weaker, the features grow fainter, and it is only rarely we see anything deserving the name of an escarpment at all. One of the most striking exceptions, occurring in the immediate neighbourhood of this town, is the escarpment of the Woolley Edge Rock, which may be traced from New Miller Dam as far south as the neighbourhood of Elsecar. Beyond this, the rock, which hereabouts is a coarse and massive gritstone about 100 feet thick, dies away altogether, and is replaced by shale. I have now given a sketch of the general geology of the district of which the Barnsley Coal-field forms a part. On some future occasion I hope to be allowed to lay before you some details about the coal-field itself.

SOME REMARKS ON FIRE DAMP AND SAFETY LAMPS. BY JOHN HUTCHINSON, MANAGER OF THE GAS WORKS, BARNSLEY.

The subject upon which I am about to offer a few remarks is one of deep interest to the Colliery Proprietors and the mining population generally of this neighbourhood. And I feel sure you will excuse me if I occupy a few minutes of your valuable time this afternoon in noticing some facts and observations recently made on this subject at the Oaks Colliery and elsewhere.

Anything relating to this ill-fated Colliery is doubly interesting at the present time, since within the last few days some of the bodies of the volunteers, who so nobly rushed into this fiery mine ten months ago, in order, if possible, to aid, succour, or rescue their fellow men from a dreadful and almost certain death, have at length, after overcoming many difficulties, been recovered, brought to the surface, identified, and interred, which is no small degree of satisfaction to their sorrowing relatives and friends. Those in the town of Barnsley, who last Sunday and Monday witnessed the funeral
processions, accompanied by the widows, orphans, and sur-
vivors of the Oaks explosion, as they passed slowly through
the streets which were lined with spectators, will not readily
forget the solemn impression then made, the sight of the
numerous train of widows brought tears into many eyes.

On the latter day the shops lining the principal thorough-
fares were closed, and business suspended.

FIRE DAMP.

Fire Damp, Marsh Gas, Pit Gas, or Light Carburetted
Hydrogen, Symbol C H 2; sp. gr., 0.552 to 0.100 cubic inches
weigh 17.12 grains. Specific gravity as compared with
hydrogen 8 to 1.

Fire Damp is a natural product which issues from the
ground, and admits of being kindled. It is a product of
decomposition from beds of coal, and when it mingles
with air forms an explosive mixture. It is a colourless,
invisible, inodorous gas, scarcely soluble in water; it does
not support combustion or respiration. When breathed in a
pure state it is fatal to animal life, but it is not very noxious
when mixed with air, even when it forms 8 or 10 per cent.
of the mixture the miners can work in it; however, when it
is very strong it has been known to render them insensible,
but the usual effects are a tightness across the forehead, with
headache, which happens some time before insensibility takes
place.

Fire Damp alone does not explode, it must be mixed with
air or oxygen before this phenomena can show itself. If
mixed with too much air, explosiveness is again lost. If the
proportion be diminished to three or four times that of the
fire damp, or increased to more than fourteen times its
measure, explosion does not happen; for where the volume
of air is very small an amount of oxygen sufficient to burn
the fire damp is not furnished; where the quantity of air is
too large it prevents the spread of flame, by conducting
away heat, and preventing the temperature rising high
enough to inflame the combustible gas. If mingled with twice its volume of oxygen, or ten times its volume of air, it detonates powerfully. When collected and consumed in the mouth of a gas jar it burns away quietly, with a yellowish-white light, somewhat similar to coal gas, but if the light is passed into the jar it is extinguished instantly. There is no immediate chemical test for the presence of this gas. A candle or oil lamp gives a white heat, which at once determines an explosion if introduced into an explosive atmosphere.

Fire Damp being very light, little more than half as heavy as air, it ascends, collects, and lodges in hollows or recesses at the upper parts of the workings, and would of its own gravity readily escape at the surface into the open air, if there was a free course open for it to do so, so that while the lower part or floor may be ventilated and free from danger, a light brought near the roof might lead to a dangerous explosion.

