Discussion.

Sir J. Wolfe Barry. Sir JOHN WOLFE BARRY, K.C.B., President, was sure the members would accord a hearty vote of thanks to the Author for bringing a very interesting, and, to some extent, novel subject before the Institution. It was a subject which was of very great interest to all engineers as introducing new possibilities in lighting with new problems and new phenomena. The Author had done wisely in bringing before the members the necessity for studying safety with the new compound. Everybody hoped to see the initial difficulties of a new development completely overcome, and looked forward to the time when acetylene-gas would prove a most useful adjunct, not only, perhaps, in enriching coal-gas, but in many other ways.

Mr. Fowler. Mr. HENRY FOWLER observed that, since the Paper was written, further restrictions had been placed upon the use of compressed acetylene, although, from the experiments tabulated in Table IX, they appeared, to a certain extent, hardly necessary. He showed, on the table, two samples of the carbide from which acetylene was generated. One was English carbide, with the characteristic red colour, and the other was the Swiss carbide, from Neuhausen, varying between grey and a bright red. The action was very simple: he illustrated it by treating the carbide with water, when it evolved the gas very readily. The gas burned as long as water was added to the carbide. It had a very strong smell, and no doubt the very small quantity which had escaped would be sufficient to enable the members to realise that. The readiness with which it would light he showed by another experiment. He placed a small portion in a test-tube, and, upon the addition of water, the acetylene rose rapidly and burned with a very smoky flame. The great objection to burning it at low pressures was that it gave off such a great amount of soot. The types of generator were very simple. He had placed on the table a Woulff bottle, to the water in which he would add a small amount of carbide, and it would be seen that the pressure generated was sufficient to cause the bladder to fill with the gas. That was the simplest type of non-automatic generator. If that were burned, the effect of the great luminosity would be apparent. The 0000 Bray Union jet was about the largest burner, and could be used for the gas without the pressure being very great.

There were on the table a number of burners of the same size. Mr. Fowler. At low pressure there was a great tendency to smoke, and the pressure had to be regulated to a great extent indeed for the size of the burner. There were also on the table two burners one of which was of exactly the same type as, and the other very similar to that shown in Fig. 11, Plate 1. Those were only for burning a small amount; they were injector-burners, in which the air was drawn in, at the same time carrying with it the oxygen necessary for combustion. They might be turned as low as required without any liability of the burners smoking. The various burners which had been used in the experiments with oil-gas were also shown upon the table, 000000, 00000, 0000, 000, and the ordinary Pope oil-gas burner. It would be noticed that a very deficient light was given by the smallest of the burners. As previously mentioned, the gas might be used in a Bunsen burner, but there was difficulty in preventing it from flashing back. If the pressure were less than 1 inch of water, there was always that tendency. If the flame were turned down it would be seen the light at once flashed back when approximately an inch of water was passed. The great smoky flame which it gave would be also noticed. But above 2 inches, a flame of about twice the heating property of an ordinary coal-gas flame was obtained. In the centre of the room a lamp was suspended, similar to that shown in Fig. 13, and used on the Manchester Ship Canal. It had three burners, and was used in ships' holds, and also for lighting the side of the dock where electric light had not been introduced. Although not comparable with the arc-light, it gave very good illumination for such positions as those mentioned. The great advantage was, that it might be used in connection with a generator similar to those shown in Fig. 12, which could be carried by two men from point to point. On the table pieces of metal were shown which had been extracted from foreign carbide; upon analysis they proved to be silicide of iron—either Fe_2Si, or $FeSi$. With foreign carbide there was a tendency to get an impure material, not that it contained ammonia, phosphoretted hydrogen, or sulphuretted hydrogen, but the lime and coke were not in a combined condition. Samples of this were exhibited. The effect of the gas on the various metals was shown with about thirteen metals; samples of each were placed in comparatively pure acetylene, the gas of which an analysis was given in the Paper contained 0·038 per cent. of phosphoretted hydrogen, and 0·03 per cent. of ammonia, whilst others were placed in acetylene containing a considerable amount of ammonia. It would be seen that the

Mr. Fowler. comparatively pure acetylene had hardly affected any of the metals present, copper being only slightly discoloured. There was an interesting specimen of a valve which had been used for two years in the presence of moist acetylene. Upon examination it would be found that there was only a slight discoloration of the parts which had been directly in contact with the gas, and that no compound had been formed which had corroded the metal. That was a strong point in its favour. He had only taken the apparatus of which this formed part to pieces since the Paper had been written, and it had not been included in the results there mentioned.

Mr. Wallace. Mr. R. WALLACE, Q.C., had seen at Foyers the manufacture of the English carbide of calcium, which, he was told by the Author, was purer than the carbide of calcium imported from abroad. It would be satisfactory to English manufacturers to know that they had produced carbide better than those who had started to manufacture it earlier. The British Aluminium Company, having let a portion of their water-power to the Acetylene Illuminating Company for the purpose of making carbide of calcium, it was thought the least that could be done would be to erect a carbide of calcium plant for generating acetylene at the shooting lodge. It was thought the best plant would be one that was not automatic—something that would work in a straightforward way—and accordingly an ordinary gasholder was adopted. He believed, as had been seen from the experiments, that acetylene gas could be generated very readily; in fact, two biscuit-tins were sufficient for the purpose. At any rate, a proper gasholder was erected, the only difficulty being that the holder itself for mechanical reasons sometimes did not rise and fall as it ought to do. The apparatus worked efficiently on the whole, and eventually a regular pressure was obtained. At first, the ordinary burners shown on the table were used. They were regularly swept out with a metallic brush every morning, so that there was no accumulation of carbon which would stop the flow of the gas or the proper combustion, but the result was that his guests said they wished he would stop the acetylene gas and give them candles instead, because all their shirt-fronts became covered with the carbon. English servants, and perhaps others, could not be expected to look after things which would not go right by themselves. For some time, therefore, he had been very dubious about acetylene gas. He thought it would have to be diluted with something which would make it less rich in carbon, so that combustion could proceed without depositing carbon throughout

Mr. Wallace.

the room. After a little time, Mr. Worth sent a burner, like that shown in Fig. 11, Plate 1, and that overcame the difficulty. The air from those apertures being admitted along with the gas, and then the current from each side meeting, produced an upright flame, and gave sufficient air to cause proper combustion, and no more of the soot deposit was found. After that everything worked satisfactorily. In his opinion there was no more danger of explosion with acetylene gas than with ordinary coal-gas. In France an attempt had been made to compress acetylene and liquefy it, so that it could be used in lamps; and hence all those disasters. These mistakes had been recognised by Messrs. Berthelot and Vieille when acting on a committee to look into the question, and he believed they had remedied the position in France by keeping to the proper and natural way of using acetylene gas without compression so as to make it into a liquid. A certain amount of pressure was good for all gases if they were to be used, because naturally the air could not come in where there was pressure, and consequently there was less risk of explosion. With reference to railway lighting, he thought the compression of acetylene gas to 7 atmospheres or 8 atmospheres would be the best way in which to use it. No doubt experiments would be tried with regard to higher pressures, and he felt sure that a greater pressure could be used with perfect safety. He believed that at recent trials deflagrated gun-cotton had actually been exploded in acetylene gas without causing the latter to explode. He thought the Home Office experiments had been made in that way. He did not know what would happen if it were detonated, but he believed that anything could be exploded with a detonator. If that experiment were tried, he did not think that it would be of any practical utility as far as the ordinary use of acetylene gas was concerned. When he was in Berlin Messrs. Pintsch had kindly repeated some of the experiments in his presence, and a more convincing, successful and accurate series of tests of all kinds he had never seen. They went into the matter extremely carefully, and the result of their work had been that they had come to the conclusion that the best way of using acetylene was to dilute it with two-thirds its bulk of oil-gas. Those conclusions had been arrived at in October, 1897, after experiments on the German railways, and he understood from the Author that they had not been modified since. He did not believe that acetylene would be used in England in the same way as it was in America, for enriching coal-gas, although there was a great demand for that in America. In country houses and places where electric light could not be

