three charges of 200 grammes (623 oz.), tambed with coaldust and blown out into a dusty atmosphere containing 12 per cent of gas, gave rise to neither ignition nor explosion, although the temperature was raised to 35

deg.

It was thus proved that the proportion of dydrated salt It was thus proved that the proportion or ayuraco sur for pre-enting ignition must increase with the temperature of the explosive atmosphere, the harmlessness of which it was desired to ensure. What can this be but that the "apparent temperature of ignition," as defined by M. Mallard and M. Le Chacher increases with the tempera-ture; it would, therefore, be a function of the pressure of subhasion and of the intromediant commerciature. It fol-Mallard and M. Le Chatcher increases with the temperature; it would, therefore, be a function of the pressure
of explosion and of the surrounding temperature. It follows that the degrees of safety possessed by the various
explosives can in reality only be rehed upon, subject to
the condition that they be made with an equal surrounding temperature; because—as may be deduced from the
Schlebusch experiments—the hint of temperature where
safety ceases to exist, may be such as is met with in the
underground workings of a collery. With a variation of
to 2 degs, in temperature, any explosive normally harmless, may become dangerous, or, at any rate, lose its
quality of safety. Deep and hot mines are therefore more
dangerous than others; and in this case again the first
remety for the evil is powerful and abundant ventilation.

As the Schlebush result must leave doubt on the subject, the author quotes, from the report of the French
Commission on Explosives, facts to prove that the exholosic itself is highly sensitive to the influence of temperature. The above Cemmission also deals with the
question in a special chapter as to the possible influence
exerted on the inflammation of iterchamp by the quantity
of steam contained in the air, in the course of which the
following observation occurs: "It is possible that if the
quantity of watery vapour contained in the atmosphere
be increased, the inflammatibity of friedamp may not be

be increased, the inflammability of firedamp may not be so much reduced as it would otherwise be." The report so much reduced as it would otherwise be." The report then quotes Mr. Dixon's deductions, that carbonic oxide does not combine with oxygen, under the influence of the electric spath, when the gases are perfectly dry, observing that a similar fact as regards gasy mixtures would be of great importance in collieries where the air is generally saturated with moisture. One more quotation from the report terminates in the following words:—"Laboratory experiments have not permitted of noticing any appreciable difference in the inflammability of mixtures containing more or less humidity."

Considering the importance attached by the author to the influence of temperature, he has recorded fractions of degrees, the thermometer used in the Produits experiments leging graduated to tenths of a degree (Lentigrade).

degrees, the thermometer used in the Produits experiments being graduated to tenths of a degree (Lentigrade). Suspended about the middle of the gas chamber, it recorded the mean temperature of that chamber; and a clay plug closed the aperture by which the thermometer was introduced, so as to avoid any escape of gas. The reason why the thermometer only marked a mean of the temperature was on account of the heating apparatus, which consisted of a steam coil of five spirals of equal diameter, held by flanges against the wall, behind the boiler. The temperature was therefore necessarily higher near the cannon's mouth; and the products of the explosion, representing a blown-out shot, thus passed through the most dangerous point of the atmosphere first of all.

In the top of that part of the boiler which constituted the gas chamber, three man-holes had been cut; and the covers which cossed them rested simply on india-rubber

covers which cosed them rested simply on india-rubber rings; but chains, the links of which are made of !/ in. rings; but chains, the links of which are made of ½ intround iron, attach them to much stronger rings rivered to the boiler plates. The covers were well lated with clay every time that gas was introduced into the apparatus; and in this way the covers formed safety valves, while they also acted, to a certain extent, as dynamo-ineters, the intensity of the explosion being shown by the manner in which these covers were lifted up, and thrown forward or torn off. One explosion, with forcire, threw one of the excepts a distance of 40 m. over the wall of the enclosure; another, with Favier explosive, threw a cover to almost the same spot; and another, 45 m. distance over a double the same spot; and another, 45 m. distance over a double the same explosives in other experiments.

Spontaneous Combustion in Coal Mines.

