Discussion.

Professor ABEL referred to a specimen of fuze which had been handed to him, and which had acquired considerable importance. It was called the Instantaneous Fuze, and was a mechanical substitute for electric firing. It was manufactured by Messrs. Bickford and Smith. His first knowledge of it was derived from America, whence it reached this country under the name of Lightning Fuze. It was of simple construction; in general arrangement it was like the ordinary Bickford slow fuze, but in internal construction it was just the opposite. Whereas in the Bickford fuze the powder match was closely surrounded by a case, so that it could only burn very slowly, in this fuze the arrangement was such that there was an air space between the powder match and its envelope, so that when fire was applied at one end, it flashed with great rapidity to the other end. He could not speak with certainty as to the velocity of transmission of fire by this fuze, but he thought it was about 300 feet a second. The fuze had been adopted for naval purposes, on account of the facility with which a charge might be rapidly ignited by its means at a moderate distance without electrical appliances. It was used for firing hand-charges to be thrown into an enemy's boats. The charge was attached to one extremity of the fuze, the other end of which was screwed into the barrel of a modification of an ordinary pistol; the charge having been thrown into a passing boat, the fuze was fired by snapping a cap, and the charge exploded in the boat. Another application was more particularly illustrated by this specimen, namely, the firing of a number of charges with practically simultaneous effect. By inserting equal lengths of this fuze into a simple priming box, which communicated with the source of ignition, the fire might be made to branch out in a variety of directions, and the charges be ignited with an approximatively simultaneous action, not equal to that of electric firing, but sufficiently simultaneous for many practical purposes. This was a useful application of the fuze, and he thought it might be interesting to the members of the Institution to see it. Professor Abe

Colonel NUGENT, R.E., understood that it was thought desirable to have an expression of opinion as to the military aspect of these explosives. For a considerable time military officers had been intent on obtaining some explosive which should answer the purposes of military engineering operations better than gunpowder. However good it might be for certain purposes, yet for hasty demolitions Colonel Nugent.

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gunpowder was behind the time, and military engineers who had watched the experiments of Schönbein, and saw his failure, had been much disheartened. Their attention was afterwards diverted from gun-cotton by certain disastrous explosions which took place. Hasty demolitions were operations performed in the face of the enemy, under circumstances of considerable peril, and the safety of an army in the field, or the success of a campaign, might often depend upon them. It was, therefore, absolutely necessary to have some explosive upon which full reliance could be placed. In such demolitions the ordinary rules of blasting were laid aside. In the first place, it was difficult to calculate the charge; and as the charge was placed hastily and without previous tamping, it was, in order to ensure success, necessary to resort to large charges, and consequently to carry an inordinate quantity of gunpowder. Under any circumstances gunpowder was not a pleasant travelling companion, and its transport was of course attended with extreme risk in cases of exposure in the field. It was, therefore, easy to imagine the disappointment which military men felt when it seemed to them that gun-cotton was uncertain in its results, and was so unstable under variations of temperature that little hope of success could be entertained. In its original form, gun-cotton had one great disadvantage—it was bulky; and the inventor and perfector of compressed gun-cotton soon perceived that it was necessary to reduce it into a smaller form, and also to produce it in a much purer state. About that time other explosives were submitted to the public—two descriptions of dynamite and two of Worley's powder, and some others; but confidence was much shaken in compressed gun-cotton by the explosion at Stowmarket, although after he had examined into the origin of that explosion, he did not share the general opinion. After that it so happened that he took part in the examination of most of the other explosive agents which were submitted to the public. They underwent long and exhaustive trials, the result being that in the estimation of military men nitro-glycerine was set aside as too dangerous. The least powerful explosives were weeded out, and finally, they were left with dynamite, compressed gun-cotton, and lithofracteur. Lithofracteur, as was stated in the Paper, was practically a form of dynamite. He might say at once that there was little to choose between dynamite and compressed gun-cotton on the score either of explosive power or of expense. Nitro-glycerine was tried, and some of the later nitro-glycerine compounds which were alluded to in the Paper, such as camphor-etted blasting gelatine, were experimented on; but compressed

gun-cotton certainly presented, for military purposes, advantages which dynamite did not. In the first place it was absolutely safe under fire and in fire. In the second place it was of rather more convenient substance than dynamite; and in the third place there was no exudation from it; consequently, it was not unpleasant to handle. It might be fashioned into more convenient shapes, and was not only unaffected by wet, but was absolutely increased in detonating power in the wet state. No doubt in the wet state a certain amount of dry gun-cotton, called the primer, was needed to ignite it, and so far that was a disadvantage. He had seen the processes of manufacture of compressed gun-cotton and of dynamite, and, as far as he was able to judge, the manufacture of compressed gun-cotton was the safer. The qualities he had referred to might be of little concern for ordinary blasting operations in every-day life, although they were grave considerations in military operations. But none of these explosives satisfied all military requirements, and gunpowder was necessary in mining. In earth, the effect of explosives other than gunpowder was too rapid, and in mining under water the best result was produced by a judicious combination of both. As charges for submarine mines, he thought dynamite and compressed gun-cotton were without rivals. But gun-cotton had one great advantage in that, however much wetted, water had no effect upon it; therefore, for military mining purposes it was considered superior to dynamite. As an instance of this he would mention that a large charge was laid at Portsmouth to which water had free access for many hours, and it was fired with full effect. The presence of the water appeared not to have deteriorated the charge to any extent. That was a great thing in military mining, because the charges often had to be put down in a hurry, under improvised arrangements, where there were no means of making them thoroughly watertight. These explosives were also useful in military operations in the field, such as the demolition of bridges and piers. The ordinary plan was to hang a necklace of gun-cotton discs around the pier of the bridge, and then detonate it in the customary way; the pier was cut in two, and the structure fell; whereas under the old arrangements holes were bored in the pier, which took up considerable time. These explosives were also satisfactory in the matter of their storage. In the case of powder magazines, great expense was entailed in building solid walls and covering them over with large masses of concrete. Latterly, as much as 40-feet thickness of concrete had been put in front of some of the buildings, in order to make them proof against the projectiles of the

