by heating to 68°, then polarizing again, carefully noting the temperature. From these readings the percentage of cane sugar present is calculated from the following formula:

$$x = \frac{a - a'}{144 - \frac{t}{2}}$$

Here a=first reading of polariscope.
a'=second reading of polariscope.
t=temperature of observation.
x=percentage cane sugar required.

In connection with the polariscope readings I also made reductions both before and after inversion, and thus obtained valuable data in regard to the nature of the amylose present, as well as securing a check on the optical results.

Following is a scheme of an analysis which will illustrate the method of procedure:

Reduction. Took 10 g. in 1000 c.c. Of this, to reduce 10 c.c. Fehling's Solution, took 27.8 c.c.
Then 1000 : 27.8 = x : .05 (.05 g = sugar corresponding to 10 c.c. copper solution.)
Whence x = 1.8 g. = 18 per cent reducing matter.
Polarization. 26.048 g. in 100 c.c. gave........ 97°.8+
After inversion at 21° " .... 2°.6—

Difference, = ... 100°.4

$$100°.4 \div 144 - \frac{21}{2} = 75.2 = \text{per cent sucrose.}$$

Reduction after inversion.
For 10 c.c. copper solution took 5.35 c.c.
Then 1000 : 5.35 = x : .05.
x = 9.35 g. = ... 93.50 per cent.
Deduct 18 per cent due to amylose = .. 75.50 "
Due to invert sugar.................... "
Sucrose by polariscope................ 75.2 "
Amylose, water and ash by difference... 24 8 "

Following are the results of twelve examinations of mixed sugar:

No.	Per cent Reducing Matter.	Per cent Sucrose by Polariscope.	Amylose, Water, Ash, etc., by difference.
1	*29.70	*71.4	28.6
2	24.6	64.35	35.65
3	25.64	68.2	31.80
4	25.00	64.72	35.28
5	22.52	66.80	33.20
6	24.4	60.34	39.66
7	26.88	60.7	39.30
8	25.00	68.6	31.40
9	30.5	59.9	40.10
10	25.8	71.6	28.40
11	26.6	61.0	39 00
12	18.0	75.4	24.60

The analysis of mixed sugars is at this time a matter of great public interest. It is important that the public be not defrauded by purchasing sugars under false names. It is true that the manufacturers, as far as I know, do not sell the mixed sugars as *straight*, but when they pass into the hands of the retail dealers they are usually disposed of as if they were genuine. I do not anticipate that mixed sugars will jeopardize the public health. When well made they are certainly palatable and harmless. For boiling with fruits, etc., as in making preserves, they are quite as efficient as cane sugars. Nevertheless a "mixed sugar" should be bought, sold, and consumed as a mixed sugar, and thus all "winking" at fraud be prevented.

* One of these numbers is evidently incorrect. On looking over my notes I cannot find the mistake, and I have no more of the sugar with which to repeat the analysis. I think the error is in the per cent of reducing matter.—H. W. W.

COAL DUST AS AN ELEMENT OF DANGER IN MINING; SHOWN BY THE LATE EXPLOSION IN THE ALBION MINES IN NOVA SCOTIA.*

By H. C. Hovey.

My object, in this communication, is to lay before the public by permission of Mr. Edward Gilpin, Inspector of Mines for Nova Scotia, the results of his investigations into the part played by coal dust in spreading and augmenting the terrible explosion that took place in the Albion mines, near Stellarton, on the East river, N. S., on the 12th of November, 1880.

Explosions are frequent in the coal mines of England and Belgium. causing loss of many lives and the destruction of much property. But in our own country, as a rule, we are fortunately exempt from such calamities. On the other side of the Atlantic there are special causes leading to these explosions; the thinness of the seams, the depth of the workings, the gaseous nature of the coals most prized for their coke and illuminating power, all combining to render difficult the great problem of producing ventilating currents sufficiently powerful and searching to insure the safety of the workmen.