In submitting the following paper on "Spontaneous, Combustion in Coal Mines," the author does so rather in the hope of eliciting valuable information in the discussing, than with any expectation of convering knowledge to those members whose experience has been gained in mines liable to this species of catastrophe. The few remarks submitted are the result of knowledge gleaned in his experience and travels in districts most liable to spontaneous combustion, such as Leicestrashire, Warwickshire, Staffordshire, and in other districts where Warnious papers add writings of others, published in the proceedings of the various spers, published in the proceedings of the various scientific bodies, and to his private correspondence with mining engineers and chemists, whose assistance he gratefully acknowledges.

Most of the dangers and difficulties encountered in a mine, can be overcome in certain well-known ways;

mine, can be overcome in certain well-known ways; water can be raised by pumping-engines; gas can be carried away by ventilation, and the danger obviated by

safety lamps; faults can be passed through by sufficient expenditure of money; but spontaneous combustion can hardly be prevented, and when once begun it is some-

hardly be prevented, and when once begun it is some-times impossible to stop it, excent by some process that involves the entire closing of the colliery. Spontaneous combustion of coal or as it is sometimes, and perhaps more correctly called spontaneous ignition, means the firing of coal without the direct application of a lighted match or other flame.

In some cases the cause of spontaneous ignition is brious. Take for instance a ventilating furnace built in seam of coal. The heat from the fire makes the bricka seam of coal. The heat from the fire makes the brick-shale work hot, and raises the temperature of the coal or coal adjoining to the point necessary for ignition, which is be-tween 700 and 800 degs. Pahr. The remedy for this kind of spontaneous gonton, if it can be so called, is very simple, and that is to separate the coal or coal shale from the lutrace by a passage conveying a current of cool air. It is not enough to provide an air space, because air is as-castly heated as any other substance; it is necessary, to provide a constant current so that there may be always cool air between the arch containing the furnace and the arch supporting the coal or other strata.

But spontaneous ignition often takes place under condi-

But sporting the coar of other strata. But sporting the coar of other strata. But sportaneous ignition often takes place under conditions where there is no fire or any apparent source of heat equal to 700 or 500 degs. F-hr. Any large heap of ordinary bituminous coal is liable to spontaneous combustion—say, one, to feet thick and 30 or 40 feet square. The larger the heap and the smaller the coal, the greater the hability of fire. Thus, a heap of coal built up of large blocks of hard coal 15 feet high will probably not take fire, but a heap of slack of equal height from the same seam would probably take fire.

If a little artificial heat is applied to a very small heap of slack, of Sty, 2 or 3 tons, it is hable to fire. Suppose, for instance, there is a bruck flue carrying the hot gases from a fire to a chiuney and 3 or 4 tons of slack are tapped against this flue, it is very likely to take fire. The reason of this again is very obvious. The outside of the boiler-flue feels cool, because it is exposed to the wind, but the inside of the boiler-flue feels cool, because it is exposed to the wind, but the inside of the boiler-flue feels cool, because it is exposed to the wind, but the inside of the external wall the heat is no longer carried. out the institute of the bolier-tue is very not, pernaps 800 degs. Fahr, or more in temperature. When the slack covers the external wall the heat is no longer carried away, and the outside of the brickwork in a few days will become nearly as hot as the interior, whose heat is quite sufficient to set fire to coal.

There are, however, other cases less easily understood. For instance, if a heap of coal be laid over a steam pipe it will soon take fire, though the temperature of the steam and the pipe never exceeds 330 degs. Fahr., which is less than half the temperature required for the ignition of coal. But this is not so curious as the ignition of coal where there is no artificial heat of any kind. Coal is not the only substance that will inflame without the application of a match. If newly burnt charcoal is ground up, at will take fire. Rags or waste soaked with vegetable oil and put in a heap will take fire. Very finely divided iron or lead will also burn. Phosphora lakes are with the warmth of the hand. The compression of air, by means of a piston in a syringe, will give heat sufficient to ignite ether or tinder soaked in a solution of nitre.