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present day. There was no necessity for anything of the sort with regard to dynamite and compressed gun-cotton. They might be put in a light building. He referred especially to compressed gun-cotton, because dynamite was not now used in the military service. Perfect confidence was felt in compressed gun-cotton, because under ordinary circumstances, though it might burn, it would not explode. In the wet state, too, gun-cotton might be carried about with impunity. It was not detonated at ordinary temperatures, except under circumstances which required considerable time. Fire did not detonate it, neither did a shot fired into it. Therefore, for all purposes of transport it was perfectly safe; yet, curiously enough, in consequence of the evil name which attached to it from past explosions, public carriers regarded gun-cotton with disfavour, and some actually declined to carry it. This reminded him of the old prejudice against railways. When railways were first introduced people thought with fright of the number of accidents that would happen, and yet it was now known that the percentage of fatal accidents was much less than in the old coaching days. Gun-cotton and dynamite were most excellent servants. They were *faciles principes* amongst explosives. He did not mean to say that other explosives were not good in their own particular spheres, but gun-cotton and dynamite were the most powerful; they might be employed with no extraordinary risk, and in intelligent hands were safe. But familiarity with danger bred carelessness, if not contempt; and from a considerable experience in the employment of both military and civil labour, he could say that no class of men were more careless than the mining class. In fact that class required to be protected against itself; and, considering the awful results that followed from the explosion of such highly powerful substances, it was scarcely possible to frame regulations which should be too strict; and too much care could not be taken to guard against exaggerating their good qualities in respect to security. In dealing with these agents some results had been arrived at which were scarcely expected at first. The explosive which was best for hasty work was also best for ordinary work. In removing rocks, for instance, in tunnelling, the use of these particular agents was attended with safety, economy, and rapidity; if they were properly applied, there was no unwholesome residuum left in the tunnel. In removing rocks in harbours and sunken vessels, and in quarrying in hard stone, he knew of nothing to equal these agents in value. The making of bore-holes, which was often a very difficult matter in exposed tideways with heavy seas sweeping in, was sometimes avoided

altogether; and often if not entirely, partially avoided. He could say from his own experience that there was great economy in the use of these two agents. In the case of sunken iron vessels which it was desired so to break up that the fragments might afterwards be easily removed, gun-cotton or dynamite could be used with great facility and economy. There was no saying to what extent these substances might be used. There was one application of dynamite, or of nitro-glycerine, of which he was unaware until recently. He had seen that nitro-glycerine, or some preparation of nitro-glycerine oil, was a specific for *angina pectoris;* and since then he had read that it was a remedy for complaints in the head and various other maladies. But even in these compounds such applications did not leave gunpowder far behind. When he was a boy, a soldier's remedy for diseases was a charge of gunpowder in water, and he could say from his own experience that it was a good remedy. Colonel Nugent.

Mr. G. G. ANDRÉ feared that the Author, in his endeavour to deal out a due meed of praise to one kind of explosive, had treated others somewhat harshly. This was particularly evidenced with regard to gunpowder, and more especially with regard to that particular kind which had lately been brought out by Messrs. Curtis and Harvey, under the name of Extra Strong Mining, or E. S. M. powder. That powder deserved a little more attention than had been paid to it in the Paper, and he might perhaps be allowed to make a few remarks upon it. When the nitro-glycerine compounds were first brought into the market they had many objectionable features. At that time their stability was not ensured. They were liable to go off from unknown causes, and then, as now, their combustion often gave rise to noxious gases. But those explosives were capable of performing work which ordinary blasting powder could not do, and therefore it became necessary to have recourse to them. It then occurred to Messrs. Curtis and Harvey to attempt to improve gunpowder, so as to enable it to perform many kinds of work which otherwise would have to be done by nitro-glycerine compounds. Of course, there would always be some very strong and tough rock which could not be dealt with by gunpowder effectively; but there were many classes of rock where a strong powder might be usefully employed instead of those compounds. He thought it would be acknowledged that Messrs. Curtis and Harvey set to work in the right way to produce the new kind of powder. They first got the best quality of materials, and put them together in the best proportions to give the greatest volume of gas; and then, as the force of the superior nitro-glycerine compounds and gun- Mr. André.

Mr. André. cotton was mainly due to their much quicker decomposition, they, by special means of incorporation, made the powder burn very quickly, so that when fired it developed much greater force than ordinary blasting powder. Numerous experiments showed that their hope had been realised, and the powder was brought into the market. The Author of the Paper, while acknowledging the superiority of the E. S. M. over ordinary blasting-powder, insinuated that its superiority was not quite so great as it was stated to be. But no evidence had been brought forward in support of this statement. The Author merely fell back on the somewhat general ground, that comparative results were unattainable, and that therefore it was impossible to know by how much one explosive was more powerful than another. But he failed to see why those results could not be attained. True, no two shots in natural rock would suffice, because it was impossible to tell what was the resistance, and two shots could not be fired under precisely the same conditions; but if one explosive was employed in driving a heading in a certain kind of rock, say for a month, and another kind of explosive was used for another month, the quantities of powder, and the progress of the work being carefully noted, results could be secured which would show the relative efficiency of the explosives. It had been found from the experience of several years, that the E. S. M. was much more effective than ordinary blasting powder. He had made some experiments by taking a number of concrete blocks of equal dimensions, and, as nearly as could be judged, of equal texture. He blew a large number of such blocks to pieces, carefully noting the quantities of powder used, and he found that the E. S. M. would produce as much effect as three times the quantity of the best ordinary blasting powder.

In the Paper complaint was made about a statement to the effect that by the detonation of gunpowder the strength was increased fourfold, and that therefore a reduction of something like 75 per cent. might be effected in the powder used. In this case there was certainly a little inconsistency, for in another paragraph it was stated, "Messrs. John Hall and Son give directions, which it is presumed must be based upon the results of practical experience, that about one-fourth less weight of the compressed charges should be used than of the powder ordinarily employed" (*ante*, p. 8). This statement was spoken of with approval, and the other was condemned, but he failed to see that they differed in definiteness. In one a reduction of three-fourths was spoken of; in the other a reduction of one-third. But the remarks in the pamphlet were necessarily definite, because they dealt with a com-

munication made to the French Academy of Sciences respecting certain experiments carried out by Messrs. Roux and Sarrau on the detonation of gunpowder. They found that in the bursting of an iron shell, when the gunpowder was detonated, one-fourth of the quantity would burst the shell; and they very naturally came to the conclusion that the powder was increased in effectiveness four-fold; and those were the results dealt with in the pamphlet. Consequently the statements were definite also. In the circulars which were issued subsequently, Messrs. Curtis and Harvey said that the force was greatly increased by detonation, and that was acknowledged by the Author of the Paper. Mr. André.