Mr. Wallace. obtained, he was certain, from his experience, that acetylene would come very much into vogue. The proper condition under which to use acetylene gas was to see that there was always a uniform pressure, and that only one type of burner on the mains was used to suit that pressure.

Prof. Boys. Professor C. VERNON BOYS thought that more information would be of interest concerning the Bunsen burner, which seemed to be something between an ordinary burner and a blow-pipe; and also as to whether the flame being bright, it in any way soiled or smoked the object being heated by it. A point had been raised in the Paper as to the difference between acetylene dissolved in acetone and acetylene liquefied by pressure. It was a very curious fact that the density of acetylene dissolved in acetone was to the density of the gas when liquefied by pressure as seven was to four; that was, very nearly double the amount of acetylene could be obtained in a cubic foot when dissolved in acetone that could be obtained when acetone was not present. As a corollary he thought the statement in the Paper that the liquefied acetylene was an extraordinarily light liquid and had a very high coefficient of expansion was not necessarily true. He believed that the dissolved acetylene was less expansible by heat, and the conclusion drawn from that was, that in consequence of the larger expansion by heat of the liquid when pure, there was more danger of the bursting of a bottle than there would be if it were dissolved in acetone, because in such a case the expansion of liquid would be less. He looked upon that as not necessarily a correct conclusion, because the greater the expansibility of a liquid by heat the greater also its compressibility. In the case of two gases commonly supplied commercially, liquefied carbonic-acid gas and liquefied ammonia, ordinary steel bottles as used for the purpose of trade might be filled completely up to the neck, in spite of the fact that the coefficient of expansion of liquefied gases was enormous as compared with that of ordinary liquids; and yet in the case of carbonic-acid gas, but not ammonia, it had been stated that a bottle filled cold might be put into boiling water without bursting. A liquid which was sufficiently expansible need no longer be looked upon as being like water—a practically incompressible fluid which would burst anything which tried to resist its expansion; the mere fact that it was expansible was evidence that it was also compressible, and being compressible the danger due to its great expansibility was not necessarily greater—it might be less. The figures in any particular case must of course be found by experiment; no one would venture to say what the figures must be. But he looked upon the conclusion in the Paper without further details as not being absolutely just. Certain difficulties occurred to him of an exceedingly practical character in connection with the use of acetylene as a standard for photometric purposes. What was wanted for photometric purposes was not what was most economical, wonderful and beautiful as a light; but a light which should be day after day and even year after year the same, in spite of barometric and general atmospheric changes; one which would be the same in spite of certain difficulties of manufacture and which would give no trouble. He did not quite know to what extent the absolute purity of gas, on which its illuminating powers so much depended, could be easily insured. No doubt it could be insured in a chemical laboratory, but could it be insured for practical purposes? Then again, although acetylene gave a most pleasing light, it was not the same colour as ordinary gas, and the practical point in photometry —a commercial point of very great consequence—was the use of some photometric substance for the purpose of testing the illuminating power of gas. He did not say that was the only object, but it was a very important object. The flame was of a different colour from that which had to be used in accordance with Act of Parliament for the purpose of testing gas. He was speaking of London gas, and a gas which gave a light of a different colour was not that which every photometrist would choose. There was enough difficulty in photometry at any time, and any new difficulty, raised by the introduction of the colour question, was one which ought not to be lightly faced. Then there was this further point—it might be that the injector burner entirely overcame the difficulty, he would not offer an opinion as to whether it would or would not—namely, the absolute permanence, the uniformity of burners so that all burners made at different times according to a definite prescription should produce identical results. There was no evidence that either the uniformity or the permanence of the burners would be such as was absolutely essential for the particular branch of photometry to which he had referred. The Paper had interested him particularly from another point of view. He would leave purely scientific questions and applied scientific questions altogether and come to that part of the Paper which appealed more closely to one's interests, one's own domestic affairs. Living in a district where he was only supplied with alternating current, which he did not care about, he was most anxious to have a light which would be useful in a private workshop, so that he could get a good light close to his work. He would Prof. Boys.

Prof. Boys. like the electric light, but without convenient electric power he did not care, for his own private part, to introduce an alternating current into the house. He wanted a good light, and he was looking forward with a personal interest to the introduction of acetylene into his house. It was said that acetylene was a pure gas free from smell. He believed that the smell of the gas—there had been a little evidence of it that evening, but very little—when it escaped was not entirely negligible. The gas might be manufactured and distributed fairly pure and the leakage would be objectionable. The fact that the gas produced by carbide of calcium had such an exceedingly unpleasant odour was well illustrated by the case of hydrogen. The text books stated that hydrogen was perfectly free from smell, but any mechanic who was in the habit of pickling iron castings with sulphuric acid would state exactly the contrary. He imagined the carbide of calcium was a case in point and that the slight impurities—he did not know exactly what they were—were those which gave it its peculiar and fortunately most necessary odour.

Mr. Jones. Mr. H. E. Jones congratulated the Author upon the dispassionate and impartial manner in which he had brought this new body before the Institution. He had done wisely and justly in pointing out all the drawbacks of the new light. The action of acetylene upon copper was unfortunate, because brass was the one metal which lent itself to all the uses of conducting gas for illuminating purposes. Iron had disadvantages owing to its rusting and corroding properties. The safety of the preparation of the gas was a matter in which perhaps old gas-makers might be of some use to the new generation of acetylene producers. The essential point for safety would be the regulation of the amount of carbide which was rendered open to the action of the water. Any attempt to limit the amount of water would be more or less a failure. By pulverising the carbide to begin with—he believed it might be done with safety—and adding it to the water in small instalments, which could easily be done automatically, any danger of the undue expansion of the gas would be eliminated. In view of the probable utility of acetylene as an enricher of gas he should welcome it as an ally. There was great need of some economical means of raising the ordinary coal-gas made from Newcastle coal—which was the cheapest mode of preparing light—up to the range of the illuminating power which it was known it would give. Any method of that kind, which would enable gas-makers to bring gas to the point which was necessary for

Mr. Jones.