In coal nimes there is a general liability to spontaneous

In coal mines there is a general liability to spontant In coal nines there is a general liability to spontaneous combustion in the majority of the coal fields of Great Britain in some districts it is exceedingly rare, and in others it is exceedingly common. Experience shows that it is very rare in thin seams and very common in thick seams; and that in seams of equal thickness it is more likely to occur where a large proportion of the seam is left in the mine, either as slack or as roof coal. In fact, spontaneous combustion, as a general rule occurs in those mines where a great deal of small and broken coal is left in the goaf, and is hardly, if at all, hown in those mines where all free coal is sent out, and broken that is the mine goal, and is hardly, it at any known in those mines where all the coal is sent out, and where there is no coal in the mine except the solid uncut seam or large and uncrushed pillars. The districts where goblires are most common in Great Britain are South Staffordshire, West Leicestershire, and Warnachebre.

and Warwickshire.
In South Staffordshire, the Ten-yard coal is worked In South Staffordshire, the Ten-yard coal is worked pillar and stall. It is got in panels, locally termed "sides," say about So to 100 yards square, in which area there would be sisteen or twenty pill: a about 10 yards square. The whole of the coal between the pillars and the ribs separating the sides or panels is got, with the exception of the toof coal, say a yard in thickness, which is left because of the danger of trying to get it. A good deal of slack and of coal mixed with dirt is also left in as being valueless. In course of time the roof falls and a good deal of coal no doubt breaks off the sides of the nultars. Thus considerable hears of coal, dut, and slack pillars. Thus considerable heaps of coal, durt, and slack are formed, and in a short time these heaps frequently get very hot, and unless precautions are taken they would burst into flames.

get very not, and unless precautions are taken they would burst into flames.

The usual method of preventing this is to put stoppings in all the roads leading into the "side" so as to prevent any fresh air having access; thus any combustion that begins speedily exhausts the oxygen, and further combustion is so prevented. The slow combustion, however, so far as it takes place, has the effect of making the mine in that part exceedingly hot. In some places air diaws through cracks in the ribs, so that a more rapid combustion can take place and great heat is produced. The main roads leading past these hot districts, are sometimes arched with brackwork, to assist in the exclusion of the air and to maintain a good road. Sometimes the brickwork gets so hot that it cannot be touched. As a general rule, however, the exclusion of the air stops the combustion. After the whole of the mine has been worked the sides are often re-opened to get the pillars and ribs. the sides are often re-opened to get the pillars and ribs.

In Leicestershire the coal is worked in two ways: In Leicestershire the coal is worked in two ways; sometimes by long-wall and packed gates, and sometimes by heading out and working back. Where the packed gates are used, the packs are made impervious to air by means of wax walls. These wax walls are made of clay, which has been worked to the proper consistency for making bricks, and is sent down in large lumps alsont 9 inches square and 18 inches long, and is built up into walls on each side of the gate road, while small dirt is packed on each side of the wax walls. These walls being soft have, we crowely the support that proof and the pack. waits on each side of the gate road, winte small that packed on each side of the wax walls. These walls being soft have no strength to support the roof, and the packs are made to a great extent of wood. The wood used is the small branches of trees cut into lengths of about a yard and built into square piles: It is commonly called "brattice wood." These timber packs are placed about 4 feet apart, and the space between them is filled up with stone made for the ripping of the gate roads. In this way the goaf between the gate roads is kept from the airtent; the only place where the air comes in contact with the goaf is close to the working face. In order to prevent the air from getting leack into the goaf near the working face, the ventilation is kept as slack as is constent with safety. The face is moved forward pretty fast, say, 2 or 3 yards a week, and consequently the goaf near the face has not time to heat. If, however, there should be a stoppage, owing to slackness of trade or a strike, the goaf would take fire at the face; and to prevent that, the wax wall has to be carried along the

strice, the goat would take fire at time face; and to prevent that, the wax wall has to be carried along the face from gate road to gate road.