But a far more important matter was the grave charge brought by the Author against Messrs. Curtis and Harvey, of having made misleading statements concerning the fumes of gunpowder, and he had laid upon them serious moral responsibility on this account. The haste with which this accusation was made had led the Author into slight inaccuracies at the outset, for he said: "Several of the printed statements respecting the merits of Messrs. Curtis and Harvey's extra strong mining powder, contain an assertion calculated seriously to mislead those employing the powder in mines; namely, that it is free from noxious or injurious fumes" (*ante*, p. 6). Now, the statement occurred in only one circular, which was issued in March 1874. But in order to sustain the accusation it became necessary to somewhat pervert the meaning of the expression used. No one who read the circular would come to the conclusion which the Author of the Paper had drawn—that it was meant to convey the impression that no noxious gases were generated. It was only a comparison with the nitro-glycerine compounds. Six years ago the nitro-glycerine compounds were less stable than at present, and bad accidents arose from their use. They were liable to be decomposed by exposure to the sun, and sometimes they exploded no one knew how. In all cases gun-cotton and dynamite produced noxious fumes. The circular said that the advantages of this powder in comparison with the nitro-glycerine compounds was, that it had much greater strength than ordinary mining powder, produced less smoke, and without injurious fumes; that it was quite as safe as ordinary powder, not liable to explode, like some, by self-ignition, and that the cost was much less than the nitro-glycerine compounds. What was meant was that this powder did not give off the injurious fumes which were given off by gun-cotton and dynamite. No other meaning could be ascribed to the statement. As gunpowder was not a new thing, it was not thought necessary to inform miners that the fumes given

Mr. André. off by this powder were those ordinarily produced by burning gunpowder. But even if taken in its perverted sense the statement was strictly true. Ordinary blasting powder was a cheap compound; the best materials were not employed; there was a deficiency of saltpetre and an excess of sulphur; not too much labour was bestowed on the incorporation. There was always, therefore, a considerable evolution of carbonic oxide, and a good deal of sulphur was thrown in a free state into the atmosphere. But that was not the case with the E. S. M., because the proportions were not such as to produce carbonic oxide, and no sulphur was thrown off. Even in the Paper the Author seemed to have anticipated the fact that after all nothing but carbonic-acid gas was to be found, for he said: "The atmosphere produced by the development of large volumes of such a mixture in confined workings is certainly not one into which miners should be invited to enter with impunity, directly after the firing of shots, upon the faith that it contains 'no unwholesome gases'" (*ante*, p. 10). It was never stated that no unwholesome gases were present. All miners knew what the fumes of gunpowder were, and they would never go into a heading directly after a shot was fired. The smoke would render it impossible for them to see. There was, therefore, not the slightest danger in that direction. Besides, after all, the quantity of carbonic acid given off by a charge of gunpowder was but small, so that by the time the miners could enter, the atmosphere was certainly in no worse a state than in theatres at the end of a performance. To charge manufacturers with grave moral responsibility for having made that harmless statement was, to say the least, running justice rather hard. But even if the assertion were true, supposing the fumes were worse than those of other compounds, as the statement occurred only in a circular issued more than six years ago, it seemed like raking up an old scandal to damage an adversary.

As he himself was directly referred to in the Paper, as the introducer of a detonator, he should like to say a few words on that subject. He thought that detonation in gunpowder could not be the same thing as in nitro-glycerine and gun-cotton. Nitro-glycerine was a liquid, and all the molecules were in absolute contact, the atoms being placed in the best position. When detonation was set up in one point, the breaking up of the compound was necessarily extremely rapid. The same thing took place in gun-cotton. When the breaking up commenced in one of the fibres, it extended with great rapidity through all the rest, because the compound was a chemical one; but gunpowder was a mechanical mixture, in which

the atoms of oxygen were found in large masses of molecules of saltpetre, even when the incorporation was conducted with the greatest possible care. The conditions were therefore altogether different from those in a chemical compound. On the mixture breaking up, the atoms of oxygen had to go in quest of the carbon with which to combine; consequently a much greater time was taken up. The detonation of gunpowder could only mean simultaneous ignition of all the grains of powder. Each grain must necessarily burn from the outside inwards, and all that could be done was to ignite the grains as nearly simultaneously as possible, and that was all that was intended to be done by the detonator referred to in the Paper. A charge of powder consisted of grains with interstices, and if the detonator were sufficiently strong to restrain the gases until a high degree of tension was obtained, when the casing burst, these gases ignited, as nearly simultaneously as possible, all the grains in the charge, and as the gases were at the same time under tension, they were forced into the grains, which ignited on the outside and partly on the inside. The period of ignition was thus done away with, and only combustion remained; consequently the charge broke up more rapidly than in the ordinary way, and with much better effect. Detonation itself was known long ago. The Author of the Paper had gone back to the year 1869, when experiments were made on the detonation of gunpowder; but in the year 1854 General Picot published a work on the Art of Siege Warfare, and in that he advocated the detonation of gunpowder by means of fulminate of mercury detonators. He said: "For detonators we used copper cases 11 millimètres in diameter, containing 1 gramme of cap-composition, fitted to the end of Bickford's safety fuze. The cost of each, including fuze, was about 7 centimes. A long-continued use of these caps showed that, for a given effect, we might reduce the quantity of powder by one-third, or with equal charges obtain a greatly increased effect. From the results obtained we are justified in believing that for mines in military operations, where light tamping is often necessarily used, and especially in those cases where no tamping at all can be applied, this mode of firing with fulminate caps offers important advantages in the greatly increased effect produced. It would be interesting to try the effect of firing a charge of powder by means of one of these caps placed in the centre, in a cannon having its muzzle stopped with clay. I believe this would be an effective and a very ready and safe way of rendering captured guns unserviceable." The statements referred to experiments carried on a few years

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Mr. André. previous to 1854. He thought, however, that something like detonation might be found a century and a half further back still. In 1725, Henry, King of Navarre, laid siege to Cahors, and in order the more effectually to break in the gates and make breaches in the walls, he detonated gunpowder in this way. He took an iron tube closed at one end, and placed in the centre vertically along the axis a small round rod. This was held by one man while another poured the charge in and rammed it down tight. When the cylinder was full, the rod was withdrawn, leaving a hole down the centre, which was afterwards filled with fine quick-burning powder. The quick explosion of this central core simultaneously ignited the whole of the grains composing the charge. To use the words of the writer, the effect of the explosion was more satisfactory to Henry, King of Navarre, than to the besieged. The best results could also be obtained from any blasting powder, especially the E. S. M., by taking a cartridge having in its centre a straw filled with the best fine sporting powder into which the fuze was inserted. The sudden explosion of the central core detonated the charge, and good results could be thereby obtained—better than in the case of the fulminating detonator, on account of the great amount of gas given off by the fine powder in the centre.