Within the last few years men of scientific and practical knowledge have studied into these disasters and their causes, hoping that some remedy might be found that could remove the dreadful uncertainty hanging over the lives of those who help to sustain the fabric of modern civilisation. It was discovered by a rigid inspection of all available accounts of explosions, that many of them had occurred in pits known to be, as a rule, not dangerous from explosive gas, or declared to be free from it shortly before the moment of the accident. Then the fact gradually became apparent that a seemingly innocuous constituent of the mines, namely, *coal dust*, played an important part in spreading and augmenting the blasts. It was as if the wadding of a gun was composed of an inflammable material which, on ignition of the charge, doubled its effect.

It is well-known that chemical action is often induced in heaps of slack, such as exist in thick coal workings, and that the heat evolved may be enough to cause ignition. The danger is increased when the broken coal is comminuted, and floats in the air, as in this form, under various conditions, it may undergo rapid oxidation. Galloway's experiments show that when the particles of dust are so fine as to pass through the gauze shield of a safety lamp, an explosion may be caused by their ignition. Bauerman states that, in the Franco-Belgian collieries, "several fatal explosions have been traced to the firing of coal dust from the flame of a shot, even in cases where no fire-damp was present in the workings."

A brief glance at the history of the Albion Mines will not be misplaced. The main seam, which has been continuously worked since 1807, attains the remarkable thickness of 37 feet 6 inches, and is a highly bituminous coal, well adapted for gas and coke-making. It contains several layers of iron stone up to one foot in thickness, but may be considered as an unbroken mass of coal.

The earliest workings, now known as "the Burnt Mines," furnished large quantities of coal, until they were abandoned in 1839 on account of fire, which blazed so fiercely from the shafts that the chains used in raising the coal tubs, were melted. A new opening, the Bye Pit, was worked till 1863, when a fire occurred from a shot lighting gas. This was extinguished; but a short time after the gas ignited at the boilers, which were within a few yards of the top of the pit. and the works had to be closed up. The Foster Pit was next opened, but in 1869 spontaneous combustion caused a fire, which necessitated its abandonment before it was fairly under way.

* Read before the A. A. A. S., Cincinnati, 1881.

At length the Foord Pit was won out, and, with its great pumps and engines, formed one of the finest coal-mining establishments in America. The ventilation was effected by a large Guibal fan, similar to those used in the Pennsylvania Mines, and capable of circulating 120,000 cubic feet of air per minute through the ramifications of the mine. The workings of the Foord Pit, which is nearly 1,000 feet deep, extend about 1,800 yards to the north, and 1,700 yards to the south, having an average breadth of 250 yards. The galleries varied in height from 9 to 15 feet, being driven in the upper part of the seam, the lower part being left for later operations. The ventilation through the south side was maintained at the average rate of 25,000 cubic feet per minute. Shortly before the accident referred to, I went entirely through the colliery, in company with Mr. Gilpin and the overman, and we remarked the perfection of the ventilation, and the consequent absence of deleterious gases, even in the remotest bords.

On the morning of the disaster the night watchmen reported the mine to be free from gas, except in small and harmless quantities. From what source, then, originated the series of explosions that began within an hour from the time this report of entire safety was made, and continued at intervals until the mine became a furnace, whose flames could be subdued only by emptying into its burning chambers the waters of the adjacent river? Was there some sudden exudation of gas from the solid coal, or was this explosion due to the firing of coal dust from a safety-lamp or the flame of a blast?

None of the forty-four men who witnessed the beginning of the catastrophe escaped to tell the story or explain the mystery, and those rescued from more distant galleries had but conjectures to offer. The workmen on receiving the assurance that the mine was free from gas, received their orders, descended the drawing shaft, received their safety-lamps at the lamp cabin and a part of them went into the north side workings and the rest went into the south side dips and waited for their tools to be sent in for distribution. At this moment the explosion took place that was first noticed at the fan-shaft, where it blew the cover of the fan-drift off, and about one minute later it was apparent at the drawing shaft, having traveled in the one case *with* and in the other *against* the ventilating current.