When an explosion does occur the life of a miner is likely to be sacrificed from several distinct causes, arising, first, from burning, as the very atmosphere in which he exists is instantly one sheet of flame, beyond the power of man to control, and from which he can seldom escape; second, by the mechanical violence of the sudden expansion of the gases on their ignition, sweeping everything before it, or, on the contrary, a comparatively and equally frightful rush of air to fill the partial vacuum caused by the contraction of volume of the exploded gases; third, by being surrounded with, and thereby compelled to inhale, an atmosphere of carbonic acid and nitrogen. This often proves more fatal than any other cause, the entire system of ordinary ventilation being generally destroyed by the first blast, and the atmosphere, pressing with equal force on downcast and upcast, the deadly gases become as it were bottled up in the pit with an elastic cork. The gas left after an explosion is much lighter than
black damp, or even common air, and it will make its way up to the roof, whilst black damp will lie near the floor.

Fire Damp requires twice its volume of pure oxygen for complete combustion. The three volumes of mixed gases after detonation are condensed into one volume; they yield one volume of carbonic acid, and two volumes of steam, which are immediately condensed. Now carbonic acid contains its own bulk of oxygen, it therefore represents one of the two volumes of oxygen which disappear, whilst the other volume of oxygen has united with two volumes of hydrogen and formed water. Light carburetted hydrogen must, consequently, contain twice its volume of hydrogen condensed with its own bulk of carbon vapour into the space of one volume.

Thus, from the composition of fire damp, it is obvious that the gas in exploding renders ten times its bulk of atmospheric air unfit for respiration. The two volumes of oxygen which ten volumes of air contain, producing one volume of carbonic acid, and two volumes of steam, which becomes condensed, leaving eight volumes of nitrogen at liberty. Fire Damp from different localities has been frequently analyzed, and exhibits a general uniformity in composition, consisting principally of light carburetted hydrogen, with varying quantities of carbonic acid, nitrogen, hydrogen, atmospheric air, and sometimes olefiant gas, and sulphuretted hydrogen. Analysis of Fire Damp by Professor Playfair:—Light carburetted hydrogen, 92.80; nitrogen, 6.90; oxygen, 0.60; carbonic acid, 0.30; total, 100.60.

THE SAFETY LAMP.

The Safety Lamp is a valuable instrument in the hands of a competent person who thoroughly understands its use in testing for the presence of fire damp in coal mines, but the miner actually at work cannot be supposed to be at liberty to pay that nicety of attention to its indications that would appear desirable, but they ought to remember that the lamps
should be gently handled and carefully attended to, kept in
the best possible order, and that they are not intended to be
made a substitute for proper ventilation. Objections have
been made by working colliers to some safety lamps for the
small amount of light produced and the inability to see their
work fairly, and thus, to make good wages, induces colliers
when either thoughtless, or otherwise satisfied that there is
no Fire Damp near, to unscrew the top of the lamp. Rules
and regulations backed up by fines, and now lately by
liability to imprisonment, have been insufficient to stop this
tendency, and to prevent the occurrence of numerous acci­
dents which have resulted from it. Hence it is that much
attention has been bestowed on the methods of locking the
lamp, to prevent the removal of the wire gauze. It will be
readily conceded that good rules and strictly enforced
discipline among the workpeople are just as indispensable as
a perfect lamp, in the prevention of those accidents, often so
cruel and so sweeping, which hurry away in one common fate
the provident and innocent with the reckless and the guilty.

In some Safety Lamps as the Clanny, Morsler, and the
Morrison, it may be said that their is no temptation for the
men to pick the lock, or to unscrew the top, because they
have what they want, they have already plenty of light. But
inasmuch as safety in a dangerous place ceases with the
fracture of the glass, our colliery managers have been gene­
rally averse to their use in fiery mines.

