but I do not think it improbable that I. and II., III. and IV. may be connected in the way just mentioned, and that both disturbances came from the same part of the world. It is the principal object of this communication to induce persons interested in the subject to study carefully the records of all self-registering instruments. If the disturbance originated at the bottom of the sea, something about it might be found in the ship journals, the tidal records might show a trace, or perhaps the magnetical records at distant places. I have many proofs that the size of a disturbance, traced by the horizontal pendulum, is not always a measure for the importance of the catastrophe which produced it; but in the present case many instances indicate an extraordinary phenomenon, of which an account is likely to appear sooner or later, in case it should have taken place at some remote corner of the earth.

Merseburg, May 18.

P.S.—Some time after having written the above, I received the third volume of the *Seismological Journal of Japan* (1894), in which there is an interesting paper by F. Omori on the eruption of Azuma-san in 1893. From this paper it appears that the volcano was in an active state since May 19, when an explosion took place, which was followed by two other ones on June 4, 4.10 a.m., and on June 7, of which the former is said to have been the strongest. It was accompanied by an earthquake, which was felt at the meteorological station of Fukushima. Supposing the above time to be Standard Time (9h. east of Greenwich), the explosion took place at 7h. 10m. p.m. G.M.T. on June 3, and thus it is seen that it coincides with a part of our great disturbance. I do not, however, believe that this is more than a casual coincidence, for the two other eruptions produced no disturbances. It is also a well-known fact that volcanic eruptions, even when accompanied by earthquakes, are generally not felt to any great distance, unless they bear a very violent character, like the eruption of Krakatoa; but from Mr. Omori's description it appears that the eruption of Azuma-san was nothing very extraordinary. I therefore believe that we must wait to find another explanation for our disturbance.

E. VON REBEUR-PASCHWITZ.

EXPLOSIONS IN MINES.

IN a lecture on some modern developments in explosives, given at the Society of Arts on December 17, Prof. Vivian B. Lewes threw out a suggestion as to the cause of explosions in dusty mines free from fire-damp, which explains the anomalies which have presented themselves in several recent explosions.

It was pointed out that until quite recently explosions in mines were always attributed to the accidental ignition of mixtures of air and methane, to which the name of "fire-damp" is given, and undoubtedly this cause is the prime factor in this class of disaster, and the introduction of such precautions as safety-lamps at once brought about a considerable reduction in the number of explosions taking place. Many disasters, however, still continued to occur under apparently mysterious circumstances, the conditions being such that any large proportion of methane in the air of the mine appeared practically impossible, but investigations of such explosions showed that coal-dust in a dry and finely powdered condition had generally been present in the mine at the time of the explosion, and the coked residue of this dust was found afterwards on the surface exposed to the explosive wave, and years of experimental investigation by scientific men of the greatest ability proved the fact that air containing so small a proportion of methane as to be itself perfectly non-explosive, becomes a good explosive again when holding dry and finely divided coal-dust in suspension, and within the last few years explosions having taken place in mines, which have always been celebrated for their freedom from any trace of methane. Further experiments have been made by Mr. H. Hall and Mr. W. Galloway, who have shown that the violent ignition of dust-laden air is possible by a blown-out shot, even if free from any trace of marsh gas, and there is evidence to show that the explosion is developed in throbs or waves.

It is therefore found that the explosions in mines may be brought about, first, by the ignition of a mixture of methane and air, in which the former rises above a certain percentage; secondly, by mixtures of air, coal-dust, and methane, in which the amount of the latter may be excessively small; lastly, by mixtures of coal-dust and air. With regard to these explosions caused by coal-dust and air alone, the Royal Commission on Explosions from Coal-Dust in Mines, in their second report, published this year, say:—

"On a general review of the evidence on this point, we have no hesitation in expressing our opinion that a blown-out shot may, under certain conditions, set up a most dangerous explosion in a mine, even where fire-damp is not present at all, or only in infinitesimal quantities; and while we are prepared to admit that the danger of a coal-dust explosion varies greatly according to the composition of the dust, we are unable to say that any mine is safe in this respect, or that its owners can properly be absolved from taking reasonable precautions against a possible explosion from this cause. But even if we had been able to come to a different conclusion, and to agree with the minority of the witnesses examined, who think that coal-dust alone cannot originate an explosion, we should still have to call attention to the serious danger which results from the action of coal-dust in carrying on and extending an explosion which may originally have been set up by the ignition of fire-damp."

