accumulated heat, causing a combustible to unite with oxygen so actively as to produce ignition. This initial temperature of combustion was, in most cases, reached very gradually; but, in order that it should be reached at all, it was necessary that air, or oxygen, should penetrate into the mass of the material, and that this should not be able to travel through it at any great speed, but should remain for a definite time in contact with the combustible material, in order that the heat generated should not be carried away by radiation or conduction; because it was evident that, if the heat were carried away as rapidly as it was generated by the union of the oxygen with the combustible, it could not be raised to the initial temperature necessary for ignition because the heat would be decreasing rather than increasing. Mr. Vincent had stated that some people seemed to hold the view that, when coal was damp, it was necessary that the water should be decomposed in order for it to take fire; but that point did not arise at all. When bodies were moist, oxidation went on more rapidly, and therefore wet coal or other combustible material, such as hay, would unite with oxygen more rapidly than when dry. There were two ways in which evidently spontaneous combustion might be prevented; one was by totally excluding the supporter of combustion, *i.e.*, air or oxygen, and the other was to so thoroughly ventilate the combustible material that all the heat produced should be carried away as rapidly as it was formed, and thus the initial temperature at which ignition took place could never be reached. These two methods were very carefully gone into by the Royal Commission, which he believed came to the conclusion that it was better to exclude the air altogether than to attempt to ventilate the combustible material, because you could not ventilate it uniformly; and even if you could, you were still liable to the chance that in some particular part heat was being generated, although the other portions might be cool. Spontaneous combustion in coal mines was a point of great importance, and Mr. Gallo-way, who had recently investigated this subject, was inclined to think that certain combustions took place on account of exceedingly fine coal-dust, which was found diffused throughout the atmosphere of the mine, and which acted like a combustible gas. The ignition point of this mixture of fine coal-dust and air was low, and under certain circumstances he thought that spontaneous combustion might occur, and undoubtedly it added very much to the force of an explosion when once set up, because it had been found in certain collieries that the explosion had been carried far outside the limits of the inflammable gas. The same thing had been observed in the case of flour mills, where the flour diffused through the air had been ignited at one point, and had traveled like a flash of flame from one portion of the building to the other.

The Chairman said that the paper which they had heard had not only been instructive, but also valuable, in eliciting a very interesting discussion, and some of the points which had been raised were so intimately connected with the subject, which he, as a member of the Royal Commission, had been investigating, that with Mr. Vincent's permission he would reply to them. In the first place, reference had been made to the state of division of the coal as influencing the tendency to spontaneous combustion, and after what they had learnt as to the effect of fineness of division of substances in promoting their union with oxygen, and the rapidity of that union, and the consequent heat evolved, there was no difficulty in conceiving that if coal were reduced to a comparative fine state, but in such a state that air could have access to a large surface, then you had the conditions favorable to ignition. If coal were very finely divided, indeed, it would pack so closely that air could have little chance of circulating, and the small quantity found in it would very soon have exhausted its action. Any attempt at ventilating coal of that description would have very little effect in promoting a further change, but if coal were reduced to a state not so fine, but still comparatively small, in which the form of the particles favored circulation of air, then if you promoted the continued action of air and the evolution of heat due to that action, you were in fact promoting the tendency to spontaneous ignition, so that there was a limit to the influence which the reduction of coal to a fine state of division might have in promoting this effect. With regard to the action of the water, there were two distinct causes giving rise to the spontaneous ignition of coal. One was the oxidation of certain portions of coal, which consisted of carbon and hydrogen, and not readily acted upon by the atmospheric oxygen, besides which the coal contains, condensed within its pores, certain gases. Then you have the action of pyrites or sulphide of iron—a substance very prone to oxidation especially in a comparatively moist condition. In the case of iron pyrites, the moisture acted as a carrier of oxygen to the sulphur and to the iron, and promoted the rapidity of oxidation when once it had been set up, so that where you had pyritic coal, full of "brasses," as it was termed, you had one, the tendency of which to spontaneous heating would be promoted by wetting. If, on the other hand, the tendency was due to the existence in the coal of certain carbon and hydrogen compounds, probably the wetting would have the opposite effect, because there the action was due to the tendency to absorb and condense oxygen, and if you filled the pores of the material with water they would be so far precluded from absorbing or condensing oxygen; and, therefore, that source of the accumulation of heat would be reduced. The action of water, therefore, might promote the generation of heat or not, according to circumstances. Indeed, a large proportion of the casualties which occurred in coal had been due to the action of pyrites, but there was also very many which could not be traced to that cause, or to its containing that particular kind of pyrites which was specially susceptible of rapid oxidation. Pyrites, although identical in chemical combination, would vary very considerably indeed with regard to its tendency to oxidation. Two samples possessing the same chemical composition, and differing only slightly in mechanical structure, behaved very differently indeed in this respect, so that you could not always assume that because coal was rich in pyrites it was necessarily prone to spontaneous combustion; still the fact remained that there was this tendency in pyritic coal. A curious point came out in the evidence before the Royal Commission, that since the Mines Regulation Act came into operation, which rendered the employment of boys comparatively difficult, coal had become more pyritic, and was shipped in a much dirtier condition with respect to this particular impurity. Boys were largely employed to pick over the coal and pick out the brasses, and when the Act came into force this ceased to a great extent, and the examination of the coal became comparatively imperfect. With regard to ventilation, Mr. Wills had given the true explanation of its useful and mischievous effects. If you so ventilated a cargo as to continually sweep air through it at all points so rapidly as to carry away the heat as fast as it was generated, you would undoubtedly put