a good internal light, at not too great an expense, would be welcomed. With regard to the cost of the various sources of light open to the gas-maker, 1,000 cubic feet of 16-candle gas, equivalent to 3,200 sperm candles, cost, according to fluctuation of price of coal and residuals, between 3*d.* and 8*d.*; 480 sperm candles therefore cost between 0·45 of a penny and 1·2*d.* 1,000 cubic feet of 24-candle carburetted water-gas, equivalent to 4,800 sperm candles, cost, for materials, oil and coke, 10*d.*; 480 candles therefore cost 1*d.* From Cannel coal, 1,000 cubic feet of 24-candle gas, equivalent to 4,800 sperm candles, with Cannel at 30*s.* per ton, less 2*s.* 6*d.* residuals, cost 33*d.* Therefore 480 sperm candles cost 3·3*d.*; 5 feet of 240-candle power acetylene gas, sperm equivalent 240 candles, cost £16 per ton = 1·7*d.* Therefore 480 sperm candles would cost 3·4*d.* In the last calculation the full illuminating value was attributed to acetylene. When used as an enricher in small amounts with common coal-gas, it would not be possible, with the burners ordinarily used, to obtain the temperature necessary for the full development of the acetylene light. For enrichment purposes, therefore, this cost would have to be considerably increased. He agreed with Mr. Wallace in thinking that the danger of explosion was in no sense higher than it would be with coal-gas. The maximum explosive mixture given by the Author, 8 per cent., was so near the 10 per cent. of common coal-gas (where a mixture of air and gas was required) that he did not think the difference serious.

Mr. Atkinson-Butterfield.

Mr. J. ATKINSON-BUTTERFIELD considered the Paper the most complete exposition of the manufacture and the uses of acetylene that had yet appeared. With regard to the temperature of the formation of calcium carbide, it had been stated that the temperature of the electric arc was absolutely necessary for its formation, and that Mr. Swinburne had found it impossible to obtain it by an oxygen furnace. In the beginning of 1897 it was reported that calcium carbide had been formed by heating calcium tartrate obtained from the residues in wine vats to a temperature of about 500° C., and that the carbide so obtained gave off acetylene on contact with water. The experiments of MacQuenne and Travers referred to in the Paper showed that calcium carbide might be formed at a lower temperature. He did not think that Zinno's experiments with calcium tartrate had been confirmed. He was interested to notice that the temperature of the flame when acetylene was mixed with 50 per cent. of oxygen was 4,000° C. That appeared enormous, but he imagined it was only a calculated temperature, as he believed it was quite impossible to measure

Mr. Atkinson-Butterfield. anything approaching that. With regard to the maximum illuminating power to be obtained from acetylene, Ahrens and Castellani had calculated from theoretical considerations that one cubic litre of acetylene would develop a light of 1·48 candle. That was equivalent to an illuminating power of about 210 candles for the English standard rate of consumption of 5 cubic feet per hour. This value, however, had been much exceeded in many cases. The highest duty given in the Paper was 240 candles at the 5 cubic feet rate of consumption; but since the Paper was written some higher results had been published. They had been obtained in Berlin by Dr. Wolff, who had found that the 0000 Bray burner, under a pressure of 60 millimetres (which was roughly twenty-three tenths to twenty-four tenths), gave a light of 85½ Hefner units at a consumption of 39 cubic litres per hour. This was equivalent to the extraordinarily high value of 278 candles at the 5 cubic feet rate of consumption. The moral that Dr. Wolff drew from a large number of experiments which were recorded in a rather obscure German Paper[1] was that the pressure used by Gerdes, Lewes and others, who obtained 240 candles per 5 cubic feet rate of consumption, was much too high. They had used about thirty tenths to forty tenths. The very high result of 278 candles was obtained with a Bray burner at a pressure of twenty-three tenths. Since those results Weber of Landolt had found that the maximum efficiency or the highest illuminating duty could be obtained from acetylene at a low pressure of twelve tenths to sixteen tenths, although he did not get nearly such a high absolute value as Wolff. With regard to mixing nitrogen with the gas, as mentioned in the Paper, it seemed reasonable to expect that the result would be to obtain a lower duty than from the pure acetylene. The nitrogen must have the effect of lowering the temperature of the flame, and carbonic acid, which had also been used, would have a similar effect. Carbonic acid, having a higher specific heat than nitrogen, lowered temperature rather more, as had been observed also in the case of coal-gas flames and oil-gas flames. The nitrogen certainly did lower the duty considerably, although Bullier obtained with nitrogen rather higher results than those given in the Paper. The value given in the Paper was 181 candles per 5 cubic feet of acetylene mixed with nitrogen; and he believed something like 190 candles had been subsequently obtained by Bullier. With

[1] "Zeitschrift für Beleuchtungswesen." An abstract has since appeared in the *Journal of Gas Lighting*, vol. lxxi. pp. 478–479.

regard to the table of the comparative cost of various gases, he noticed that the holder price was given in every case, and that the coal-gas price was put at 2*s.* 6*d.* per 1,000 cubic feet. That seemed high for the holder price of coal-gas, and he thought it was hardly fair to it; although, of course, in places where acetylene was likely to come into use, coal-gas would necessarily be dear. Mr. Atkinson-Butterfield.

Mr. J. A. F. ASPINALL observed that for the past 2 or 3 years the Lancashire and Yorkshire Railway Company had been collecting information and statistics with regard to acetylene gas, mainly for the purpose of using it for the lighting of railway carriages. The Paper which Mr. Fowler had so ably compiled was the outcome, to a large extent, of those investigations. So far as they had gone, the experiments showed there was no reason to suppose that there was any danger attached to it, especially when the gas was mixed with oil-gas. The question as to whether acetylene would be used in larger quantities than at present seemed to depend rather upon those who manufactured the carbide than upon anything else. If manufacturers would be good enough to sell it to the public at a reasonable price, no doubt it would be more used. He had had pure acetylene in a railway carriage now for some 2 years, and there was no difficulty whatever with it; it had been mixed in other reservoirs in different proportions, 13, 14, 15, 20 and 30 per cent., and some of the best results had been obtained with about 20 per cent. of acetylene, although Pintsch seemed to favour an admixture of 30 per cent. He would mention one point in connection with railway-carriage lighting, namely, that the reservoirs which were to be filled with gas must be such as could be replaced if the carriage went a long journey. For instance, if a carriage ran from Plymouth to Aberdeen it must be able to get gas at the other end, and as pretty nearly all railway companies now had their installations for oil-gas, it was very difficult to start a new gas like acetylene without upsetting the whole of those arrangements. If the same reservoirs and lamps and burners could be utilized by mixing certain proportions of acetylene with oil-gas, it would be very much more convenient. If a carriage on a railway in the south had its reservoirs filled with that combination of oil and acetylene gas and then went north, it could equally well be filled with oil-gas pure and simple at the other end and give a fairly good light coming back again. The light would not be quite as good, as the burner had to be made a little smaller for the combined gases. That was the great difficulty, that Mr. Aspinall.