Mr. Webb. Mr. ORLANDO WEBB said there could be no doubt as to the great power exerted by gunpowder in a compressed state as compared with ordinary gunpowder. Twenty years ago he prepared charges of gunpowder, both for the Enfield rifle and Whitworth's large guns; and at Southport, where Whitworth's 12-pounder, 5-pounder and 3-pounder were fired at different elevations, the range was found to be about one-fifth more for each shot when the compressed powder was used. He also took some charges down to General Hay at the School of Musketry, Shorncliffe, for the Enfield rifle, and was anxious to have them tried. General Hay took one of the pellets in his hand, and said, "You say this will explode rapidly: if any gentleman comes to me and tells me anything, I am bound to accept it until the contrary is proved; but all I can say is, if this does explode rapidly you completely destroy the whole theory of gunpowder as I have understood it from my earliest days." However, he tried it. He first fired a diagram of twenty shots at a range of 600 yards with some powder which he afterwards learned was made at Waltham Abbey expressly for General Hay. He then fired a diagram with the compressed powder. When the first charge was inserted into the rifle he said, "Now for a

ricochet; and if we do not get it I shall be very much astonished." He did not get it. He found that with a lower trajectory he could make better shooting with the compressed powder; and he afterwards stated that the powder used for firing the first diagram was a very superior powder made for himself, and much stronger than the ordinary government powder. Mr. Webb had therefore no doubt that compressed powder would produce a much greater effect than ordinary powder. The compressed powder was prepared under Brown's patent, and the grains were preserved. If he understood rightly Curtis's powder was of the pasty kind, and the grains were not preserved. He had received a communication from Mr. Nobel to the effect that Mr. Nobel entertained a very high opinion of his invention. It was, as far as he could gather, something of the same sort as Messrs. Curtis and Harvey's, but the mode of firing the powder was different. With regard to the question of noxious gases he would not say that any detonation could be produced without gas, and without, to a certain extent, noxious gas; but he did not think Mr. André was right in all the propositions which he had put forth. In 1873 Dr. Hudson, a gentleman who had great experience and a large medical practice amongst the miners in Cornwall, read a Paper before the Royal Institution of Cornwall,[1] "On Dynamite, in its Sanitary Aspect." In an addendum to that Paper, bearing the date of the 10th of March, 1879, Dr. Hudson treated of powder smoke in mines and the injurious effects that it produced. He mentioned several cases, and quoted the following sentence from the report of the Kinnaird Commission of 1862 and 1863: "It appears that the excessive rate of mortality among Cornish miners is mainly caused by the large number of deaths from diseases of the lungs." He then proceeded to say that "the affections of the lungs from which miners suffer, although commonly known by the name of miners' decline, is not of the nature of tubercular consumption, but corresponds to and is indeed the same disease as is developed in other places among workers in dusty places. It is called 'grinders' rot' in Sheffield, 'stonemasons' decline,' 'rag-pickers' disease,' 'wool-sorters' asthma,' &c., in other places." Then he went on to say, that great improvement had taken place in the health of miners for some years past, and he stated his reasons for that. Among other things he spoke of ventilation in mines, and concluded thus: "But most prominent among the beneficial causes, I place the

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[1] *Vide* "Journal of the Royal Institution of Cornwall," vol. iv., 1871–73, p. 257 *et seq.*

Mr. Webb. replacing of gunpowder by nitro-glycerine explosives. I have been underground for the purpose of acquiring personal knowledge of this fact, and in a mine where gunpowder is the main explosive employed, the air is just like a London fog, thick, black, as if it could be cut; whereas in a mine where dynamite was mainly used, the underground atmosphere was clear, and you could see a long distance along the level." Some persons were so bold as openly to state that no noxious gases were produced by the explosions of strong compounds. An extraordinary case came under his notice some time back. He was in a court of Justice while a trial was proceeding. The question involved was the explosion of lithofracteur, and a gentleman who knew a good deal about explosives, and who might be considered a high authority on the subject, gave evidence to the effect that no fumes were given off by the explosion of lithofracteur. The learned Judge said, "I suppose you mean not so bad as dynamite?" but the answer was, "No, my lord, I do not mean that, I mean no fumes." Now it so happened that on that very day a gentleman was taken out of a tunnel or shaft in North Wales insensible from the fumes of lithofracteur. He concurred to some extent in the observation made by Mr. André, as to the slur that had been cast upon manufacturers for some statements that they had made, and particularly that Nobel's Dynamite Company had asserted in one of their advertisements that dynamite was not affected by damp, and that this was calculated dangerously to mislead. But the statement was rather calculated to instruct and caution persons using dynamite, since it was impossible for any person to read that statement without seeing that it was meant that the explosiveness of nitro-glycerine was not destroyed or affected by damp. It was not calculated to mislead the miners or to do mischief. But, on the other hand, persons high in authority, and even Government officials, had been guilty of stating in harbour bye-laws that the explosive character of dynamite was to be destroyed by putting it in water. He could not conceive of anything calculated more effectually to mislead, or to do greater mischief, than such a statement. It was well known that if a cartridge was put in a cup of water the nitro-glycerine immediately separated itself from the earth in which it was contained and sank to the bottom. It there became a liquid explosive of a dangerous kind, as had been shown by accidents from time to time. He thought it was rather hard that parties who had lent themselves to such statements should twist and turn an expression, inserted in an advertisement for a totally different purpose, namely, to caution the public that

