Mr. SUGG said since the Paper was written, he had combined the whole of its recommendations in an instrument, in which the dial was divided off so as to show the quantity of gas required to give a light equal to any number of sperm candles up to sixteen. A burner was fixed to it which, when the flame was exactly at the height of 3 inches, gave always a light equal to sixteen sperm candles. The quantity of gas required to produce light of that intensity would vary according to the quality of the gas, and was shown in the tables.

Dr. LETHEBY remarked, through the Secretary, that Mr. Sugg had done good service by bringing this important subject before the Institution, with a view to discussion; for it must be admitted that the present means, and parliamentary provisions, for estimating the illuminating power of coal gas were, as Mr. Sugg said, in an unsatisfactory condition. He might add, indeed, that this was not only the experience of practical men like Mr. Sugg, and the gas-testers appointed under various Acts of Parliament, but it was also seen in the difficulties and disputes which were constantly arising whenever gas companies and local authorities were in conflict, as was too often the case, on the question of the illuminating power of the gas supplied to the public. These difficulties began about the year 1848 or 1849, when at the instance of three distinguished chemists who had passed away, namely, Professor Graham, Dr. Leeson, and Mr. Cooper, the Great Central Gas Consumers' Company adopted, under severe obligations, a parliamentary standard of illuminating power, and a prescribed method of determining it, the standard being an illuminating power of twelve wax candles of six to the pound, each consuming 120 grains of wax per hour, and the gas was to be burnt at the rate of 5 cubic feet an hour from an Argand burner of fifteen holes and a 7-inch chimney. It happened that he was the officer appointed by the Corporation of London in 1850, under the provisions of the Great Central Companies Act, which had just become law, to test the quality of the gas supplied to the city, and to see that the obligations of the company were duly fulfilled. This was the first appointment of the kind that was ever made; and he soon found that all the provisions of the Act for estimating the illuminating power of the gas were radically unsound and unreliable; in fact, the whole subject of gas photometry was in a crude and imperfect condition, and he felt that it must be reformed from end to end. The wax candles, for example, prescribed by the Act, were among the worst sort of candles that could be used for photometrical purposes; and the reason was obvious, for as a wax candle, like a common tallow candle, required snuffing, and grew dimmer and dimmer as the head of carbon accumulated upon the wick, it was a difficult question to decide when that delicate operation of snuffing should be performed. One of the first things, therefore, which he did was to rectify the standard candle; and after about one thousand experiments for the purpose of determining the relative illuminating power of wax and sperm, he adopted the latter, using a plaited wick which snuffed itself. This had been the standard candle from that time to the present, for it was adopted by Parliament in 1852. He moreover used two candles instead of one, in order that the light might be intensified, and the rate of combustion equalised. This also had become the practice in photometry. After a time, however, the sperm candle became a subject of perplexity, from the circumstance that during the American war, when long-fibre cotton was difficult to obtain, a short-fibre cotton was used in the construction of the wick, and thus the combustion of the candle became irregular. More recently, in consequence of the increasing value of spermaceti, the candle was frequently adulterated with paraffin and stearic acid, so as to be untrustworthy as a photometrical standard. There was a want, therefore, of a radical improvement in this particular. In the next place, the photometer was a very imperfect instrument, with reflecting surfaces, and with the Bunsen disc exposed on both sides to extraneous light. This he remedied by the use of screens, and by inclosing the disc in a chamber or camera, which only permitted the access of the direct light from the gas and the candles, as was seen in the photometer which bore his name. The burner also, which was described in the Great Central Company's Act as an Argand of fifteen holes with a 7-inch chimney, was so constructed by different makers as to give, with the same gas, when burning at the same rate, an illuminating power that ranged from about ten to fifteen candles. This was caused by the want of uniformity in the size of the apertures through which the gas escaped from the burner, and in the diameter of the hole through which the air passed to the interior of the flame. There was not, in fact, at that time the slightest provision for the proper adjustment of air to gas; and therefore, with different burners, of Act of Parliament quality, the photometrical results were most discordant. Very little experimental inquiry showed that the smaller the apertures, and the higher the pressure at which gas issued from the burners, the lower was the illuminating power; and, on the other hand, the larger the hole which gave access of air to the interior of the flame, the lower also was the illuminating power. A careful examination of these facts by Mr. Sugg and himself led to the construction of the burner which bore their names, and which, until recently, had been the standard burner for photometrical purposes—the size of the internal hole being graduated according to the quality of the gas; and thus, with the assistance of perforated discs upon the gallery of the burner, the proper adjustment of air, and thereby the proper combustion of gas of different qualities, had been approximatively secured. More recently, however, the improvements of Mr. Sugg in the same direction had produced a still better burner, which was rightly proposed as the standard burner for general use. These improvements consisted, first, in the reduction of the pressure of the gas to a minimum at the point of combustion; secondly, in a well-regulated supply of air to the interior and exterior of the conical flame; and thirdly, in the adoption of means for keeping down the temperature of the burner, in order that the issuing gas might not be expanded by the heat of the burner. Possibly further improvements might yet be made in the construction of test burners, but sufficient progress had already been made to justify the proposition of Mr. Sugg, that his burner should be accepted as a standard instrument, so that litigation and trouble on this head might be in future prevented. And now came the important question—how was the burner to be used? Should it be, after the old Parliamentary fashion, of forcing 5 cubic feet of gas through it per hour, whether the burner consumed it properly or not, or should the quantity of gas necessary to produce a flame of given intensity or of given measurement be determined? It was, he thought, abundantly evident, that the present practice in this country of forcing 5 cubic feet of gas an hour through a burner, whether it would effectively carry this quantity or not, was radically wrong; for with any given burner and chimney, suited for the proper combustion, and full development of the illuminating power, of that quantity of gas, it must be that when gas of inferior quality was passed through it at the same rate, the gas would be over-oxidised, and therefore made to appear of less illuminating power than it really was. On the other hand, superior gas would be under-oxidised, and would escape as smoke without developing its full value. This was actually the case with the Birmingham burner referred to, which, at the time of the passing of the Companies Act in 1864, and at the request of the Parliamentary Committee, he designed, in conjunction with Mr. Bowditch, as the standard burner for