a stop to the chance of spontaneous ignition, for this so-called spontaneous ignition was due to the gradual heating up of the material until the point was reached when chemical action was set up very rapidly, and to an extent sufficient to raise the substance to a red heat. But in the case of coal cargoes, it was absolutely impossible so to arrange a ship that air could be uniformly and with certainty drawn through every portion of the cargo. The mere fact of its being more or less broken in different parts would point how difficult it must be, but even supposing it entirely consisted of a uniform mass it would be very difficult to draw air through it so as to keep it completely cool. If, however, this could not be done, no doubt ventilation became mischievous, because then it only supplied additional oxygen instead of allowing that existing in the mass of the coal to become exhausted in its action. Many remarkable instances were produced, with regard to this point, before the Commission. It was at first believed that ventilation was the thing to be aimed at in coal ships, but it soon came out that the majority of casualties arose in ships where attempts had been made to ventilate, and one very remarkable instance was mentioned. Four large ships were laden with coal at Newcastle, all the ships receiving the same kind of coal and at the same time, so that there were the same conditions as to weather, &c., and the ships were exactly of the same burden, from 1,500 to 2,000 tons each. Three of them, which were bound for Aden, were notably lost from spontaneous ignition, whilst the fourth arrived at Bombay and discharged her cargo safely. The only difference was that the three of them were ventilated, whilst the fourth was not ventilated at all. There was one other point, however, with regard to ventilation, which had not been noticed. Mr. Vincent had dealt only with the one subject of spontaneous ignition; but there was another source of accident, namely, that due to the ignition of explosive mixtures of air with the gases which gradually escape from coal, especially if placed on board ship soon after it was brought from the pit. Masses of coal, especially from certain seams, contained within its pores a considerable quantity of inflammable gas—the same mixture, in fact, which constituted the fire damp of coal mines. This gradually escaped—sometimes only to a trifling extent, at other times to a considerable extent—and would gradually diffuse itself through the air in the vicinity of coal cargoes, and thus form an explosive gas mixture which might eventually reach some source of light and become ignited and produce an explosion. Many of the casualties to coal vessels were due to this cause, and ventilation of a particular kind was very valuable in guarding against accidents of this description. If you could keep up a constant current of air over the top of the coal cargo, these explosive gases would be drawn off and carried out of the ship; so that surface ventilation was extremely important in connection with coal cargoes, and should be insisted upon; whereas ventilation through the cargo should not be attempted. In conclusion, he proposed a vote of thanks to Mr. Vincent for his interesting paper.

The resolution was carried unanimously, and the proceedings terminated.

FLASH-SIGNALS.

By D. BRUCE PEEBLES.

THE apparatus consists of an ordinary gas-governor (1)—the one we have here is a dry governor, but it may be either of the wet or dry kind; it is entirely inclosed—and a small controlling governor (2) arranged to throw the pressure of the inlet gas upon the bell or diaphragm of the larger or supply governor, thus opening the valve. A small stream of the inlet gas flows into and out of the diaphragm, or bell chamber, and may be let away through an orifice, either into the main outlet or by a separate outlet-pipe, thus

PEEBLES' ELECTRIC FLASH-SIGNALLING APPARATUS FOR LIGHTHOUSES, RAILWAYS, ETC.

allowing the governor to be easily controlled, and weights being put on or taken off, the small governor opens or closes the valve of the large one.