Mr. Aspinall. a burner which would suit acetylene would not absolutely suit an oil-gas. The burners could not be continually changed. There was little doubt that gas lighting was the most convenient form of illumination for railways; and although better things might be seen in the future with regard to the electric lighting of carriages, at present there were immense difficulties in having a large number of dynamos running underneath the rolling-stock. Almost anybody could turn a gas-tap, but every wheel-tapper could not be made into an electrician. It was to be hoped that some improvement which would enable one to utilize the acetylene gas without trouble would be seen. Regenerative gas-lamps, which were now being pretty largely used for oil-gas lighting, were an immense advance upon the ordinary form of flat-flame burner lamp, and he looked for still further improvement with that improved gas.

Mr. Parker. Mr. T. PARKER observed that when referring to the combination of carbon with calcium, the Author had stated that the temperature of the electric arc was required before this could take place. His experience with the electric furnace did not lead him to suppose that was so, or that the limit of the electric furnace was the temperature of the arc. So far as he had been able to trace it, the temperatures in the electric furnace were dependent upon the amount of energy delivered in the space of that furnace, the chemical absorption of energy in the furnace, and the qualities of the furnace to dissipate heat from itself. Therefore it was difficult to say what the temperatures of the furnace were, or what was meant when speaking of the temperature of an electric furnace. He would be interested to know the variation of current and voltage, or the total resistance of the circuit outside the furnace, so that the condition of the furnace might be traced as far as possible; and the Author might be able to suggest valuable help to those using electric furnaces, which might lead to other applications beyond those now made. It was stated that the cone formed in the furnace was in a fluid condition in some cases, and there had been efforts made to get it to run out of the furnace. He had no doubt that the manufacture of carbide of calcium would become a great industry, and therefore the discussion of those features was of the utmost importance. He presumed that the Author used the materials dry, but he would like to know whether that was so or not, or whether they were mixed in the shape of paste and then dried afterwards; also if the calcium was used in the form of carbonate, oxide or hydrate. In his own practice there was a wide difference in the use of the continuous and alternating currents for this purpose, and if the Author could give any of the features of the employment of both currents it would be very useful. In using large currents with the electric furnace when continuous currents were used, the heat tended to develop at certain parts of the furnace, that was at the positive electrode; when alternating currents were used the heat was more generally distributed in the furnace. But the statement in the Paper would lead to the conclusion that there was little difference as to which was employed. It would be interesting to know whether the 1,700 amperes to 2,000 amperes mentioned by the Author was required at the outset, and what change of voltage was necessary to maintain it as the work of the furnace continued. In considering the energy of the translation of calcium oxide to calcium carbide, the Author appeared to have left out a quantity in the estimate, which would be the amount of heat that passed in the liberated gases into the material as it fell down into the active part of the furnace, which would account for the actual practical result being very nearly the theoretical amount. He had made many investigations as to the cost of electricity per HP. year at the terminals of the dynamo, and was convinced with the cheap coal in England it was possible to compete with water-power such as was found in Niagara. The fact stated by the Author that if only a small quantity of water were added to calcium carbide, when generating acetylene, the temperature of dissociation might be reached, was most serious, having regard to the use of carbide of calcium for the production of acetylene. It would be interesting and useful if the Author would give (as he had stated in the early part of the Paper that the decomposition was equal to about 900 B.T.U. per lb.), the temperatures due to decomposition of a given quantity of carbide of calcium under given conditions and surroundings. Mr. Parker.

Mr. F. G. Worth remarked that since the beginning of 1895, and even earlier, the manufacture of carbide of calcium and acetylene, and the various difficulties in dealing with both had received his close attention. In the early part of 1895 a small private development company started in England the first commercial manufacture of carbide of calcium in Europe. He had the honour of representing that company. It was a long time ago, and it might seem that little had been done between 1895 and 1898. Very much had then to be learned, and there was still something to learn. He thought honour was due to Professor Lewes, who, in January 1895, gave the first lecture on acetylene and carbide of calcium. As to the physical properties of calcium carbide, he noticed the Author said that when pure it was of a reddish brown colour. Mr. Worth.

Mr. Worth. That, he ventured to say, from the experience of the Company, was incorrect. Experiments on various classes of lime and of coke were started by him in 1895. The Company at first would not sell any carbide, but gave it away for experimenting purposes. He regretted that the Author had made his experiments with continental carbide. If he had asked the Company referred to they would have given him English carbide with pleasure, and why Mr. Fowler had gone to Switzerland for it he did not know. Reddish brown was not the best carbide obtainable, because it had been found from experience that reddish brown carbide meant an excess of lime, unless the crystals were very predominant. The best carbide made gave rainbow colours on a dark black surface. He spoke of British carbide with some diffidence as the manufacturer, but he had shown samples of it to various scientific authorities in different parts of the world. There was not one who did not recognise that the British carbide—he did not suppose what he said would displease any one present—was the best carbide made anywhere. Another point in the Paper under the head of calcium carbide, was that when carbide became highly heated whilst decomposing, the various impurities it contained were apt to take a gaseous form and to contaminate the acetylene produced. That was true, and he thought it might be said that some of the differences indicated in the Author's Tables at the end were due to this, as the Author had fairly said the apparatus he had used for the production of acetylene gas was not perfect. It was certain—he had himself seen it—that carbide of calcium producing 5·5 cubic feet of gas could be put in certain apparatus and might only give off 4 cubic feet, because the great heat developed in the apparatus polymerised a considerable portion of the gas into other constituents which gave no lighting effect. He had an experience at the house of a friend who complained that the carbide was very poor indeed. He found on investigation that it was entirely the fault of the apparatus. Ordinary carbide of calcium was no good at all against phylloxera, as the Author had pointed out. It had been tried for phylloxera, oidium of the vine and other purposes, and, fortunately for human beings, it was found that the acetylene given off did not poison the insects; in point of fact, he thought he might say that they thrived in it. Experiments had been carried out since in other directions—not quite in the directions indicated by the Author—which he was not at liberty to mention; but he thought it would be found practicable to make a gas producing metallic carbide of considerable value for the purpose of destroying phylloxera.

The King furnaces, Fig. 5, were not now in actual use at Niagara, having been somewhat modified. A great number of furnaces had been designed, some of which were very complicated, but in calcium carbide manufacture, the simplest form of furnace would always be the best. The pre-heating of the raw materials seemed at first to be desirable, but in practice the complications which it involved were so great, and there were so many mechanical results which were difficult to deal with, that he thought pre-heating would not be followed. With regard to tapping carbide, that could be easily done, but in his experience it was not economical. At Foyers, 700 to 800 E.HP. was being used with between 55 and 58 volts and 4,000 and 5,000 amperes, so that it would be seen that the carbon holders were of a fairly large size. With regard to the carbide made, the figures at Foyers were very little different from those given by the Author. It had been found that 0·45 lb. to 0·5 lb. of packed carbide per kilowatt-hour, giving 5 cubic feet, on an average, of acetylene to the lb., could be obtained. There was a great difference between packed carbide and the carbide as removed from the furnace in the ingot. The ingot was covered with a thick crust, which had all to be removed. The carbide had to be broken by mechanical and other means, according to the different qualities, sorted and packed, in order to give the consumer a fair average quality of carbide. The question of water-power and steam-power was a vexed one. He had looked into the matter closely at the beginning of 1895, and tried hard to get steam-power. He had gone to the chief electrical companies with the hope of being able to straighten out their curves. The lowest price offered for a long time was 1*d.* per unit, or about £30 per E.HP. per year. After a great deal of difficulty, one very bold manager said he thought he could bring it down to ½*d.*, or £16 per E.HP. per year. He then endeavoured to see whether any manufacturers could be got to guarantee to deliver the electricity by steam-power, at £4 to £6 per E.HP. per year. The manufacturers made statements as to what their respective machinery could do, but not one of them would give anything like a guarantee. Certainly if to-day a body of men would guarantee to supply steam-power at £4 per E.HP. per year, he would be glad to take 1,000 HP. at once. Water-power was obtainable at £4 per E.HP. per year. He thought the discussion really stopped there, because, if those who said that steam-power was cheaper than or as cheap as water-power in this country would only put their heads together and make Mr. Worth.