If a light, producing a white heat, such as a lamp or candle
be used in the mine, no matter whether in the intake or the
upcast air course, an explosion is liable to happen. If the gas
ever becomes ignited the flame will follow so long as there is
gas sufficient to support combustion either with or against
the current. Much has been said and written upon the
cause of colliery explosions, yet under the best known
management they do occur. The very name of “Safety
Lamp" appears sufficient to satisfy all our scruples at once, it is relied upon with implicit confidence, and generally believed to be what its name implies. A Safety Lamp is wanted, it is bought, sold, used, and believed to be such, no one taking the trouble to test whether it is or is not what it professes to be. If an explosion does unfortunately occur, it is indeed rarely that the cause can be traced to its source satisfactorily, but the lamp is never once thought about, if the miner has his lamp all in perfect order he is said to be quite safe; let us see if such is really the case.

During the last few months I have, in conjunction with Mr. Wilson, under-viewer of the Darfield Main Colliery, and Mr. Minto, of the Mount Osborne Colliery, conducted a series of experiments upon the different kinds of Safety Lamps in use, with a view to show their comparative merits, care being taken that each lamp of its kind was perfect and in good working order.

These experiments were witnessed by a number of gentlemen connected with the various collieries in the neighbourhood. A rectangular box, constructed of deal boards 12 feet long, and measuring 11 by 4 inches inside, was inserted into a flue in connection with a chimney shaft to produce a current. A current of pure air is sent through this box, the quantity and velocity of which was regulated by a small sliding door near the inner end. In the top of the box, about the centre, is a small sliding door, which on being removed discloses an opening of sufficient size to admit a safety lamp. Through this opening a lamp can be dropped into the centre of the "level," and can be seen through a small square of glass fixed in the side thereof. A service pipe of coal gas is connected by means of an India rubber pipe, which is terminated by a small metal pipe and tap, and the gas allowed to play into the end of the box; by means of this pipe it will be seen that the current of pure air passing through the
imaginary level can be diluted at pleasure, and the changes which the lamp undergoes can be easily seen through the square of glass in the side of the box. A Stephenson lamp was inserted, when the gas was turned on there was first a flickering of the flame, which had burnt steadily while the air was pure, and at one time it appeared totally extinguished; a tiny blue light, however, remained wavering about within the top of the gauze, which gradually increased in size as it was drawn through the gauze by which it was enclosed. The gauze in a short time got red hot, and after the lapse of one minute and thirty-five seconds the gas in the box exploded; the lamp was then removed and was found to be still burning and uninjured, but generally the light was extinguished without exploding the mixture in the box. With the current of air passing through the box at the rate of five miles an hour, not an uncommon velocity in a pit, as ascertained by the anemometer, the following comparative results were obtained:

<table>
<thead>
<tr>
<th>Lamp</th>
<th>Time (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Davy Lamp</td>
<td>5</td>
</tr>
<tr>
<td>Mousard Lamp</td>
<td>6</td>
</tr>
<tr>
<td>Clanny Lamp</td>
<td>12</td>
</tr>
<tr>
<td>Belgian Lamp</td>
<td>13</td>
</tr>
<tr>
<td>Stephenson Lamp</td>
<td>25</td>
</tr>
</tbody>
</table>

All the above-named lamps were tested under the same circumstances. Some further experiments showed slight variations in the time, but all tended to two results. In the first place it was shown that all the safety lamps were really unsafe in a current of atmospheric air and gas when mixed to an explosive point. And, secondly, that of the lamps now in use the Stephenson is the best and most reliable.

In a still atmosphere of mixed air and gas all the above lamps were extinguished without igniting the surrounding atmosphere.

It will be noticed that the foregoing experiments were
made with ordinary coal gas. An opportunity offering at the Oaks Colliery, it was thought desirable to make similar trials on the gas given off from the coal strata, and actually issuing from the Oaks Pit, 1,025 cubic feet was being given off per minute on the 22nd of August, 1867, the data on which the experiments were made.

With the above-named arrangements of apparatus, &c., and a velocity of 4 1/2 miles an hour,

The Davy Lamp exploded in from 10 to 30 seconds.
The Clanny do. do. 13 to 32 do.
The Fluted Clanny improved was extinguished in from 3 to 60 seconds, but did not explode.
The Belgian Lamp was extinguished in from 5 to 160 seconds, exploded in 30 seconds.
The Cockney Lamp was extinguished in from 3 to 18 seconds, did not explode.
The Stephenson Lamp was extinguished in from 3 to 120 seconds, exploded once in 45 seconds.