damp would not destroy its explosive effect, and thereby to warn them against mischief that might ensue. He thought it hard that those very parties should bring it as a positive charge against Nobel's Company, that they were making misleading statements calculated to imperil the lives of their fellow-citizens. The statement did not originate with Professor Abel, who only quoted it from one of the Reports of the Inspectors of Explosives, and he had nothing to do with the harbour bye-laws. The Explosives Act had been referred to in the Paper in such a way that he presumed it was intended that the meeting should offer comments upon it. That Act was the most extraordinary combination that the Statute Book contained. There were one hundred and twenty-two sections, four schedules, two hundred and nine sub-sections, eleven Orders in Council having the force of an Act of Parliament, and four orders of the Secretary of State. The most striking feature in it was that it abounded in penalties. Almost every clause contained one, and he ventured to say that at the present moment there was not a dealer in explosives, not a person who had anything to do with them, who was not subject to one penalty if not more. It had been said that the Act worked smoothly, but that was simply because it was not put in force to its full extent. He, however, could mention instances in which it had been acted upon, and put in operation most harshly and unjustly. But there was this additional difficulty: that if harshness was exercised the matter could not come before a jury unless a penalty of £100 was sought. There could not even be an appeal unless the penalty was £20, and then the appeal could only be to Quarter Sessions. The only court before which the question could be brought was a court of Summary Jurisdiction—a magistrate or two magistrates, and they were not always the most impartial tribunals in the country. In addition to the penalty, the magistrates might at the same time condemn the explosives to the amount of £1000 or more, but no matter what the value of the substance condemned was, the only amount taken into consideration was the actual penalty. That was a most extraordinary state of things. With regard to the carriage of explosives, manufacturers were in this difficulty, that railway companies would not carry them—ostensibly for one reason, but in reality, he believed, for another. The cause assigned was that dynamite and gun-cotton were of a dangerous character; but it was well known that they were not so. The railway companies knew that they were in the habit of carrying articles which were ten times more dangerous. Some years ago he had a difference

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with the London and North Western Railway Company about the carriage of dynamite. He told them that they never had suffered, and never would suffer, from carrying it, and that they were carrying much more dangerous articles, such as petroleum. Within two months of that time the Abergele accident occurred, and the Traffic Managers of the Company had looked upon him with great suspicion ever since. He believed, however, that one of the great causes of the difficulty was the rules that had been imposed upon companies by the Government. If he were a director of a railway company he would not think of carrying explosives, because the cost occasioned by observance of the bye-laws would be much more than he could charge. A still greater difficulty arose from the harbour bye-laws. At the present time the only mode of sending dynamite and other explosives to many parts of the country was by sea. Nobel's Company employed two steamers and a sailing vessel constantly taking their explosives to different places; but every harbour had a different set of laws. Many harbour authorities would not receive explosives at all. Some of the laws were certainly peculiar. The harbour of Leith had become notorious with regard to this matter. Amongst its provisions was one that no explosive should be received into the docks unless it was brought in a railway van propelled by manual or animal power. Then one man must be provided by the shippers at their own expense to attend the van, and as many more men as might be required must be provided by the harbour authorities; but no man should be employed unless he was certified by the shippers to be of sober habits, thoroughly instructed in the bye-laws, and was, for the time being, in clothes without pockets or metal buttons, and wearing boots or shoes having no exposed steel or iron. The number of men employed was always to be such as the superintendent of the harbour or docks should deem sufficient. Exporters and importers were to pay such rates as were considered just, and all wages and expenses incurred were to be defrayed by the shippers. The thirteenth bye-law was a very peculiar one. "No horses shall be allowed to enter the docks, or to be on the pier in connection with the gunpowder explosive trade, unless they are shod with or have their hoofs encased for the time being in magazine boots." Another bye-law was that before the shipment of gunpowder or explosives commenced, the superintendent of the harbour and docks should cause that part of the pier at which it was to take place to be carefully swept and to be well soused with water both before and after the shipment. In addition to that, a passage between the carriage and the ship or boat

along which the van should pass, must be covered with woollen cloth, or in such other way as the superintendent should direct. In the event of any explosive being spilt, the shipper, or person or persons in charge should immediately cause the material to be thrown into the water. Besides the men employed by the shippers, the superintendent should place on the pier two watchmen, who were to remain on duty until the boat left the harbour, and the wages of the watchmen were to be paid by the shippers. If any person neglected any of these points, the penalty that might be inflicted upon him was £10, and the loss of all his stock. If, therefore, the superintendent or harbour-master employed a man who was not certified by the shippers as being of sober habits, or who had a pocket in his clothes, the shipper, although he had not himself employed the man, and had no control over him, would be liable to a penalty, and might forfeit all his goods. That was a most unsatisfactory state of the law; but the bye-laws in many other harbours were equally peculiar. These bye-laws were the subject of some comment in the newspapers; and the authorities of Leith felt rather annoyed at the observations that were made. They held a meeting, and they complained bitterly. They said that they prepared reasonable bye-laws, and that all the strange provisions complained of had been inserted by the Board of Trade. It was a serious hindrance to manufacturers and dealers in explosives to be subject to such laws, and the extraordinary thing was, that the laws varied in different ports. The Author had said in his Paper that he had reason to suppose that the Explosives Act, under which these bye-laws were framed, would receive some amendment in the course of a short time. He sincerely hoped it might; but in their annual reports for 1876 and 1877 the inspectors said that they were exceedingly gratified and pleased with the way in which the Act worked, and that it could not be improved. They, therefore, had not the most distant idea of any amendment.

Mr. Webb.

Mr. R. M. GARDINER noticed that the Author of the Paper gave, as one of the causes why compressed gun-cotton had not been applied to industrial purposes, the doubts raised in the minds of the public by the great catastrophe at Stowmarket, but he thought it had been found practically that gun-cotton was dangerous as a mining agent, not only from its inflaming in charging the bore-holes, but from the poisonous carbonic oxide which it gave off. It was thrown out of the market for that reason. It never could be used with safety by the miners. Afterwards the Stowmarket Company attempted to get into the market a modification

Mr. Gardiner.

Mr. Gardiner. of gun-cotton nitrated with nitrate of soda, but they were obliged to send it out in a moist condition, and, consequently, there was great difficulty in getting it to explode. Next, tonite or cotton-powder was produced. As it was exempt from carbonic-oxide gas, and was always in a dry condition, and, therefore, readily exploded, it overcame the defects that were found to exist in the other manufacture. Although the Author appeared to have thought tonite was liable to give out noxious fumes, he probably arrived at that view on theoretical grounds; but, practically, it was found that miners could go in immediately after the charges had been exploded and resume their work. They could not do that with any other explosive. Another serious mistake which the Author had fallen into, and which no doubt he would be glad to have pointed out, was, that railway authorities carried tonite or cotton-powder under the disguise of a fancy name. That was entirely wrong. The railways did not know the name of tonite; it was always invoiced to them as cotton-powder, and therefore they knew exactly what they were carrying, and were perfectly satisfied as to its safety.