Mr. Worth. an offer to supply steam-power all the year round at that rate a great many customers could be obtained; but, so long as it remained a theory, nothing was to be done. The burners always presented a difficult question. At first, when starting with carbide of calcium, the Company he represented recommended people not to adopt acetylene for lighting, on account of the "soot storms," of which the Author had spoken. Gradually that difficulty had been overcome, and there was now a burner which would give a brilliant light without smoke or soot, and even those burners would be materially improved. With regard to mixed carbides and diluents, work had been proceeding on them for some time, and possibly at some future date the results might be placed on record. Since 1894 the Company had been working on the different problems of carbide of calcium and acetylene gas, and the experiments would fill a pretty large volume. He did not think the suggestion of mixing nitrogen with acetylene gas would be practicable. It could hardly be expected that, in a country house, people would have a nitrogen plant as well as an acetylene-gas plant. It might be all very well for the lighting of villages, but it would not go much further than that. The question of metals was most important. The statement of the Author, when speaking of copper, was, he thought, to some extent, unintentionally misleading. Brass and brass-fittings were not at all liable to form acetylides. For two or three years brass-fittings had been in use, and no acetylides had been formed. Moissan, Bullier, Gerdes, he himself and many others, had tested brass and other metals under pressure with both moist and dry gas, and no difficulty had been experienced with ordinary brass-fittings. He had the authority of Messrs. Pintsch for saying that, on the German railways, where mixtures of acetylene gas and oil-gas were used, the fittings were brass. The Home Office regulations dealt with that question and did not in any way recommend the prohibition of brass, but they did recommend the prohibition of pure copper. The impurities in the gas depended very much on the raw materials. Hundreds of experiments had been carried out with different classes of lime, coke, and so on, in order to get the best class of materials, and he had the authority of some of the leading scientific men, both at home and abroad, for saying that they had been successful in producing a commercially pure carbide of calcium. No carbide of calcium could be made quite pure; it was impossible so long as absolutely pure materials were not obtainable commercially. With regard to the explosive properties of the gas, the Company referred to had worked for a long time with pure acetylene gas in railway-carriage cylinders compressed up to 8 atmospheres. The danger was little known at the time. With proper precautions, however, he did not think there was any danger. He happened to see Mr. Berthelot on the subject, and he was the first to tell him that, beyond 2 atmospheres, there might be, under some circumstances, a possibility of an explosion with pure acetylene gas compressed. He at once informed the engineers of the different railway companies. Liquefied gas had given rise to a great many accidents, but he did not think, simply because a gas had unfortunately caused loss of life, it should never be used in future. He did say, however, that it had been very imprudently used. He had lighted his own office with liquid acetylene gas at the beginning of 1895, and he had taken over some very large cylinders of the gas to Paris, and one of them went to Mr. Cailletet at the Sorbonne. The Company had finally given up liquefied acetylene gas because it was thought it might be dangerous, and that was confirmed by Mr. Berthelot and others. Subsequently liquefied acetylene gas had exploded with fatal results in Berlin and Paris, and that led to Home Office legislation in England, which had proved a very fortunate thing for the industry, as it had prevented a great number of improper apparatus getting on the market. The Author said he thought that the Home Office were about to pass regulations with regard to the explosiveness of acetylene gas. That regulation was passed in November of last year, and acetylene gas, compressed beyond 100 inches of water-pressure, whether compressed alone or mixed with oil-gas, came under the Explosives Acts, unless an exemption had been obtained from the Secretary of State. He had begun making apparatus a good many years ago, but, though successful, he had given it up. A reason for doing so was that there were a great many people who were doing the same thing. In England there were certainly no less than 200 specifications. In his office he had some 135 for water dropped on to carbide, and possibly 40 or 50 where carbide was dropped on to water; and there were many other variations. He hoped that before long, in the interests of apparatus makers themselves, it could be shown which class of apparatus might be safely used, and which class, under certain conditions, constituted an element of danger. The cost of acetylene was a delicate question. He naturally looked upon £16, of which the Author had spoken, as a very low price indeed. When it was recollected that not much more than 1 ton of good carbide of calcium could be made per E.HP. per year, it was evident calcium carbide could not be made for £2 per Mr. Worth.

Mr. Worth. ton. There were a great many other expenses connected with the manufacture which could not here be dealt with. With regard to the lighting of railway-carriages, he had made some experiments on the previous day in the presence of Her Majesty's Inspectors of Explosives and other gentlemen, including Mr. Rickman of the firm of Messrs. Pintsch, without whose assistance the experiments could not have been so quickly carried out. Messrs. Pintsch were good enough to lend all the necessary apparatus. Mr. Aspinall and Mr. Fowler had worked in that direction, and Mr. Park had at the end of 1895 made some experiments with oil-gas and acetylene compressed, which were very satisfactory. Those experiments had been stopped because Mr. Worth had been informed by Her Majesty's Inspector of Explosives that any mixture of acetylene compressed would come under the Explosives Act, and, naturally, they waited until the present law came into force. The recent tests had been made in a very complete manner. The gas was not carried through meters, because it was considered that might be unreliable. There was a gas-holder for acetylene graduated, and a gas-holder for oil-gas graduated, and one of Her Majesty's Inspectors took the readings. Those were then pumped into an ordinary railway cylinder lent by Messrs. Pintsch. The gas was compressed, 30 per cent. of acetylene and 70 per cent. of oil-gas, up to 15 atmospheres; and then a tuft of gun-cotton was fired in the interior of the cylinder and deflagrated a platinum wire. There was no sign of any decomposition whatever, with the exception that just round the platinum wire there was a thin film like a very thin piece of cotton, which was carbon. That was considered entirely satisfactory, because it showed that the dissociation was absolutely local, and only took place where there was incandescence of the platinum wire. Nothing else whatever was changed in the gas. It was now proposed to carry out photometric tests, and he would be pleased at some future time to communicate them. The difference which occurred in some instances between the Author's results and those obtained by Mr. Gerdes and Messrs. Pintsch in Berlin, whose accuracy he would vouch for, might possibly arise from the fact, which the Author had mentioned, that he had a considerable percentage of air at one time in making his experiments with oil-gas and acetylene. It also might be due to the fact that the generator employed by the Author developed great heat, and consequently the acetylene gas became polymerised into hydrocarbons.