One of the most interesting and instructive explosions which have taken place recently was that which occurred a little more than a year ago at the Camerton Collieries, Somersetshire, in which as far as investigation could go, no trace of combustible gas could be found in the mine at any period prior to the explosion or subsequent to it, and in which everything pointed to the explosion being entirely due to the presence of dry coal-dust in the air.

Of absorbing interest, also, are the experiments made by Mr. Hall at the latter end of 1892 and the early part of 1893, and reported upon by him to the Secretary of State on January 23, 1893, in which he shows by conclusive experiments that dry coal-dust under conditions frequently present in coal mines and in the entire absence of fire-damp, may be inflamed by a blow-out gunpowder shot, and cause a disastrous colliery explosion.

The evidence which can be collected from the investigation in the Camerton disaster, and from Mr. Hall's experiments, point to a cause for such explosions, which has apparently been overlooked, and which Prof. Lewes thought worthy of the gravest attention. Both at the Camerton Colliery and in Mr. Hall's experiments, powder was the blasting agent used, and such powder as is employed for this purpose, gives amongst the products of combustion nearly half the volume of permanent gases in the condition of carbon monoxide, methane, and hydrogen.

In the Camerton explosion, it seems probable that about $1\frac{1}{4}$ lbs. of such powder were used in the shot which caused the disaster, and this quantity of powder would give, roughly, a little over three feet of inflammable gas, which when mixed with pure air would give over 10 cubic feet of an explosive or, at any rate, rapidly burning mixture, and experiments which have been made upon the effect of fire-damp and dust combined in causing colliery explosions show conclusively that even when the fire-damp is present in such minute quantities as to form a mixture very far removed from the point of explosion, it still makes the mixture of coal-dust and air highly explosive; and from experiments which Prof. Lewes has made, it is clear that traces of carbon monoxide will do exactly the same thing when the air is laden with coal-dust, whilst the temperature of ignition is slightly lower than with methane, so that in the case of the Camerton Colliery, it being perfectly well ascertained that the air was charged with coal-dust, the probabilities are that not 10 feet, but a far larger volume of explosive mixture was formed by the rapid escape of the products of combustion into the coal-laden air; and this being ignited, either by the flame or red hot solid products driven out into it by the blown-out shot, would initiate a considerable area of explosion.

The classical researches of Prof. H. Dixon have shown that hydrocarbons and, probably, carbon burn in air to carbon monoxide, and that this carbon monoxide will not form explosive mixtures with air, or even with oxygen, if they are absolutely dry; but if water vapour is present, they explode owing to the oxidation of the carbon monoxide to dioxide, causing the propagation of an explosive wave, which reaches its maximum velocity when the percentage of water vapour, between 5 and 6 per cent., and inasmuch as the air of the mines would always contain some moisture, and as the products of combustion also would give a large volume of water vapour, these requirements would be amply fulfilled.

Still more conclusive on this point were Mr. Hall's experiments. In these a charge of blasting powder was fired from a cannon suspended in a shaft, the air of which was proved by careful chemical analysis to be absolutely free from any trace of combustible gas.

In order to get some idea of the condition of the air inside the pit during the explosion, samples of air were taken and were analysed. Two brass tubes were fastened to the rope that was used to lower the cannon, one twenty yards from the bottom, the other forty yards from the bottom.

These tubes were so arranged and constructed that the explosion, as it passed the tubes, unsealed the outlet pipe, and the escaping water sucked in a sample of air which was trapped by a special arrangement, and kept in the tube until the rope could be wound up. By this method it was intended that the sample of gas taken should represent that state of the air whilst the flame was passing, or directly afterwards.

The tube nearest the bottom, as the analysis will show, did partly collect the gas in the above condition. The tube at the top, however, commenced to act prematurely, and was probably started by the sound wave which preceded the explosion. This tube simply contained ordinary air.

The following is an analysis of the gases found in the lowest tube:—

	Per cent.
Oxygen ...	3 9
Nitrogen ...	75·9
Carbon dioxide ...	12·1
Carbon monoxide ...	8·1
	100·0

This ingenious arrangement was due to Mr. W. J. Orsman, and it is probably the first successful attempt which has been made to get a sample of gas during the progress of explosion, and there is not the slightest doubt that the presence of such an amount of carbon monoxide converts mixtures of coal-dust and air into a highly explosive body.