14-candle gas. They were compelled to use a metal top, in accordance with the instructions of the Committee; for the Corporation of Birmingham, who were in opposition to the gas company, would not have a burner with a steatite top, and this they would now regret, having lately purchased the works of the company. This burner was exactly suited for 14-candle gas, but if the gas were better or worse than this, the burner would do it injustice. The same was the case with other standard Argand burners, as the Dublin, Leamington, &c., which had been constructed on their principles; and therefore, if Parliament insisted on the passing of 5 cubic feet an hour through a test burner, the gas companies should be permitted to select that burner which, while fulfilling the conditions of the Act of Parliament, developed the illuminating power of the gas to the fullest extent. It was far better, however, that the second alternative should be resorted to, namely, the use of a standard burner, like a standard measure, as Mr. Sugg proposed, and the determination of the quantity of gas to be passed through it, so as to develop a flame of standard intensity or standard height. The intensity of the flame might be measured, as was the practice in France, under the advice of Dumas and Regnault, by keeping it exactly equal in illuminating power to that of an Argand burner, of prescribed conditions, consuming a given quantity of colza oil. Or it might be measured, as he had proposed, by ascertaining its penetrating power in passing through a medium of given opacity—say a piece of dark bottle glass cut in wedge shape. But if the height of the flame were the test, nothing was easier than to fix on such a height as would be best suited for the maximum development of light, and then to determine the quantity of gas per hour necessary to produce such a flame. Long ago, the late Dr. Fife showed that the quality of gas, as regarded illuminating power, might be determined by burning the gas from a jet of given dimensions, and observing the rate of combustion necessary to produce a flame of given height, or by observing the height of the flame when the gas was burnt at a given rate. Under the name of Lowe's Jet Photometer, the last method was practically in use at gasworks for the purpose of ascertaining the quality of the gas as it was made; and there was no reason why the other plan might not be pursued, for the principle was manifestly correct.