The small governor (2) is loaded to give a supply of gas just sufficient to keep the burners lighted, or this may be done by means of a by-pass, with regulating stopcock; and a separate weight, sufficient to give a maximum supply of gas, is connected to one end of a lever (3), the other end of which is fitted with an armature (4) in a position to be acted on by a small electro-magnet (5). When the electric circuit is closed, the magnet causes the lever to lower the weight on to the small governor diaphragm and open the valve; but the weight is suspended from the lever by a loose link (6), so that only the pressure of the weight acts upon the governor. When the electric circuit is broken, the lever, having its armature end sufficiently heavy, lifts up the weight from the governor, and closes the valve. We see, therefore, that the small governor acts on the large one, by loading or unloading the bell or diaphragm with pressure instead of weights; and this principle may be modified and carried out in several ways. The electro-magnetic action is got from a small bichromate battery (7), and the small timepiece (8), which makes and breaks contact, is arranged to give six flashes each minute—but any other reasonable number of flashes can be given, if required—while 1,000 lights can be

as easily acted on as the seven we have here. For lighthouse purposes, or wherever a timepiece is employed to work the apparatus, it may be considered preferable to dispense with electricity, and place the lever (3) in a position, so that it may be acted on directly by the clock, and this can readily be done by a simple mechanical arrangement, as a very small amount of power is required to lift the lever and lower the weight on to the small governor. We now put the apparatus in action, and it will be observed that the flashes are given with a precision that leaves nothing to be desired. It will be readily understood that, while the rapidity of the flashes can be greatly increased, the duration of the flash can be prolonged, if necessary. The small current of controlling gas may either flow into the main outlet-pipe, or into a separate pipe, as before stated; but it is advantageous in this case to make the outflow pass through the small orifice by a separate pipe (9), as by increasing or diminishing the size of the orifice the flash may be made sharp or sluggish, as wished, without in any way altering the pressure of the gas supplying the signal-lights.

This method of flash-signals may also be applied to railways, and a train may be made to give a visible signal of its approach at any distance from the station. A powerful gas-light might be placed at any central point which could easily be seen from any part of the station where the train is expected, and it would only be necessary to get the wheels of the engine or carriages at a mile or two miles distant, as the case might be, to touch a spring, make contact, and close the circuit, when the light would at once flash forth at full power, warning those at the station that the train was approaching.

The light could either be allowed to go down after the train had passed the contact spring, or remain as a signal until some of the officials at the station released the catch-pin, thus letting the gas down again to a minimum.

The system might also be used for giving a visible time-signal all over a city, say, at nine o'clock every night, so that in every house in which gas is used, the time could be obtained by noticing the gas-flame, which would be lowered for a second or two at the particular hour agreed upon. This could easily be done by acting on the station-governor at the gas works, and correct time would be insured by using one of Mr. Frederic Ritchie's regulated clocks, a number of which are now in use in Edinburgh and other places.

It seems well adapted also for Professor Jenkins and Sir Wm. Thomson's system of eclipse signalling by the Morse alphabet, the dot and dash being represented by long and short period of darkness.

A method of balloon signalling might also be established wherever a supply of gas could be obtained. The balloon would carry up flexible gas-tubes, and the flame would be protected by a lantern and wind-guard. In such a case, if used for war purposes, a cypher would be fixed on for giving the messages, and the gas might be compressed and transported to any suitable place for giving the signals.

There is yet another purpose it might be applied to. A small apparatus of this sort might be attached to the gas-pipe of any licensed houses whose landlords were suspected of setting Forbes Mackenzie at defiance. It would, in such a case, be set to turn off the gas at eleven o'clock P.M., and put it on again, say at six A.M. The authorities would only have to see that the clock and battery were attended to once a week, and might then rest assured that, so far as gas was concerned, no supply would be had after the legal hour of closing.

Lastly, it could be attached to the station-governor of any gas-works, and adjusted so as to give the day and night pressure at any hours the manager wished, so that, if all of us here who have station-governors had also a controlling apparatus such as this, we might have set it before leaving home to-day, with a certainty that the night pressure would be put on in our absence at the exact hour we arranged the timepiece to make contact.—*Journal of Gas Lighting*,

AERIAL TELEGRAPHY.

AERIAL telegraphy without wires or poles is spoken of as among the possibilities of the future. Professor Loomis claims to have communicated with an assistant twelve miles away by means of an aerial current. The current was reached by flying kites a certain height at each point, the string used being a copper wire. When both kites had attained the same altitudes, in the same current, messages were sent and received at the distance mentioned by an instrument at the ground end of the wire, the only connection being the atmospheric current between the kites.

EVEN in the best qualities of glass, the long continued action of sunlight produces iridescence. When the glass is examined at right angles to the surface, nothing appears to impair the purity of its transparency; but when it is looked at obliquely, minute and regular striæ are easily discovered.

PROF. KOHLRAUSCH has tested the conductivity of alcohol, and he finds that it, in several instances, conducted better than pure water. This is contrary to the general belief that water conducts much better than alcohol. In the books both alcohol and ether have been set down as non-conductors, or as semi-conductors.