prehensive experiment by numerous workers since attention was first drawn, about forty-two years ago, by Faraday and Lyell to the functions exercised by coal-dust in "aggravating and extending the injurious effects of firedamp explosions." The results and conclusions which have been arrived at in this direction, and to which the labours of the Commissioners have contributed, are sufficiently complete and definite to warrant the following authoritative statements: The disastrous effects of firedamp explosions in coal-mines are almost always aggravated and extended by the existence of coal-dust in dry mine-workings and roadways. A gas-explosion in a dry mine, even if only of comparatively trifling nature, will raise and inflame coal-dust existing at the seat of the explosion or in the vicinity: the flame attending the explosion will be thereby increased and carried to more or less considerable distances, and may thus become communicated to any accumulations of explosive gas-mixture which may exist in goaves or other lurking-places at a distance from the seat of the original gas-explosion. The employment of an insufficient quantity of an explosive in a shot-hole of a strength which is in excess of the power applied, or neglect of sufficient tamping, will produce a blown-out shot—that is, an almost complete projection of the highly-heated products of explosion, and of a body of flame from the mouth of the hole as from a gun. And almost the same effect is produced if the charge of explosive is unnecessarily great. In a wet mine, or in the entire absence of coal-dust, the flame produced by a blown-out powder-shot is not projected to any considerable distance, but is considerably increased in volume if dry or slightly-damp small coal has been used as stemming for the shot. In a dry locality, where coal-dust exists, the flame is sure to be considerably increased and extended by the ignition of portions of the dust-cloud raised; and this result is occasioned even in the entire absence of firedamp. It is, however, well established that, even when the atmosphere is quite free from firedamp, an exceptionally inflammable and abundant coal-dust may, by its ignition, produce explosive effects similar to those caused by gas. If gas is present, even not above 2 per cent., under favourable circumstances the flame may be propagated to distant localities, where accumulations of explosive gas-mixture or deposits of very inflammable dust may exist, and extend the disastrous effects. Whenever a coal is worked which contains inflammable gas, the atmosphere will, at one time or another, and it may even be said generally, contain some small proportion of firedamp.

Hitherto the absence of any indication in a lamp has been taken as conclusive evidence that a mine was free from gas, but that test fails when the atmosphere contains less than 2 to 2·5 per cent. Such a slight proportion not only enhances the danger due to dust, but is sufficient actually to give rise to an explosive mixture with the dust raised by a blown-out shot. By improved indicators such small proportions of gas can now be detected; but there is no means of preventing such contamination, which, though insufficient to cause danger alone, does so if dust co-exists in abundance in dry mine-workings when powder-shots are fired. It is thus seen that the firing of powder shots in a dry mine, where dust exists in abundance, must always be attended with disastrous results if even so small a proportion as 2 per cent. of firedamp is present. Removal of the dust, or laying it, by application of water alone, or in conjunction with deliquescent salts has not been found convenient or trustworthy; therefore the only safe method when powder is used is by combining the removal as far as practicable with very copious watering.

7. Explosive Agents.

It will thus be seen that the safe use of powder entails much difficulty; but the extensive practical experiments of the Commission and others have demonstrated that efficient substitutes for powder are available, and that one or other of the following alternative means may be employed both in coal and stone with equal efficiency, and at very little, if any, greater outlay.

(*a.*) In some coal-seams the lime-cartridge will perform work quite equal to that accomplished with powder,* at no greater cost, and with absolute immunity from danger of explosion.†

(*b.*) Mechanical appliances exist which will do efficient work, not only in some kinds of coal, but also in some stone or shale over or underlying coal.

(*c.*) The so-called "high" or violent explosive agents, which are represented by dynamite or gelatine-dynamite and by gun-cotton or tonite, can now be applied, not only for working economically in stone or shale, but also for coal-getting, by using them in conjunction with water, according to one or other of the usual methods.

The "high" explosives may be used, as indicated in (*c*) with security against the ignition of coal-dust thickly suspended in the air by a blown-out shot or by the effect of an overcharged hole, even when the air contains some small proportion of firedamp.

To Dr. McNab belongs the credit of having first practically shown that the addition of water to the powder-charge in a shot-hole would be of value in extinguising the flame caused by a powder-shot; but, though Dr. McNab's system proved useful in saving time in stone-drifting and similar works, owing to the absorption of some of the products of combustion by the finely-divided water, it was proved that no reliance can be placed upon it for producing a sufficiently extinguishing effect to prevent an explosion, in a gas-mixture or in a dust-laden atmosphere containing a small proportion of gas, by a blown-out powder-shot.

A series of experiments made by the Commission by firing blown-out shots with dynamite, compressed gun-cotton, tonite, and gelatine-dynamite, and with the addition of water-tamping, all failed to ignite a favourable explosive mixture; while the same explosives *minus* the water-tamping, or powder *plus* the water-tamping, never failed to produce an explosion. The use of water-tamping, as applied by Dr. McNab, but in conjunction with the so-called "high" explosives, appears therefore to afford protection against coal-dust explosions when blown-out shots occur.

---

* See Report of Control and Inspection of Mines, New Zealand, 1883, letter referring to lime-cartridge blasting from Mr. Inspector Cox, F.G.S., to the Under-Secretary for Mines.

† In the report of Mr. Evans, F.G.S., H.M.'s Inspector of Mines for the Midland District, five non-fatal accidents are recorded as having occurred during 1885 from the ramming of lime-cartridges having blown out whilst watering the hole.