As the explosion takes place, and as the carbon monoxide ready produced is oxidised to carbon dioxide by the action upon it of water vapour present, and also by its direct combustion with oxygen, the hydrogen of the water vapour is set free, whilst the heated coal-dust also yields certain inflammable products of distillation to the air, and partial combustion also of the coal-dust gives a considerable proportion of carbon monoxide once more, and these driven rapidly ahead of the explosion form with more coal-dust and air a new explosive zone, and so by waves and throbs the explosion is carried through the dust-laden galleries of the mine.

The experiments made by Mr. Hall, and investigations in various colliery explosions, make it abundantly manifest that no explosive should be licensed for use in mines unless it can be absolutely proved that it gives off no imflammable products of combustion. The following table will show the results given by some of the explosives most largely used, which point very clearly to the fact that, with the exception of the Sprengel explosives, such as roburite and nitroglycerine, none of the bodies in use conform to this important requirement.

Products of Combustion of Blasting Explosives.

Powder.	Carbon dioxide.	Combustibles.	
		Carbon monoxide.	Hydrogen and marsh gas.
Gunpowder ...	50·6	10·5	3·1
Blasting power ...	32·1	33·7	7·9
Sprengel explosives—			
Roburite ...	32·0	nil	nil
Ammonite ...	33·0	nil	nil
Nitroglycerine explosives—			
Nitroglycerine ...	63·0	nil	nil
Gelignite ...	25·0	7·0	nil
Carbonite ...	19·0	15·0	26·0
Blasting gelatine ...	36·5	32·3	8·6

Whilst not only these considerations, but Mr. Hall's experiments, point to the absolute necessity of legislative enactments at once forbidding the use of blasting powder in any coal mines, no matter how free they may appear to be from fire-damp or from dust, if the returns made as to deaths caused by gunpowder and other explosives in mines for the year 1893 are examined, it will be clearly seen that the exclusion of gunpowder, in handling alone, would do away with 80 per cent. of the accidents. So that if explosives of the Sprengel class were employed, accidents due to the explosives used would be practically eliminated from the mining death roll; and it is only a question of time as to when England will foll w the action of France and Germany in altogether prohibiting the use of blasting power in dusty mines.

THE POSSIBILITIES OF LONG-RANGE WEATHER FORECASTS.[1]

IF we had perfect command of this subject, we should be able to trace the motion of a particle of aqueous vapour from point to point over the whole earth, and could predict whether at any time in the future it will fall as rain, or rise and fly away as an invisible gas. In the absence of this higher knowledge the only long-range forecasts that we are at present able to make are based upon empirical and very imperfect rules deduced from our study of the accumulated climatological statistics. Of course, such predictions do not imply any special knowledge of meteorology. Among the methods adopted in long-range forecasts are the following:

(*a*) The average rainfall, temperature, &c., for any period, such as a month, and deduced from many years of observation. is called the normal. The excess or deficiency of this month in any given year is called the departure for that year. A general prediction may be made to the effect that the rainfall for a given month and place may be expected to lie within the range of the values indicated by these known departures.

(*b*) The series of annual or monthly values just mentioned gives us the means of finding out whether there is any simple sequence or connection between them and the apparently unconnected values that occur from year to year. Thus, it sometimes happens that rainy seasons come after two or three dry seasons, or that after the same month has been dry in three successive years, one is then justified in predicting a wet month. Thus, Governor Rawson elaborated a system for the prediction of rain and the sugar crop in Barbados.

(*c*) Slight but appreciable widespread, rather regular fluctuations of temperature, pressure, and rain have been revealed in the climate of Europe by Dr. Brückner, who finds that a deficient temperature and an excess of rain have alternated with excess of temperature and deficiency of rain in periods of thirty-six or thirty-seven years during the past two or three centuries; the glaciers increase and diminish in volume, or advance and retreat, in correspondingly regular but somewhat retarded intervals. Predictions may be based on these well-established periods.

(*d*) Droughts are sometimes due to what happens in distant regions: thus, if there is a heavy snow on the Himalayas during the winter, there is a special liability to drought in lower India in the following summer, so that the prediction of a drought may be based upon the reports of snow-fall in a distant region several months before the drought occurs; but other droughts may occur without this preliminary snow-fall. This connection

[1] Reprint of an article contributed by Prof. Cleveland Abbe to the U.S. *Monthly Weather Review*.