The illuminating power of gas was dependent on the proportions of the rich and heavy hydrocarbons which the gas contained; and as these were of much higher specific gravity than the hydrogen and marsh gas, which were the chief constituents of coal gas, it was evident that the density or specific gravity of the gas would rise in proportion to the quantity and quality of the hydrocarbons contained in it. Now, the experiments of Dr. Fife, as well as the more recent investigations of Professor Graham, had shown that the flow of gas through a small orifice was inversely proportional to the gravity of the gas. A light gas, for example, would pass much more freely and easily through such an orifice than a heavy gas. The law, indeed, as expressed by Professor Graham, was that the velocity, or rate of flow, was inversely as the square root of the density. If, therefore, the flame were used as the exponent of density, as it really was in the case of the heavy hydrocarbons, its height under a constant rate of flow would determine the density or quality of the gas; while with a flame of a given height, the rate of flow would be the means of arriving at a like result. This was the principle which the Author had in view, and no doubt it was susceptible of practical application. His experiments, indeed, showed that this was the case, and that the results obtained by it were accurate and trustworthy. The simplicity of the process was, moreover, a great recommendation, as it was capable of being applied under all circumstances, without the complicated machinery at present in use; only a standard burner being required with a handy, portable, and accurate meter, together with a delicate thermometer and a good aneroid barometer.

Mr. VERNON HARCOURT remarked that he had not had an opportunity of seeing the apparatus previously, and therefore could not presume to offer an opinion upon its practical value. One or two points mentioned by the Author were of great interest, and one certainly which he had not previously understood, viz., that flames produced by different samples of gas at the same burner did not differ from one another except in size, and that provided the total surface of the flame was the same, whatever the quality of the gas burnt, the amount of light it gave was the same. That was certainly at variance with common observation as to coal gas. Remarks were often heard as to the apparent brilliancy of the light, which were intended to refer to the effect produced by a given area of flame upon the eye; but from what Mr. Sugg said he understood a 3-inch flame, from the same burner, would always give the same amount of light, whatever the quality of the gas. Another question suggested by the Paper was as to the reason why the size of the flame should vary, as it was known to vary, other conditions being alike, with the quality of the gas. One reason for this was the decomposition of the heavy hydrocarbons at the high temperature of the flame. It was well known to chemists that at that high temperature these hydrocarbons were resolved into a larger volume of lighter gases. As soon as the gas had passed through the burner and had been heated part of it was decomposed, and a larger volume of gas was formed; so that actually with a richer gas, though the quantity passing through the meter was the same, the quantity in the flame was a larger volume, and therefore, to obtain a flame of a given length, it was necessary to burn less gas as measured by the meter. He did not understand why an Argand burner with a 3-inch flame was used, because, comparing the instrument with the jet-photometer, it appeared to have at least two disadvantages. It would seem an easy matter to determine the height of the flame, but actually its top consisted of a number of shifting peaks, and although it was possible to arrive at some rough average, yet its position could not be determined with accuracy. The error so produced appeared to be increased by using so short a flame. With a flame 6 inches long a small error as to the position of the top of the flame mattered less than in the adjustment of a 3-inch flame. The uncertainty as to the position of the top of the flame in the latter case was much greater, and the error caused by that uncertainty was greater. He could not understand why, in this instrument, such a flame was adopted, instead of the long flame with a well-defined top which was used in the jet-photometer.

Mr. Law said that portion of the profession engaged in gas engineering was much indebted to Mr. Sugg for the attention he had given to the subject of the Standard Gas Burner. No doubt the burner he had introduced was that which gave the most uniform results, and without which the present perfection of gas photometry could never have been attained. The most imperfect part of photometrical apparatus was that employed as the standard by which the instrument could be perfectly adjusted. Whatever photometer was used—whether Bunsen's, or Wheatstone's, or the wedge—they all depended ultimately upon the estimation of the human eye; and not only did that estimation differ in different individuals, but in the same individual in different states of health or other physical circumstances. He had placed on the table an instrument which he believed would become the standard photometer, because it was entirely independent of the physical conditions of the human eye, and really measured the intensity of the light by the velocity of its revolution. It was a recent discovery of Professor Crookes, and seemed to presage some great discoveries in reference to those extremely attenuated media of which Mr. Grove first showed the correlation, such as light, heat, magnetism, actinism, and electricity. The instrument was actuated by the intensity of the light. The cause of its revolution was not so important to inquire into in reference to this subject, but it was a fact that the velocity would vary according to the intensity of the light. It was most sensitive in its operation; it consisted of arms of aluminium with discs of talc, which were black on one side and polished on the other, and the influence of light upon it produced the revolution; it was in a perfect vacuum. The mode of making use of it would be to let it move at such a low velocity as would enable the revolutions to be counted; and the number of revolutions would determine the intensity of the light. If it were further improved by making one of the arms magnetic, a registering apparatus might be put outside, so that the number of revolutions might actually be recorded. In reference to the proposed mode of estimating the illuminating power of gas, he could speak from experience of the great value of having some simple mode which did not depend upon the estimate of the eye of different persons, such as in the Bunsen photometer; for he knew by experience, that fiscal engineers in foreign parts, not accustomed to this kind of observation, would estimate the gas at two or three candles different from the practised gas-maker who was used to the instrument.