Mr. Mackie Mr. S. J. MACKIE said that, having done something to the best of his ability to advance the progress of gun-cotton, he might be permitted to make a few remarks. In the former part of the discussion a great deal had been said as to carriage, transport, and other matters relating to the law, and a great deal had been left unsaid on the respective merits of the explosives which were most generally used. The nature of the Paper was such as necessarily to lead to a certain amount of crimination and recrimination, because the Author had passed criticisms very freely upon all the best known explosives, and no one had a better right to do so, standing as he did without a compeer even among those who were employed in a similar capacity by foreign Governments. But the tenor of his criticisms was certainly felt keenly by the manufacturers of explosives, and by inventors. At the present time inventors suffered a great deal by placing their inventions before the Government, because as long as an article was *sub judice*, commercial men waited for the verdict of the Government officials. He had felt some surprise at the large amount of patronage given by the Author to dynamite, particularly gelatinised dynamite, of which there was very little experience. The Author had also referred to nitrated gun-cotton. Whatever merit or demerit was due to the use of nitrate of baryta, Mr. Mackie believed that he himself was the first who ventured to use it in connection with gun-cotton. He did it under peculiar circumstances. He did

not say it was the best oxidiser, nor would he admit that it was the worst. He had been previously experimenting with chlorated gun-cotton, a material of a sensitive nature, and he had tried it for three hours against dynamite, and it had not been vanquished; but he had allowed a small sample to remain behind, and though he had a written undertaking that it should not be used except by the person himself, it was entrusted to a servant, and an accident ensued. He then sought for an oxidiser which should be less sensitive than chlorate of potash, and which should not trench on the ground that the Author had taken previously in the use of nitrate of potash and nitrate of soda. He had been surprised to hear that tonite gave off no carbonic oxide during an explosion. He did not say that it gave off any quantity which would be noxious in ordinary use, but to assert that any explosive in exploding did not give off carbonic oxide was, he thought, a mistake. Certainly in the use of explosives under ground there was a variety of adverse circumstances to contend with, and in ill-ventilated mines there was scarcely an explosive that could be used which was not liable to produce a feeling of nausea under certain circumstances; but the ventilation of mines was now generally so good that there was little danger on that score, and in tunnels the use of the power drill introduced so large a quantity of air, as to ventilate intermittently the tunnels to a considerable degree; and after firing it was the common practice to use the air-blasts from the supply-pipe to prevent detrimental effects from fumes. In reference to the subject of legislation he could scarcely avoid making an allusion to the nature of the present Act of Parliament, particularly as to mines in which the quantity of explosive was limited to 5-lb. charges. That was a very small quantity, and certainly in tunnels it would be useless. He thought that there should be some enlargement of the quantity in any new Act that might be passed. He knew it was the fashion to abuse miners and quarrymen for their rashness and negligence. Perhaps few men had had more experience of miners and quarrymen, and workers in tunnels, than himself, and he could not believe that they were the reckless persons they were often supposed to be. He might remind engineers that their great conceptions had been carried out by the intelligence, skill, and bravery of those men. Many things which were looked upon as rash were often matters of necessity. Miners were employed to do dangerous work; they had to buy their own fuzes and powder, and to fire their own shots, without any education or instruction; moreover, they were generally employed on piece-work, and time was conse- Mr. Mackie.

Mr. Mackie. quently to them an important element. Whenever a miss-fire therefore occurred, the miner could not afford to allow any lengthened period to elapse so that he might approach it with absolute safety. The present Act, in that respect, was also at fault, for it required a period of eight hours to elapse before the charge which had missed was approached. A miner would not give up that time, and he thought that something might be left to individual tact and ability. His own rule had been to double the time that should have elapsed before the shot should have fired before he ventured to go near it, and he thought that limit was sufficient. With regard to dynamite and all nitro-glycerine compounds, he did not think that they approached gun-cotton in safety and wholesomeness, and they were subject to deterioration, if not to danger, after having been once warmed. He had recently been in North Wales firing with dynamite, and he observed that although a man had warmed the dynamite, and brought it to the bank, it was not there five minutes before it was hard again and useless. The thawing of dynamite was one of its greatest dangers. Gun-cotton did not require to be thawed. It might be used damp, as the Author had taught with great benefit to the world as well as to gun-cotton manufactories, which previous to the introduction of water were dangerous, and constantly the source of catastrophes. Certainly gun-cotton was a most valuable explosive when used in combination with gunpowder. During the last four days he had been successfully firing gunpowder shots with small charges of ordinary Stowmarket gun-cotton of good quality, and the result had been exceedingly satisfactory. He had little doubt that in the future gun-cotton would take its proper place, and rise to that eminence which it would have attained years ago had it not been for the catastrophe at Stowmarket, which he believed not merely to have arisen from preventable causes, but might possibly have been an act of maliciousness. For military and naval purposes he thought that it was without a rival. For torpedoes gun-cotton compressed in any form had this advantage, that it was not prevented from exploding by the leakage of the case containing it. Other explosives were liable to injury from damp, and nitro-glycerine and dynamite were affected by leakages; but gun-cotton might be placed under water and fired without any protection.

Professor Abel. Professor ABEL, in reply, observed that the even hand with which reproof had been dealt to him by representatives of the interests of gunpowder, dynamite, and gun-cotton, would, he thought, be a sufficient answer to the suggestion of partiality

made by Mr. André, in his remarks bearing upon gunpowder. He thought he might claim to be an old and true friend of gunpowder. It had been the subject of some of his most arduous labours, and he had hoped that he had shown himself anxious to promote its improvement from a scientific and a practical point of view. Mr. André seemed to think that he was very severe in reference to gunpowder, chiefly because he had stated that even such specially prepared gunpowder as the E. S. M. of Messrs. Curtis and Harvey could not compete with nitro-glycerine and gun-cotton preparations in certain work, which those agents were particularly calculated to perform. He had been careful to point out that there were two classes of explosives, the one class represented by nitro-glycerine and the other by gunpowder; the one class comparatively gradual in their action, and therefore valuable as cleaving and displacing agents, and valuable also as propelling agents; the other class violent and sudden in their action, and therefore valuable as rending and shattering agents. No decided line could be drawn between these two classes of explosive agents; the one merged into the other; and such gunpowder, as military powder, prepared with great care and properly applied, might be made to some extent to produce effects analogous to those produced by dynamite or gun-cotton. That was the case with Messrs. Curtis and Harvey's E. S. M. powder, for, in point of fact, what Mr. André particularised as their special improvement of gunpowder, consisted simply in their having made blasting powder which closely resembled military powder in its composition and general character. He might state, for Mr. André's satisfaction, that his experience, extending over the last fifteen years, in reference to the comparative merits of powder and the more violent explosives was not based upon the comparison of ordinary blasting powder with the violent agents to which he had referred, but of ordinary military gunpowder. Therefore, in his estimates of their relative value, powder had been placed under the most advantageous position. As regarded the statements of the manufacturers respecting the strength of their improved powders, he had neither approved of Messrs. Hall and Son's statement nor condemned those of Messrs. Curtis and Harvey; but notwithstanding Mr. André's comments on what he had said of the difficulty of establishing precise comparisons, he still deprecated the publication of figures of comparative value, as precise, which were unreliable approximations. Mr. André referred to what he had stated in connection with the detonation of gunpowder, and there were considerable discrepancies between Mr. André's remarks and what