At this date the fire damp contained 4 per cent. of carbonic acid which would seriously affect its combustible properties; the gas was free from other impurities. I may here observe that the Stephenson and other lamps were several times extinguished before explosion took place, owing, it is believed, to its being impossible, or nearly so, to spread the gas equally through the entire current; there was also a strong wind blowing at the time, which materially affected the steadiness of the current passing through the box.

We also ascertained the following facts, viz., that the said fire damp issuing through a 3 inch pipe would ignite at a piece of 1/3 inch iron wire heated to bright redness when held in a stream of the gas. The same results were obtained with a 3 inch round iron rod, with a bar of 1 1/3 in. square heated in the smith’s fire to bright redness, and carried through the air about fifty yards, occupying about sixteen seconds in
transit, it would ignite continuously the pit gas as it issued from a batswing burner for one minute twenty-five seconds, the same bar was then immediately applied to a batswing burner supplied with ordinary manufactured coal gas, which it continued to light for one minute and twenty seconds longer; this showing that the pit gas required a greater degree of heat to fire it than coal gas. It would likewise readily ignite at glowing charcoal, also at red hot wire gauze when played upon on a particular point for some seconds.

Thus I think we have succeeded in establishing the foregoing facts, and calling attention to them; which, I trust, will be of service to the miner, as well as to the scientific world. I am of opinion that a safety lamp worthy of the name has yet to be invented. There are certainly no lack of labourers in the field, but the work yet remains to be done.

Scarcely ever before in the South Yorkshire Coal Field was the benefit of the Stephenson lamp of such signal service as proved to be the case a week ago at the Stafford Main Colliery, near Barnsley. It appears that about half-past six o’clock, a large portion of some old breaks had fallen, and given off a very large quantity of gas, which was driven down the north side of the pit, extinguishing all the lamps in its course for a distance of about 400 yards. Within less than an hour all the men, numbering over 300, were deposited safely at the pit bank, and in a short time the alarm which had been suddenly raised abated. The seam of coal being worked is the Silkstone, the shaft being about 243 yards deep.

A defective lamp or a naked light, there cannot be the slightest doubt, would have hurried into eternity the great body of the miners in the pit. The colliery itself is one that has the reputation of being very well ventilated, no expense being spared for that purpose by the proprietors.
The above confirms on a large and practical scale, the conclusion we have arrived at on the small scale, viz., that hitherto the Stephenson lamp is the one most to be relied upon, under all circumstances, and that some of the so-called safety lamps ought to be rejected as worthless, for there is the appearance of safety without the reality.

OBSERVATIONS ON VENTILATION IN RELATION TO COLLIERY DISASTERS. BY RICHARD CARTER, C.E., BARNSLEY.

Having on two previous occasions—the 16th July, 1857, and 1st November, 1860 respectively, brought the subject of Colliery Ventilation under notice of this Society, I can only plead its vast importance, not only to private enterprise, but also to the interests of the community generally, as my apology for reverting to it again on the present occasion.

Ten years have elapsed since the first paper, which was immediately prompted by the dreadful explosion at Lundhill; and although something has been done to ameliorate the frightful hazards attendant on ventilation in practice, the interval has not sufficed to produce anything like immunity from those desolating calamities, which seem periodically to spread their fatal and ruinous gloom, over this, and similar colliery districts of the country. Minor calamities have from time to time served to keep the subject alive in the public mind, but it was reserved for another repetition of disaster at the Oaks Colliery, within little more than a mile from where we are now assembled, to renew with appalling force and impressiveness, the dread relation, in which the subject of ventilation is still associated with the interests of humanity, as well as commercial and national wealth. The awful fatality which attended the Oaks explosion of the 12th December last—surpassing in heart-rending sacrifice of life, all the events of its kind which have hitherto