Mr. BARLOW, Vice-President, did not think Mr. Crookes' instrument had been presented in a form suitable for measuring light alone, because it was affected not only by light, but by heat. It would require some provision to exclude the action of heat, because the worst gas was that which gave much heat and little light; and the instrument would be caused to revolve by gas of inferior quality almost as much as it would be by gas of high illuminating power. Care would therefore be required to exclude the effect of heat, otherwise bad gas might be registered as good.

Professor ABEL observed that Mr. Crookes had already given serious attention to that subject, and no doubt would be able so to arrange the apparatus as to shut off the rays of heat, and to obtain trustworthy records of the different illuminating power of the light emitted from different sources. He had sanguine anticipations of the results that Mr. Crookes would obtain in this direction. He had listened with great interest to Mr. Sugg's communication. The only point that occurred to him in reference to it was the one Mr. Harcourt had noticed, viz., the uncertainty of measuring the exact height of so short a flame.

Dr. Pole said it might perhaps be useful to state what was actually done in regard to testing gas, and the employment of burners in London. The ordinary method of testing gas was by means of the photometer, by putting a gas flame on one side of the disc and a standard candle on the other, and comparing the effect of the two in the usual way. Then the question arose as to what kind of burner should be used. Dr. Letheby had given a good historical account of what had been done with regard to burners, and Dr. Pole would take it up at about the point when the Act of 1868 was passed, which directed for the first time on a good scientific basis the testing of gas throughout London, and when a new clause was introduced with regard to the construction of the burner. It was not attempted to define what kind of burner should be used, but the clause left it to the Gas Referees to prescribe the burner: "The burner shall be such as shall be the most suitable for obtaining from the gas the greatest amount of light, and be practicable for use by the consumer." The illuminating power of gas varied immensely according to the burner used; it was supposed a sensible consumer would get the best burner he could, and the company of course had a right to have their gas tested by that burner. It came to the same thing as saying that the company should have their gas tested by the best burner which could be used by the consumer, and that was how the legislation stood at this moment. The Referees examined a great number of burners, and chose the one called Sugg's Standard London Burner as answering that condition; and that it had been used by the public was proved by its large sale. It also gave a pretty high illuminating power to the gas tested by it. It was prescribed by the Gas Referees and had been in use ever since, being considered a very good burner.

Then came another question, the quantity of gas passed through the burner; and here it was found that the same burner would give different results with gas of the same power according to the quantity which passed through it. Thus 5 cubic feet an hour passed through a burner would give one result, but if in the same burner only $2\frac{1}{2}$ cubic feet an hour were burnt it would not give the same proportionate result as before. He had occasion to go into the cause of this some time since, and found a curious law applicable to burners generally. It was expressed by the equation