Dr. Kennedy. Dr. A. B. W. KENNEDY hoped the Author, or one of the members, would be able to say something about the optical properties of the light which had been shown. He was familiar with the fact that the ordinary incandescent gas-light, although appearing very bright from a distance, seemed to be greatly absorbed by most colours round it, and reflected badly. The light which had been shown was most striking in that respect; it was dazzlingly bright at a short distance, but it illuminated nothing in the room, so little indeed that he could hardly see a person sitting at the opposite side of the table. It had a most singular effect, which no doubt would be explained if the Author could say anything as to its spectrum. The other point which he wished to mention had been rather raised in the discussion than in the Paper, as to the cost of power production on a large scale, such as was necessary for carbide manufacture. A few weeks ago he had an opportunity of examining the carbide works at Foyers. There, of course, water-power was available. It was a popular idea—and he did not wish to contradict it—that as long as ample water-power could be obtained, one was not likely to get power guaranteed at similar prices from coal. But as a matter of fact the prices really did not differ very much. Mr. Worth had spoken of £4 per electrical HP. per annum. He had been planning some large works in the North, which would be opened shortly for electrolytical manufactures, where coal was procurable for 6*s*. a ton, and where they would be working, as at Foyers, continuously day and night. He estimated—and he was sure his estimate was rather over than under the mark—that the power would cost about 0·36 of a penny per unit. With coal at 4*s*. a ton instead of 6*s*., as it was obtainable at certain places, and with some allowances which he thought should be made, this did not much differ from $\frac{1}{4}d.$ per HP. per hour. This came to £9 per E.HP. per annum, including salaries, maintenance and depreciation allowance. He was not surprised that nobody was willing to provide power in order to sell it at a lower price than £4 if the power were generated by steam. If people manufactured carbide on a large scale they would probably generate the power for themselves, and then they would not have to ask anybody to sell it to them. The places where water-power was obtainable at £4 per HP. were unfortunately few indeed in this country. If it were possible to work with coal at 4*s*. per ton, as was the case in some places, it might be practicable to manufacture at a cost to oneself of £6—but he would not say for £4—by the use of steam-power. He did not say that by way of putting steam-power against water-power. Water would naturally be used if it could be obtained, although every one was not fortunate

Dr. Kennedy.

Dr. Kennedy. enough to find a spare dynamo, as at Foyers, ready to be let to him.

Mr. Hunter. Mr. W. H. HUNTER remarked that some months ago it had been his duty to provide at the Manchester docks of the Manchester Ship Canal, a light which would meet three somewhat difficult conditions. In the first place it was necessary that it should be a light which would be locally bright. It was required for the purpose of loading and unloading vessels at night, the operations embracing many classes of goods; and as it was essential that those engaged in the work should be able to read the marks upon the packages, a locally brilliant light was required. In the second place, it was work that might be carried out at any unknown point of a comparatively large system. Therefore it was necessary that the light should be portable. In the third place, as the operations were carried on in the holds of steamers in the midst of all kinds of goods, it was most important that the light should be absolutely safe so far as fire was concerned. He obtained particulars of different lights which were available, and decided at last to recommend the adoption of acetylene lamps. The Author had shown a rough section of the generator used. Some small defects had been found in the working of the generator which they had endeavoured to remedy; but speaking generally, for the purposes for which it was required, the light had been an entire success. It had furnished a brilliant local light at the docks. His experience was that the penetrative power of the light had been underrated. His confidence in its penetrative effect was such that he had adopted it for a guiding light in the Manchester Ship Canal. At an awkward point at the mouth of the River Weaver he had placed one of the generators somewhat of the type in use at the Dock, and he had placed upon a pole above that generator three lamps, one above another. The complaint of the pilots was that the light was rather too dazzling, so he had substituted a red glass for the white glass in the large lamp. As a guiding light it had answered admirably during the limited time it had been tried. The scale on which the light was used was so small that the fine matters of cost spoken of did not apply; for the purpose referred to it was the cheapest lamp obtainable. It appeared to him that acetylene lamps in portable holders had a great future before them in connection with dock-work, and in connection with small guiding lights such as he had described. He desired to give an example, of which he was rather proud, of the readiness with which the British working man adapted himself to somewhat unusual and, to him, unexpected circumstances. At first some difficulty had been experienced with the lamp-men at the docks with the new light, as was commonly the case, but that difficulty had been overcome. Three or four days ago on going into the lamp-room at the docks, he had noticed in operation there an entirely admirable, because simple, generator, which the lamp-man had himself devised. The man had taken an ordinary paint drum, inside which he had placed a second paint drum of somewhat smaller diameter. Then he had poured water into the first drum and had attached a piece of hose-pipe to the top of the inverted (second) drum, and had slung, in a small piece of wire-netting he had constructed, a piece of carbide of calcium. The carbide of calcium drew down the upper part of the drum until the calcium reached the water. Gas was generated and the smaller drum rose and a gas supply was obtained, which had been carried to an ordinary gas-jet through a piece of india-rubber pipe. It gave an admirable light in the lamp-room. Material of that kind which could be so readily and simply applied was certainly not without its value to engineers. Mr. Hunter.

Mr. C. E. BLOUNT remarked that as the result of investigations, not only of Mr. Willson but also of experimenters in England, it was now known how to make carbide fairly economically and with cheap power, whether coal or water-power were used. Although power might not be obtained at £4 per HP. per year, even at £9 per HP. per year the cost of energy for the production of carbide was comparatively moderate. If, however, water-power was available at £4 or less per HP. per year, the cost of carbide would speedily fall to a reasonable value. There was, therefore, no difficulty in turning out the carbide. A point which was an exceedingly practical one, and therefore appealed forcibly to engineers, was to consider what was to be done with the carbide when it was made. In that direction the Author had sought to show them the way. It was well known that at the time carbide first came on the market it was proposed to be used as a material for enriching coal-gas, but the experiments which were then made demonstrated that its great luminosity disappeared when used as an enricher. Abandoning that, which gave much the largest scope for use, the devisers of means for employing calcium carbide had turned their attention to humbler outlets. They had realized that it was not going to supplant carburetted water-gas, or even cannel, in enriching coal-gas; but in isolated positions where coal-gas plant was unavailable or unadvisable, the use of a compact, portable material which might be trusted to generate a gas giving a brilliant candle-power with the very simplest apparatus, Mr. Blount.