The only additional facts definitely ascertained were gathered by an exploring part led by Mr. Gilpin, who, shortly after the original explosion and at the risk of life, descended into the pit and penetrated as far as the after-damp would allow them to go. The locality where the unfortunate workmen whom they tried to save were known to be was 1,200 yards south of the shaft; and the point reached by the party was only about 600 yards in that direction.

It was evident that the flame of the explosion had not reached as far as this, for there were no marks of fire on the dead bodies of men and horses found, nor was the splintered wood-work charred. They carried two corpses to the surface for examination, and it was found that one of these died of the after-damp, and the other from being dashed against some timber.

The walls of the galleries had been swept clear of timber, and presented the appearance of having been brushed with a broom. This was due to the passage of great volumes of dust which lay on the floor of the level in waves and drifts, into which the party often sank up to their knees. A similar effect was visible in the mine level, but not to so great a degree; as it was damper about the floor, and from the effects observed it would appear that, while the explosion passed along each level simultaneously, it had greater power in the lower one, as the doors were blown toward the upper, or main level. Clouds of the finer particles were carried up the shaft, and were swept on into the North-side levels.

At the lamp-cabin, where the safety lamps were cleaned and given to the men after being examined by the shot-firers, an open light had been kept burning for years, as it was considered a safe place, being within a few feet of the bottom of the shaft. But here a *secondary* explosion took place, demolishing the cabin, burning the horses between the shaft and the cabin, and fatally injuring the lamp-man by igniting his oil-soaked clothing, so that he died in a few days. The effect of the explosion did not extend far into the north side, and some of the men there were ignorant of the disaster until warned by the over-man to leave the pit.

Secondary explosions caused by extracted, or generated gas, are nearly always in the vicinity of the primary one; but here is a case where the second was half a mile from the first, with an intervening space of at least a quarter of a mile known to be free from gas, because men were in it with lamps which showed no indications of its presence.

The ignition of these volumes of dust would, no doubt, have done serious injury to the shafting, had not the latter been wet and indeed saturated with water oozing under pressure through the upper strata into the shaft, and then falling to the bottom; so that, although elsewhere the mine was a very dry one, it was here in such a condition that the flame would be extinguished as soon as it touched the damp walls. The necessity of watering dusty mines has been pointed out by Inspector Gilpin, and this is said to be practised in some of the Belgian collieries. The present instance shows that such a precaution would tend to reduce the range of the explosion of the dust.

Attempts were made to restore the ventilation of the workings in the Albion Mines, when the presence of a large fire was discovered, and this made it necessary to flood the galleries. In about 48 hours after the explosion, a trench had been cut through to East River, and the water was let in at the rate of 15,000 gallons per minute, until, within a week, all the workings were filled. This, of course, made further investigations impossible, and nothing will be known beyond what has here been told.

The subject is one of acknowledged importance. There have been frequent explosions in flouring mills, said to be attributable to the ignition of flour dust. At a late meeting of the Manchester Geological Society, (in England), experiments were made to show that even finely powdered slate will spread the flame of gas explosions. Since the preparation of the present paper, a report has been made before the royal commission on accidents in mines, by Mr. F. A. Abel, Chemist to the British War Department, in which it is claimed, as demonstrated, that coal-dust is not only a fiercely burning agent, but when suspended in air currents may operate as an exploding agent. It operates, aside from its inflammability, as a finely divided solid, in "determining the ignition of only small proportions of fire-damp and air, and consequently in developing explosive effects," *i. e.*, under circumstances which, in the absence of the dust, would be attended by no danger.

HISTORY OF ALHAZEN'S PROBLEM.

Abstract of a paper read before the American Association for the Advancement of Science, Cincinnati, August, 1881, by MARCUS BAKER, U. S. COAST AND GEODETIC SURVEY, Washington, D. C.

Alhazen's problem is an optical one and was thus stated by the Arabian Alhazen for whom the problem is named. "*Given a luminous point and a point of vision unequally distant from the center of a convex spherical mirror, determine the point of reflexion.*" The solution of this problem involves the solution of the following geometrical problem now generally known among mathematicians as Alhazen's problem. *From two given points in the plane of a given circle draw lines meeting in the circumference and making equal angles with the tangent drawn at that point.*