$$L = m\,I\,(q - c).$$

Supposing L to be the light given off by the flame of a burner, I the illuminating power of the gas, and q the number of cubic feet of gas burnt, per hour; m and c were two constants, and that equation would give for all burners he had tried the light given out by burning a certain quantity of gas. The values of m and c came out as follows. For Argand burners generally m varied, according to the goodness of the burner, from 0·2 to 0·33, and c was pretty nearly 2. For flat-flame burners m varied from 0·1 to 0·2, and c was about 0·5. The inference was, with whichever burner, that the more gas burnt in the burner—that was, up to its maximum power, so that it did not smoke—the better was the result obtained. That led to this, that since the burner ought to burn the gas to the best advantage, it was necessary to have the flame pretty high, and the standard London Argand was made so as to burn about 5 feet an hour without smoking. That was how the burners used in testing gas in London had been arranged. Then came this difficulty. The gas of course varied in power; no gasworks could keep their gas always of the same strength; sometimes it was a little less than at other times, and sometimes more. When the illuminating power of the gas increased there was a tendency to smoke and flare above the chimney, and that had to be corrected. The examiners could not alter the quantity, because the Act mentioned 5 feet an hour; all they could do was to check the smoking by putting on a different chimney, which did the gas harm. On the other hand, if the power of the gas diminished, then the burner was not doing its best, as the flame became too low. Now, without going so far as Mr. Sugg had done by changing the plan altogether, the liberty of altering the quantity would, he thought, be a great convenience; when the gas became of a higher illuminating power, the quantity could be reduced, and when it had a lower illuminating power the quantity could be a little increased. This would have another advantage, inasmuch as it would represent more nearly what the public did. The public, in using the gas, kept the flame at pretty nearly the same height, and if the gas was too rich, rather than have it smoke, they turned it down, or if it was too poor, they increased it. Hence, the power of varying the quantity in testing the gas, according to the illuminating power, would in reality correspond to the ordinary conditions of practical use, one of the objects aimed at by the legislature.

Dr. Pole then referred to the late discoveries of Mr. Crookes, particularly as to the possibility of measuring the intensity of light by its mechanical radiating force, and he described, at some length, the several ingenious methods by which Mr. Crookes, in a paper lately read before the Royal Society,[1] had shown how the intensity might not only be accurately measured, but automatically recorded. He did not assert that these instruments were at present in a position to be used for a photometrical purpose of the importance of gas-testing in London; but Mr. Crookes' discoveries contained the germ of a great improvement, which might one day be of considerable value.

Mr. J. N. Douglass considered there must be some mistake on Mr. Vernon Harcourt's part as to the power of the flame being due to its length. He did not think Mr. Sugg could mean that a flame 3 inches long, giving a light equal to sixteen candles, could not be shortened without impairing its intensity. In lighthouse burners it was desirable to confine the length of the flame, and indeed to obtain a flame nearly spherical, for the purpose of utilising it more completely by the optical apparatus; and he had found that such a flame as that of the Sugg burner could be reduced to less than half its length, still retaining the same illuminating power. Nearly three years ago he had to apply, for the first time, Argand gas burners in the focus of parabolic reflectors for the Caistor leading lights at Yarmouth. He tried several gas burners, and among them Sugg's London Argand burner, which he found to be the best; but still the flame of this burner was too long for the purpose, it being about 1 inch in diameter and 3 inches in length. He therefore made some experiments, basing them upon the principles adopted in the improved "Trinity House" oil burners for obtaining perfect combustion and the required form of flame. He succeeded in arriving at the desired result, and also in attaining nearly the same economy in combustion as had been found in the improved "Trinity House" oil burners. On comparing the new one with the Sugg burner of the same dimensions and number of holes, the two consuming the same quantity of gas, viz., 5 cubic feet per hour, he obtained nearly 33 per cent. more light with the former. He submitted the burner to the Elder Brethren of the Trinity House and to their scientific adviser Dr. Tyndall, and took it to Mr. Sugg, who tested it with the same results, and who afterwards made the burners for the Caistor lights, which had been in use ever since. Mr. Sugg had since modified his London burner somewhat in accordance with the one referred to. The original London burner had a cone, but no central deflector or button, and there was no air passage between the cone and the glass chimney. The improved burner was the most perfect Argand

[1] *Vide* Proceedings of the Royal Society, vol. xxiv., p. 282.

burner he had yet met with for general lighting purposes. The use of inner and outer deflectors to Argand gas and oil lamps had been patented by Mr. W. Wilkins, in 1862–3. By the application of these deflectors, and other improvements to oil burners, he had found that with the present "Trinity House" improved lighthouse burners, which were adapted for burning either animal, vegetable, or mineral oils, when consuming colza oil the standard had been raised 39·38 per cent, *i.e.*, the illuminating power had been increased 22 per cent., with a reduction in the consumption of oil of 17·38 per cent. If considered economically, irrespective of the increased power per burner, a saving of oil had been effected of 32·47 per cent. These results were sufficient to show the importance of an efficient gas or oil burner. At the same time it could not be too clearly kept in view, in adopting a standard burner for estimating the illuminating power of coal gas, that as the efficiency of such a burner was improved the specified candle power of coal gas would be raised *pro ratâ*, otherwise the benefit to be derived by such improvements would fall to the gas companies instead of to the public.