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Professor Abel. had appeared in print concerning his views on that subject. As far as he understood, Mr. André now stated that gunpowder could not be detonated; that detonation was peculiar to chemical compounds, such as nitro-glycerine or gun-cotton, in which an action could be established which was carried on from molecule to molecule with practically instantaneous effect. He ventured to correct Mr. André on that point, and having given the subject special study, he would go so far as to say that detonation was a peculiar description of metamorphosis which could be developed in an explosive substance independently of its chemical character; that its development did not depend upon whether the explosive agent operated upon was a chemical compound or a mechanical mixture. One explosive material was more readily susceptible of detonation than another, but all were susceptible of detonation. If submitted to the action of initiative detonation, which acted in a manner analogous to the blow of a hammer, those materials were all susceptible of sudden conversion into gas, and they only differed in this respect, that the amount and the character of the required initiative detonation varied with the nature of the explosive agent; whereas, with certain chemical compounds the blow required for their detonation was slight, with others it was considerable, and with chemical mixtures such as gunpowder it was still more considerable. It was also known that the character of the detonation to which certain compounds and mixtures were very susceptible did not so readily affect others, and therefore in those respects explosive substances differed; but all, whether compounds or mixtures, were susceptible of the comparatively sudden chemical disintegration distinguished as detonation. When Mr. André spoke of the experiences of Henry of Navarre, which were interesting only from an historical point of view, he was not dealing with an example of detonation at all, but merely with an instance of the application of means of facilitating rapid explosion or rapid ignition of a charge. He stated that a central cavity of a charge of powder was filled with fine-grained and rapidly explosive powder, by which means rapid ignition of the entire charge was developed; and he gave that as an early instance of what might be considered to be detonation. It was nothing of the kind, but simply rapid ignition of the charge, by means similar to those which it had even been found desirable to adopt in the case of the application of large charges of slow-burning powder in guns, where it was certainly not desired to develop detonation. With regard to Mr. André's description of what was published by General Picot, in 1854, the case was other-

wise. That was an instance (of which he was not previously aware) of detonation being applied to gunpowder some considerable time before Nobel had called attention to that peculiar mode of developing the maximum force of explosive agents. Mr. André had further stated that he had dealt harshly and unjustly with an eminent firm of gunpowder manufacturers by referring to a circular issued by them six years ago containing the statement that the E. S. M. powder presented the advantage of not evolving noxious vapours, and that his doing so seemed like raking up an old scandal to damage an adversary. He entirely deprecated any such consideration of his position in reference to Messrs. Curtis and Harvey, and he ought to state how he came to be aware of such a statement (which he had described as misleading) being contained in the circular in question. When he prepared his Paper, he was anxious to have full information with regard to improvements that had been effected in gunpowder and other explosives; and knowing that Messrs. Curtis and Harvey had devoted considerable attention to the improvement of gunpowder for blasting purposes, he applied to them, as to others, for information as to what they had been lately doing; they were so good as to reply to his inquiry by sending him a number of circulars, among which was the one in question. True it was written six years ago, but it was sent to him the other day by Messrs. Curtis and Harvey, and he therefore presumed that it represented their present views with regard to the merits of their powder. Mr. André had also complained that he had hastily said that circulars had been issued by Messrs. Curtis and Harvey, whereas the statement referred to was the only one that existed. It was, however, only by referring to the collection of printed documents sent to him that he had obtained his information. With regard to the statement that "the manufacturers claim for this powder that it is of much greater strength than ordinary mining powder, that it is quite free from injurious fumes," it was true it occurred in an extract from a newspaper, and it was also true that other similar extracts had been taken from newspapers; but those extracts had been reprinted by Messrs. Curtis and Harvey in the form of trade circulars, and he therefore presumed that they endorsed the opinions therein expressed. He might speak in the same way with reference to Mr. André's comments on detonation, but he thought he had said sufficient on that point. He had referred in quite as strong terms to Messrs. Hall, the initiators of the important improved form of gunpowder known as compressed cartridges, as to Messrs. Curtis and Harvey, because in their circular they

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Professor Abel. had stated that this powder was particularly characterised by evolving no unwholesome gases. Mr. André had stated that it was not considered necessary to direct the attention of the miner to the ordinary gases evolved by gunpowder, which he said were perfectly harmless, and he added, that the quantity of carbonic acid evolved by a charge was small. No doubt if he used a small charge in a hole he would get a small amount of carbonic acid; but with Mr. André's large experience he would know that where blasting was practised to any important extent very large quantities of powder were used during the day, and that therefore small charges multiplied evolved large quantities of carbonic acid. It was, he thought, needless to discuss the point as to whether the carbonic acid and nitrogen evolved from powder were harmless gases. Mr. André had stated that such powder as the E. S. M. was composed of ingredients in proportions carefully calculated to produce perfect decomposition, and therefore to evolve only carbonic acid and nitrogen gases. That was also the case with the best military powders, such as those manufactured at Waltham Abbey, by Messrs. Curtis and Harvey, Messrs. Hall, and others; but in actual practice there was no such thing as a complete, simple chemical change; as a matter of fact it had been established by abundant experiments carried on with military powders under conditions most favourable to their perfect chemical metamorphosis, that in no instance did a complete and simple chemical change, such as was indicated by theory, take place in practice. A large number of analyses had been made of the gaseous products of Government powders obtained by exploding charges varying in amount from small quantities to several pounds weight in closed spaces, where the explosion had been developed under the maximum pressure attainable under the particular condition of the experiment, and in every instance carbonic oxide had been formed in appreciable quantities, the proportions found varying from 7 to 18 per cent. Such quantities could not be disregarded in reference to the injurious effects produced by gases evolved from the explosion of gunpowder. He considered, therefore, that he was right in saying unhesitatingly that gunpowder manufacturers, whether they compared their powder with nitro-glycerine preparations or with ordinary blasting powder (Messrs. Curtis and Harvey did both in their circulars), had no right to mislead the miner, who depended upon them for information, by stating that a particular powder was characterised by evolving no noxious or unwholesome gases. Mr. Orlando Webb had also reproved him for having found fault with a statement made by the