Mr. Alfred Ely, in a valuable paper read before the Chesterfield and Derbyshire Institute, in pril, 1877, describes another method of excluding the air from the goaf at the face. He packs a leank of dirt all the way.

goaf at the face. He packs a bank of dirt all the way along the face on a slope from the roof to the floor. The face of this slope he then covers with a layer of sand 6 inches thick, which has the same effect as a clay wall in keeping out air.

Where the system of heading out and working back is employed; no wax walls are required, except during a stoppage, and then a wax wall is run along the face between the coal and the goaf, so as to exclude the air from the goaf.

In some collicies, the manager extractor.

In some collieries, the manager arranges as far as possible to finish off a district before the summer when possible to inhis off a district ready in trade is slack, and then he opens out a new district ready for the ensuing winter; the point to be aimed at being that the air current must never pass over or through heaps of slack or broken coal as in a goaf.

heaps of slack or troken coat as in a goat.

In Warwickshire the liability to spontaneous combustion is met by working the face as quickly as possible. For this purpose a number of coal-getters are concentrated in a small area. Where ever practicable, the mine is worked by heading out in the solid, and then bringing the coal back.

the coal back.

In many Warwickshire mines, the bulk of the coal lies to the dip of the shaft; in this case the headings are driven down to the dip I undary, and then the coal is brought back, the goad being allowed to fill with water. Both in Warwickshire and Leicestershire, a considerable portion of the coal in the seam worked is not got, being of slightly inferior quality to the coal that is got. Also a good deal of slack is left in the mine, so that there are great heaps of slack and broken coal.

good deal of slack is left in the mine, so that there are great heaps of slack and hroken coal.

But the question now arises, Fow can this coal take fire considering that the natural temperature of the earth in these mines is, say, from 60 degs to 65 degs. Fhr?

The explanation formerly given was that the iron pyrites, that is, disulphide of iron (fe S), which is often found in the coal and in the shales, is decomposed by the

found in the coal and in the shales, is decomposed by the oxygen of the air, and that this decomposition is accompanied with heat. It has been found by experiment that in some cases great heaps of shale, containing a large percentage of iron pyrites, have taken fire through the decomposition of the pyrites. But the amount of pyrites in the coal mines is too slight to have any appreciable effect in heating the coal, and this theory is now given up by those who have most studied the question.

Prof. Vivian B. Lewes, has made some valuable contributions to the knowledge of this subject in papers read to the British Association, in 1891, and subsequently to the Society of Arts. He states that it has been demonstrated by Richters, that newly cut coal will absorboxygen; some coal absorbing 12 times its own bulk, and other coal 3 time its own bulk.

How the oxygen gets in and is compressed into the

and other coal a time its own fulls.

How the oxygen gets in and is compressed into the very small space it must occupy is another question, but there is no doubt that it does go in, and that active chemical decomposition of the coal takes place, forming carbonic acid gas and wa.er, and that this decemposition is accompanied with considerable heat.

The hotter the mine the more rapid the decomposition, so that the process of heating when once begun goes on at an accelerating ratio, or in geometrial progression provided there is a sufficiency of oxygen to keep up the

In mines where the air is successfully kept from the on mines where the air is successumly kept from the goal however, the heat rises up to a certain point sufficient to make the mine very warm, but does not exceed that point, and then cools down again, because there is not enough air for further slow combustion.

The return air of a mine, the natural temperature of the country of a mine, the natural temperature of the state of the country of the state of the st

The return air of a mine, the natural temperature of which is about 62 or 63 degrees Fahr, will probably be 70 degrees, and in some places warmer still.

In order that the heat may get up to the point of com bustion, it is necessary that the coal or slack should have no opportunity of cooling. In the case of a very large heap of slack the heat which is generated in the centre cannot escape, and in the case of a small heap of slack, which is buried in the goal of a mine, the heat there also is kept in by the cover of shale and roof. But while the

^{*} Paper by A. Lupton, Transactions Federated Institution of Mining Engineers.