Professor W. G. ADAMS observed that it had been pretty generally admitted, that the means of estimating the illuminating power of coal gas was in an unsatisfactory state. This was true of the power of measuring as well as of the power of producing the illuminating power; and all existing photometers were defective in that they relied on comparisons made by the eye of the observer between illuminations from two distinct sources. Attention had been drawn to another method of measuring the intensity of light by means of the radiometer, invented by Mr. Crookes, where the action of light and heat falling on a pith disc, which was blackened on one side, caused it to rotate, thus establishing a direct relation between two of the physical forces, radiant heat or light and motion. He wished to draw attention to the direct relation between two other of the physical forces, light and electricity, which was established by Mr. Willoughby Smith three years ago; who discovered that when light fell upon a piece of crystalline selenium which was in an electric circuit with a battery and galvanometer, the electrical resistance of the selenium was diminished by the exposure. During the last two years Professor Adams had been experimenting on this subject, and his results had been laid before the Royal Society.[1] They seemed to show that those rays of the spectrum which

[1] *Vide* Proceedings of the Royal Society, vol. xxiv., p. 163.

produced light were the rays to which chiefly, if not entirely, the change of electrical resistance was due. The dark heat rays produced little or no effect on the electrical resistance of the selenium. He had inclosed pieces of crystalline selenium in a box with a lid to exclude the light, the bottom of the box being made of ebonite, into which were fixed the binding screws for supporting the selenium, and making contact with the electrical circuit. The resistance of the selenium was balanced, before exposure, by a high resistance formed of a thick blacklead pencil mark on ebonite, which was varnished with a thin coating of shellac varnish. The spot of light of a delicate reflecting galvanometer was then at the zero of the scale. On opening the lid of the box the resistance of the selenium was diminished, and the spot of light travelled along the scale. Several series of experiments had been made to determine the relation between the intensity of the light and the change of resistance which it produced. The intensities of different sources of light had been compared by means of Bunsen's photometer, and the change due to the exposure to these sources had been determined by the throw of the galvanometer needle, the duration of each exposure being ten seconds. In one series of experiments, the action of a single candle placed at different distances from the selenium had been measured, and compared with the action of an Argand lamp of the illuminating power of sixteen candles. The following deflections of the needle were obtained:—

	At ¼ mètre.	At ½ mètre.	At 1 mètre.	At 2 mètres.
With the Argand lamp	..	170	83	39
With one candle . .	82	40	18	8

In another series of experiments, with a different piece of selenium exposed to the light of a single candle at varying distances, the results were:

	At ¼ mètre.	At ½ mètre.	At 1 mètre.
With one candle . .	45	25	15
" " . .	40	20	10

The results obtained showed that the action of the light during exposure for ten seconds, as indicated by the throw of the galvanometer needle, was inversely as the distance of the source of light, *i.e.*, directly as the square root of the illuminating power. Hence with the selenium photometer, when two sources of light at different distances produced the same change of resistance in the selenium, their illuminating powers were directly as the squares of their distances from the selenium. Not only might the relative illuminating powers of two sources of light be compared by this photometer, but a direct relation might be obtained between the illuminating power of the light and the change of resistance produced by it in a given piece of crystalline selenium at a given temperature.

Mr. SUGG, in reply, said he had placed on the table the jet-photometer, to illustrate the difference between it and the Illuminating Power Meter, and that it might be seen how far the results corresponded in the manner mentioned by Mr. Vernon Harcourt. Dr. Letheby had referred to the variations in the illuminating power of the standard sperm candles. This subject had already been brought before the Institution in a Paper by Mr. T. N. Kirkham, M. Inst. C.E.,[1] in which the results were given of a great number of those experiments—especially of one series made in conjunction with Dr. Odling, and in which he found there was a difference ranging as high as five candles in the estimation of 14-candle gas. That arose in this manner: Dr. Odling purchased the candles in different places, and the difference in their manufacture was sufficient to cause the wide variation of five candles. Dr. Odling was quite satisfied at that time that the candles were not a reliable standard. By making them carefully that error had been mitigated; but it was still open to inspectors testing gas throughout the kingdom, except those testing under the Gas Referees, to buy their candles wherever they liked; and if those candles were adulterated with paraffin or stearine, there was sure to be a difference in the illuminating power. The object of the illuminating power of the meter was principally to have a check upon the candles; and he did not propose, as Dr. Letheby seemed to imagine, to do away with the ordinary photometric test, but simply to put, at one end of the photometer, his standard burner, which would always give a light equal to sixteen sperm candles, so as to check the candles if they did not burn properly. He had made a number of experiments with these candles in comparison with the standard burner, and found that the candles gave a different result, varying from 15 to 17; whereas the flame had always been supplied by the same quality of gas, and therefore there could be no variation. With respect to the Birmingham burner, Dr. Letheby remarked that, probably, now that the authorities had taken the matter of gas into their own hands, they would regret the adoption of the Birmingham standard burner for the purposes of testing the standard gas. At the present moment they had escaped from that difficulty by adopting the London