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Dynamite Company, that the article manufactured by them was unaffected by damp. Mr. Webb had pointed out, as he had also done in his Paper, that no doubt the manufacturers meant that the explosiveness of the material was not affected by damp; but Mr. Webb had gone so far as to say that no other meaning could be attached to the statement. He would ask what might be the effect, on persons not specially instructed, of an implicit belief in the statement that a nitro-glycerine preparation such as dynamite was unaffected by damp? One of the greatest dangers connected with the employment of nitro-glycerine as a blasting agent was the fact that, being a liquid, if it were poured into an unsound hole having cracks and crevices leading no one knew whither, it would pass away into contiguous portions of the rock; the hole might be exploded successfully, but when another hole was drilled in the neighbourhood, a portion of the nitro-glycerine that had escaped might be met with, and the friction exerted by the tool employed in drilling would inevitably be sufficient to explode it. That danger was a formidable one, and almost insuperable in connection with the application of nitro-glycerine. It also existed with nitro-glycerine preparations in which the liquid was merely mixed with some absorbent or thickening material. If the preparation (such as dynamite) were placed in water it would, as Mr. Webb had pointed out, very soon part with its nitro-glycerine; the water would penetrate the mass, and the nitro-glycerine would be displaced. If dynamite were placed in a wet hole, or if miners (as they were sometimes directed to do) employed water-tamping, the same kind of displacing action would occur if the charge were not fired at once or nearly at once. If the hole were unsound there would be the same kind of danger as in the application of nitro-glycerine pure and simple; the liquid would be displaced by the water, and, finding its way through cracks and crevices to other parts of the rock, it might lead to accident. Therefore, when it was said that dynamite was unaffected by damp or by moisture, he thought that miners (who had not studied the subject like Mr. Webb and himself) might be led to believe that it was perfectly unacted upon by water, and might consequently put it into wet holes, or might use water-tamping, without knowing whether the hole was sound or not, and without taking the precaution of putting the material into waterproof cartridges. All that he had intended to point out was that the statement in question was likely to lead miners to be over confident in the use of the material, and to abstain from employing essential precautions. Broad as his back was, as a Government official, he

Professor Abel. felt that he could hardly be saddled with the harbour regulations of which Mr. Webb had given some amusing illustrations. Mr. Webb himself had since felt the same, for he had written to him stating that on looking at what he had said in print, it appeared that he had imputed to him (what he had not intended) some connection with the preparation of the harbour regulations, directing that dynamite was to be destroyed by putting it into water. Mr. Gardiner had referred to a statement in the Paper that tonite, or the particular form of nitrated gun-cotton manufactured by his Company, was liable to evolve noxious vapours; and had contended that it was not right, in the case of that Company, any more than in the case of gunpowder manufacturers, to say that misleading statements had been published. Provided dynamite, or a thoroughly nitrated gun-cotton, containing sufficient saltpetre or other nitrate to completely oxidise the whole of the carbonaceous matter, were exploded under perfect conditions, only a small quantity of carbonic oxide might be evolved; but if the conditions were not perfect, as was often the case in practice, the quantity of noxious vapours evolved from a mixture containing a large quantity of nitrate was considerable. His statement was said to be based on theoretical grounds. He felt bound to return that observation, and say that, theoretically, Mr. Gardiner's tonite should not evolve noxious vapours, but practically it did so, and that frequently. His conclusions were based upon actual experiment, which he had been careful to make before putting forward the statements in his Paper. Mr. Gardiner had also alluded to his having stated that railway authorities, who had of late years behaved in so remarkable and intelligent a manner in connection with the transport of explosives, did not exhibit that remarkable intelligence towards tonite which they had exhibited in dealing even with wet gun-cotton, because the former was delivered to them for transport under a fancy name. Mr. Gardiner stated that it was not called tonite when delivered to railway companies, but cotton-powder. But cotton-powder was quite as fanciful a name as tonite. It certainly contained the term "cotton," but the word "powder" would convey to railway directors the idea that it was some sort of gunpowder. If it had been called by its true name, nitrated gun-cotton, he was sure the railway authorities would not have exhibited the special indulgence towards the Company to which he had referred. Mr. Gardiner had also stated that the disuse of gun-cotton could not be ascribed to the unfortunate accident at Stowmarket, either directly or indirectly. As the matter very nearly concerned those who had worked

arduously at the application of gun-cotton, he had written to Mr. Prentice, the managing director of the late Gun-cotton Company, asking him his views on the subject; that gentleman's reply substantiated what he had stated, that the disuse of gun-cotton in the trade was not so much ascribable to the fact that it evolved more noxious gases than nitrated gun-cotton under ordinary conditions, as primarily to the check which the industry received in consequence of the lamentable explosion at Stowmarket, which for some considerable time put a stop to the possibility of obtaining supplies; while, just at that time, dynamite came into the market and established its pre-eminence. With reference to the remarks of Mr. Mackie, he (Mr. Abel) was not likely to be blind to the advantages of gun-cotton. He had pointed out what its advantages and uses were; but as his experience had extended, he had come to the conclusion that the more modern nitro-glycerine preparations were in many respects, for industrial purposes, superior to gun-cotton preparations; and this conclusion applied especially to those materials which, as Mr. Mackie had observed, were as yet comparatively unknown in England—those remarkable materials which Mr. Nobel had lately prepared by combining gun-cotton in small quantities with nitro-glycerine. These preparations, the basis of which was gelatinised gun-cotton, possessed qualities which eliminated some of the important defects of the nitro-glycerine preparations hitherto used. They required the fulfilment of special conditions in order to develop to the fullest extent their explosive power; those conditions, however, were not difficult to fulfil, and he firmly believed that in the thickened nitro-glycerine preparations existed the powerful explosive agents *par excellence* of the future. Professor Abel.

Correspondence.

Mr. Henry Hall (one of H.M. Inspectors of Mines) stated that the experience of coalminers in the practical use of some of the explosives mentioned by the Author was as follows:—Dynamite had been little used in the actual working of coal; it was tried experimentally, but the result showed it to be too speedy in action, shattering the coal in the immediate vicinity of the drill hole without lifting and bringing it down bodily. So far as getting coal was concerned it had failed, but in sinking operations, it was still largely employed. For blasting shales dynamite was not superior to gunpowder, but in wet or hard rock it was much superior. The fumes were much worse than those of gunpowder, Mr. Hall.