Mr. Blount. had a great future. For buoys and for country-house lighting and railway-carriage lighting (always provided it could be shown that it was safe) the use of calcium carbide would be exceedingly large. It would then be found that the industry was one which had much to recommend it to the enterprising capitalist. In that connection the Author had told Mr. Blount something which was new to him, viz., that brass fittings, as distinct from those of copper, were not dangerous. He was sorry to learn that, because he had built up a beautiful theory to the effect that, as brass and copper fittings could not be used for the distribution of acetylene, a large use might be found for aluminium. Thus the calcium carbide industry and the aluminium industry, which were, he was informed, likely to suffer from over-production, would be of mutual service. The calcium carbide would provide an outlet for aluminium in the way of fittings, and at the same time the aluminium would make the utilization of calcium carbide practicable and safe. Now that delightful dream was shattered by the information that brass would do. He wished to pay tribute to the prescience of Mr. J. Swinburne. The Author stated that as the use of water-power increased so would its cost approximate to that of steam-power. That was a truism, but one which everybody overlooked. He believed Mr. Swinburne had been the first to point out that the cost of water-power, although now a negligible quantity, would cease to be so as soon as people realized its worth, and by the inevitable process of economics the cost would soon be equal to that of steam-power. When that happened he supposed steam-power would be seen going down to its limiting value and water-power rising to the same figure; at all events, water-power would not be so extraordinarily cheap as to produce carbide at much less than £16 per ton. A most important point was raised by the Author as to the toxic properties of acetylene. The Author had stated with truth that the toxic properties of acetylene were more or less in dispute. He had stated: "The action of acetylene on the blood is the same as that of carbon monoxide, viz., combining with the hæmoglobin and rendering the blood incapable of taking up oxygen, and so causing death by suffocation." It must be remembered that the experiments were made with acetylene not necessarily pure. When the gas had been a great deal more studied than it had been when the physiological experiments were carried out, Mr. Blount thought that it would be found that pure acetylene had not so large a toxic effect as was supposed. If that were the case, the danger which it was admitted might occur from its other properties, might not be exaggerated by any tendency to poison people in the deadly way that carbon monoxide would. It would be lamentable if a gas used for lighting purposes were to be shown to have properties as eminently toxic as those of carbon monoxide, because the action of that particular gas had always been brought forward as one of the great objections to the use of several excellent illuminants, whether rightly or wrongly he declined to say, but it had always been counted against such illuminants. A new illuminant credited with a toxic power in any way comparable with that of carbon monoxide was *ipso facto* condemned. In his opinion the real danger of acetylene seemed to lie, not in its toxic properties, but in the fact that it was an endothermic compound. Acetylene, as was well known, could not be obtained in any way but by employing some means whereby energy could be impressed on the substances from which it was prepared; that was, if it were synthesised in the simplest way by the action of carbon on hydrogen, so much energy must be impressed upon it as was measured by the enormous temperature of the electric arc. Similarly in making its parent, calcium carbide, the constituent materials must be raised to a temperature comparable with that he had mentioned. The resultant gas contained locked up in its molecules the greater part of the energy which had been impressed on it during its formation, and was accordingly an explosive. No doubt that was why the Home Office had brought it under the Explosives Act. As long as that explosive property existed—and it could not cease to exist while acetylene remained C_2H_2—acetylene must be a dangerous material, and must be handled with adroitness and discretion. No cunningness in manipulation, no care in legislative regulation, would eliminate that factor of danger; but the knowledge of that factor of danger should in no way make one shrink from employing the gas rationally, and if it could be shown—and the Author had gone far to show—that, when suitably diluted, the danger, although still existent, became practically negligible, the field of usefulness of acetylene would increase at once. Mr. Blount.

Mr. H. B. RICKMAN had made experiments with pure acetylene compressed, acetylene mixed with air, compressed, acetylene with coal-gas compressed, and acetylene with oil-gas compressed, and had placed in those compounds brass and copper fittings, and other alloys of copper. They were kept in the compounds for 9 months, and it was found that, so long as the acetylene was dry and pure and there was no ammonia present, either by itself or with the compounds he had indicated, it had really no effect upon the brass fittings. He thought, therefore, that, so Mr. Rickman.

Mr. Rickman. long as those conditions were fulfilled, the matter might be considered settled. Most exhaustive experiments had been made to find out whether there was any danger or not. No doubt, under certain conditions, for instance, if ammonia were present and the acetylene was damp or not pure, a powder might be found which was explosive, but if care was taken and if a pure and dry acetylene was used, with no ammonia, there was no danger. With regard to the commercial use of acetylene, supposing that it came into general use, as it apparently would, there was one very great use for it, one which, as Mr. Worth had stated, would, he hoped, be very soon permitted by the Home Office as being perfectly safe. At any rate, experiments had been made, compressing 30 per cent. of acetylene and 70 per cent. of oil-gas to a pressure of 14 atmospheres, and then firing a charge of gun-cotton in the middle with no result, and that fact showed that the combined gases must be fairly safe to use. There was a great field for acetylene where it was necessary to carry about a small amount of illuminating material, and in a receptacle, not very heavy or cumbrous, it would be very useful. For instance, a gas-buoy, with ordinary oil-gas, burnt, according to its size, from 2 months to 3 months. By mixing 20 per cent. of acetylene with 80 per cent. of oil-gas, double the illuminating power could be obtained. If the gas-buoy had only to be refilled every 2 months or 3 months, that was an important consideration for the mariner, as he would have double the light. If the mariner did not want double the light, the buoy would only require to be charged every 4 months or 6 months; and this was an important matter for Dock and Harbour Boards which had control of buoys. It was also of enormous advantage in the case of railway-carriages, because the passengers would have either double the light or the carriages need only be filled half as frequently, or the passengers might have 50 per cent. better light, and the carriages be filled 50 per cent. less frequently. Then, again, it would be very useful in transport. The Metropolitan Railway, for instance, transported their gas from Neasden. If they transported 90-candle-power gas instead of 45-candle-power gas, there was an enormous advantage in not having to move such a large quantity of, comparatively speaking, low illuminating material. He thought there were almost endless possibilities in it, and, so far as he could see, having regard to the illuminating power of the two combined gases, he did not think it would be any dearer. Taking calcium carbide at £16 a ton, and assuming that 1 lb. produced 5 cubic feet, he thought that, even when the oil-gas was, from local circumstances, dear (of course oil varied according to the district in which it was produced, according to whether the coal was cheap, or the oil was cheap, or the labour was cheap, and in what quantity it was produced), it would be advantageous to mix it with acetylene. There was a great future in mixing those two gases together, and, he believed, it would create almost a revolution in those cases where it was necessary to use a high illuminating material in a very restricted space. Mr. Rickman.

Mr. Holroyd Smith thought the portion of the Paper dealing with the production of the calcium carbide itself seemed somewhat deficient, because hardly a single furnace shown in Plate 1 was a correct representation of any furnace in actual use. For example, Fig. 3 represented what was called a Willson furnace; but it was one which anybody acquainted with the subject would recognise as a Siemens furnace, and would like to know why it had the Willson name attached to it. There was nothing in the Paper to indicate which, in the Author's opinion, was the best current to use, but he thought the members must feel obliged to Mr. Parker, who had given one good reason why the alternating should be better than the continuous current, and it might be remembered that as far back as 1885 Mr. Parker showed the advantage and advocated the employment of alternating currents in electro-metallurgical furnaces. He would be glad if the Author would state whether the alternating or the continuous current was used in the existing Willson furnace. If alternating, what was the electromotive force and the periodicity of the current employed? It would be interesting information for those who were making a study of the subject. It seemed to him that the success of the furnaces depended, not only upon the material employed but also upon the current used. He was disposed to think that the alternating current, monophase or polyphase, would form a most important element in the production of the calcium carbide. He certainly agreed with the remarks of Mr. Worth; he fancied that it was an error to suppose that preliminary heating was necessary. He thought the statement was hardly correct that the carbide had been run out of the furnace in a molten condition, but not economically. He was glad to hear an admission that it had been done, but he thought it could also be shown that it could be economically done. As had been pointed out, a great quantity of carbide taken out of the furnace had to be broken away and discarded, and not packed for delivery; it was only the kernel of the ingot which was of value. Therefore, if energy was being spent in producing that which profited nothing, Mr. Smith.