[1] *Vide* Minutes of Proceedings Inst. C.E., vol. xxviii., p. 440.

Standard Burner; but in other cases where the Birmingham burner had been adopted they would, no doubt, have to contend with the difficulty of getting bad results. The burner placed upon the meter was an ordinary consumer's burner, and not specially made for the purposes of the photometer. Mr. Vernon Harcourt thought there would be a difficulty in reading the exact height by inches, because of inequalities in the height of the flame. Supposing a burner were made expressly for photometric purposes, no doubt the flame could be kept perfectly level on the top, but the slight variations in that standard burner did not make any appreciable difference. Several members of the Institution had tried the regulation of the flame themselves, and the only difference was about half a candle, not a great difference when it was remembered that they had never seen the instrument before. Mr. Vernon Harcourt had also spoken of the more easy method of reading the height with the jet-photometer. This instrument showed the illuminating power of the gas in a manner somewhat similar to the Illuminating Power Meter, namely, by the height of the flame. If the gas was rich, the flame went up higher; and if poor, the flame was low. By regulating always to one height of flame, and reading off the pressure required to give that height of flame, a correct estimate could be formed of the illuminating power of the gas. There was only one difficulty, which he hoped to remove, and that was the difficulty of the Standard Burner. For every quality of gas at the present moment a different standard burner was required; and as they all differed among themselves, it was difficult to fix the readings of the jet-photometer to any particular point which would be universally correct; for if it was correct for one standard burner, it was sure to be wrong for another. That difficulty was again complicated, because with gas beyond twenty candles the Argand burner was replaced by a burner which gave a flat flame, and the flat-flamed burner gave a higher result for the higher illuminating power of the gases than it ought to. Up to 30-candle gas it made a difference of about three candles. That difficulty did not exist with the Illuminating Power Meter, because it was adapted for gas from twelve candles to thirty-two candles; and although with 35-candle gas there seemed to be a little difference, it depended upon the chimney placed over the flame. If a long chimney was put on, which favoured the richer gas and deteriorated the poorer, it would give the benefit to the richer gas; but by putting a chimney suitable to both kinds, the illuminating power of the burner could be made exactly the same, whether 12- or 35-candle gas. Dr. Pole mentioned that, according to law, official testing must be made with 5 cubic feet of gas; but it was known that for a long time that had not been complied with. In the case of Birmingham, in particular, if the gas was over fourteen candles, it used to flare over the chimney, and it therefore became necessary to reduce the quantity; and so also in many other places. In London it was not so done, because the Gas Referees had made a provision to avoid it. They said that when the gas was so rich that it tailed over the top of the chimney, a still longer chimney should be put on. If that was done in London, it was just as easy to do it in other places, as Birmingham, where the burners would not consume the proper quantity of gas. His proposition was to provide one standard burner for all qualities of gas, by which means all difficulty was avoided, simply by reducing the quantity of gas used in accordance with its richness; and so correctly and proportionately to estimate the quality of the gas burned. With respect to the radiometer, there appeared to be some difficulty in its application to gas photometrical purposes. It certainly went round fastest with the hottest burner; and it would go round as fast with a heated poker as it would with the burner. No doubt the movement was as much affected by heat as by light; but with one standard burner and one height of flame, if the radiometer was placed at a sufficient distance, that difficulty might be got over to a great extent. Also if the number of revolutions could be reduced, it might be possible to check the accuracy of the burner, and so have another check upon the sperm candle, or perhaps eventually do without sperm candles at all.