Mr. Smith. that item had to be taken into account in considering the question of economy. That afternoon he had opened a case of carbide sent to him for examination, which had been produced in a furnace using an alternating polyphase current—a continuous furnace in which the material was put in at one end and run out at the other, working night and day. In that furnace there was no need of stopping for cooling and reheating; there was no need to stop even if the carbons employed had to be changed. The process gave this very important result, viz., that the production was approximately uniform. The whole of the calcium carbide produced was marketable. If the members would look at the samples he had put on the table, it would be seen how the slag—it was in appearance something like slag from a blast-furnace—had run out of the furnace; and even the portion which had run out in a thin flake had that reddish-brown colour which the Author had stated to be the appearance of good carbide. The moisture in the room had taken away from their crystalline appearance, but anyone was at liberty to make a fresh break in order to see what clear dark crystalline, almost rainbow, hues there were upon a carbide which was produced in a furnace by the continuous process and with alternating currents.

Mr. Amos. Mr. E. C. Amos remarked that there were advantages in the use of the alternating current which had nothing to do with the actual production of carbide, mainly due to the fact that an alternator was preferable to a continuous-current dynamo in construction and principle, in its adaptation to some of the furnaces employed.

Mr. Thomson. Mr. T. Frame Thomson observed that the lowest level at which Dr. Kennedy seemed to contemplate power produced from coal was £9 per E.HP. per annum. He would like to know whether that included interest and depreciation, because the £4 which the calcium manufacturers paid also included profit to the people from whom they bought the power, and therefore did not by any means represent the lowest possible level of water-power.

Mr. Fowler. Mr. Henry Fowler, in reply to the Discussion, remarked that the German railways had decided to use a mixture of 25 per cent. of acetylene and 75 per cent. of oil-gas for carriage lighting. He had not compared the value of an acetylene Bunsen burner with one burning an equal quantity of coal-gas, but had found it to have great advantages over the latter when using a borax bead. A slightly luminous flame, like that shown, could be advantageously used for reduction with the blow-pipe. He agreed with Professor Boys as to the disadvantage of introducing a standard for photometry of a different colour to that of the gas usually Mr. Fowler. tested, but thought that acetylene would be found useful as a supplementary standard. The gas prepared from commercial carbide had a decidedly unpleasant odour, the pleasant smell recorded by Moissan being from gas prepared from carbide made from very pure lime and carbon produced from sugar. Dealing with the question of the effect of the gas on brass fittings and brass-work generally, he called attention to the brass cock which he had laid on the table, and which had been in contact with compressed moist acetylene for two years and only showed a slight discoloration, and no corrosion whatever. The use of pulverized carbide was disadvantageous, as when in that state it readily absorbed moisture and formed acetylene, and this would to some extent prevent its ready use in this state in automatic generators. When the carbide was in large lumps, the layer of lime formed on the surface seemed to protect to some extent the nut, or kernel, of carbide which lay behind it. For the enrichment of coal-gas, unfortunately, acetylene, unlike many other hydrocarbons, did not give at all a high enrichment value, and he thought that at present an extensive use in this direction could hardly be looked for. Mr. Butterfield had raised the question of calcium tartrate, which, heated in a retort, gave a substance which yielded acetylene upon being treated with water. This could hardly be looked upon as a commercial method of producing acetylene, but perhaps some little encouragement might be gathered from the low temperature used. The temperature of the flame of acetylene with oxygen was the calculated one. With regard to the pressure usually being too high to give the full photometric value for the gas, when it was first used it was doubtless tried at the low pressures which gave the best value with ordinary coal-gas. He thought that the pressure of 2·3 inches of water was as high as could be advantageously used. With regard to the figures given in the Paper (p. 17), the price of oil-gas was not holder price, but that at which it could be delivered into the reservoirs of a railway-carriage; the price of acetylene was based upon the same figures. The temperature he had taken for that at which the carbide was formed was 3,500° C., which most authorities agreed to be about that of the arc. Covering the pencils during making rendered the resistance very even, and there was not the great tendency for the arc to strike from side to side that there was when the pencils were raised above the mixture. The resistance would of course vary considerably with the circuit used, but in most cases would be low. The loss of

Mr. Fowler. current in the cone was stated to be between 5 per cent. and 10 per cent. By mixing the constituents intimately before charging into the furnace, was meant that they were ground dry to as fine a degree as was consistent with economy, and then were thoroughly mixed so that the atoms of carbon and calcium might be as close to one another as possible. Both alternating and continuous currents were used in the manufacture of the carbide, but he thought the latter would prove expensive in the types of furnace shown. In some small experiments he had seen made, the change of voltage was very little, but it doubtless would prove advantageous to have it low at the commencement and then to raise it. Mr. Parker had taken exception to the statement that there was sufficient heat given off by the carbide in forming acetylene to reach the dissociation point of the gas itself. Taking the specific heat of acetylene as 0·2 and the amount of gas generated as 0·406 lb. by 1 lb. of carbide giving off 900 B.T.U., the final temperature would be slightly over 6,000° C., as against 780° C. required for decomposition. He thanked Mr. Worth for the information he had given. One use of a mixture with nitrogen would be that it, like oil-gas, could be used as a diluent, so that the gas might be used in a compressed state with a greater degree of safety. In all his researches he had not come across a case where compressed acetylene had been dissociated by shock alone; and, as it had been pointed out in the Paper, it was only under very exceptional circumstances that heat sufficient to dissociate the gas could possibly occur in or under a railway-carriage; it would only be in the case of a collision where the wreckage caught fire, and that was a very unusual circumstance in this country. For over 2 years acetylene compressed to six atmospheres had been used on the Eastern Railway of France. He hoped that the Home Office would see fit to alter their Order of Council and allow the use of a mixture of acetylene with oil-gas, as if 20 per cent. of acetylene were used, the pressure on it alone would never exceed 2 atmospheres. The differences between the results of tests of mixtures of oil-gas and acetylene made by Mr. Gerdes and by himself were very slight when allowance was made for the fact that Mr. Gerdes used what was, from an English standpoint, a very poor oil-gas. With acetylene with a spectroscope the blue rays predominated, and he thought that the bad reflection Dr. Kennedy had complained of was due to his having been too close to the actylene flame and having looked too long at the light. Figs. 1, 2 and 3, Plate 1, were only intended to be diagrammatic.