Dr. Letheby observed, through the Secretary, that the Author appeared to be of opinion that high temperatures were the best for the carbonization of gas, it having been, as he said, for some time the practice of good carbonizers to subject the coal in the retort to as high a temperature as was attainable with coke fuel, for the double purpose of getting a large return in coal carbonised per retort, and a high yield of gas per ton of coal, with a proportionally low yield of tar. This was, no doubt, the practice in London, where the struggle was to meet the views of the directors of gas companies as regarded the yield of gas per ton of coal; but it was not generally the practice in the country, where gas engineers were more independent of the boardroom. It was certainly anything but a good practice, for the temperature of the retort, when heated to its highest point with coke fuel, was an incipient white-heat—a temperature which not only broke up the hydrocarbons of the tar, and produced secondary compounds of little or no use to the gas manufacturer, but which also broke up the rich volatile hydrocarbons of the gas, and thus, by depositing carbon in the retorts, furnished gas of low illuminating power, which required to be supplemented with the expensive products of cannel. It seemed, indeed, as if the object was to create a difficulty for the sake of overcoming it. An incipient white-heat was, moreover, the temperature best suited for the production of that *bête noire* of gas manufacturers, bisulphide of carbon. Besides which, there were the difficulties alluded to in the formation of a viscous pitchy matter in the hydraulic main, which was most objectionable. The gas and tar, in fact, coming "from the white-hot sides of the retort," were ready for quick condensation; and they not only formed a viscous matter in the hydraulic main, but they frequently choked the ascension pipes of the retorts. In addition to which there were the hindrances to condensation in the subsequent treatment of the gas, and the throwing of extra work upon the scrubbers. Experiments in the laboratory, as well as practice in gasworks out of London, had shown that a full red-heat was the highest point to which coal should be subjected in the retort. At a temperature, indeed, of 1,500° Fahr., which was a cherry red, the most profitable results, as regarded the quality of gas, were obtained; and from that point to 2,000°, which was a full bright red, the distillation might be carried with safety, but not beyond it. Looking at the other side of the question, the only advantages he could perceive in the use of high temperatures were the production of a denser coke, of a large volume of poor gas, and of a tar rich in secondary products, which were absolutely hurtful to the gas manufacturer, although valuable to tar distillers.

Passing from the retorts, no doubt the gas should be very gradually cooled, that it might be kept for some time in contact with tar and ammoniacal liquor, both of which were endowed with large powers of absorption as regarded the chief impurities of gas. His observations, indeed, at many of the gasworks of England had shown that, wherever the hydraulic main and the eduction pipe leading from it to the condensers were of great length, the impurities of gas, especially naphthaline, carbonic acid, and sulphur, were greatly reduced. He had no doubt that the elongation of the eduction pipe, with only a slight incline for the flow of the tar, and in such a situation that the gas might be slowly cooled before it reached the condenser, would be of great value in practice. The condenser should be so placed and arranged that the temperature of the effluent gas should be as near 60° Fahr. as possible; for the object was to condense, as far as practicable, the impurities of the gas, and so save the subsequent work of scrubbing and purifying.

The position of the exhauster was generally after the condenser; but if, by the elongation of the eduction pipe from the hydraulic main, the temperature of the gas could be brought down to about 100° Fahr., the proper place of the exhauster would be before the condenser, and for the following reasons :—1st. It was desirable that as little air as possible should be drawn into the gas, seeing that if it entered at the retorts it would produce carbonic acid, which was a most objectionable impurity, and if it entered elsewhere it would destroy the illuminating power of the gas. It was well, therefore, to reduce its chance of entrance to a minimum. 2ndly. When the exhauster acted upon the gas in the condenser it had a tendency, by reason of its exhausting power, to draw off the volatile impurities (sulphide and carbonate of ammonium) from the liquor, and so prevent their condensation; whereas pressure upon the gas in the condenser, as would occur when it followed the exhauster, would tend to promote condensation, as well as the chemical combination of sulphide of carbon with sulphide of ammonium.

Then came the action of a very important part of the apparatus—the scrubber—to which the Author had not devoted so much attention as it deserved. He spoke of getting with brushwood and coke scrubbers 30 gallons of liquor of 8-oz. strength from every ton of Newcastle coal; but unquestionably it would be better to obtain half that quantity of liquor with double its strength; for the aim in purification should be to produce a liquor of the greatest possible strength, not less than 20-oz. when measured by its capacity for neutralising strong sulphuric acid, or of a gravity of 10 of Twaddell, or 1,050, water being 1,000. The object of this was twofold. 1st. A liquor of this strength contained not less than 2,400 grains of sulphide of ammonium per gallon, endowed with a capacity of combining with rather more than its weight of bisulphide of carbon. It was also endowed with the power of combining with carbonic acid to the exclusion of the more manageable impurity—sulphuretted hydrogen. 2ndly. A liquor of this strength was far more valuable to the manufacturer of sulphate of ammonia than the mere proportional strength of acid represented, for it cost less in carriage and less to manufacture. The method of producing a liquor of this strength, and using it in gas purification to the best advantage, was not by means of a scrubber packed with brushwood and coke, but by means of a fine spray of liquor thrown into the scrubber from jets pointing in all directions. With such an arrangement the surface of the liquor was infinitely extended, and it acted without pressure upon the gas, and throughout the entire area of the scrubber, there being none of the space occupied with solid, and therefore inert, materials. If it were not for the offensive character of the materials, and especially of the foul lime from the purifiers, it would be advantageous to let the gas pass on through the purifiers with just so much ammonia in it as the douche of liquor failed to absorb, because of the well-known action of ammonia upon bisulphide of carbon, whereby the latter was converted into sulphocyanogen and sulphuretted hydrogen, a process in action throughout the mains of every gas company, causing the water of hydrants and meters to become charged with sulphocyanide of ammonium; but the offensive character of the materials from the purifiers necessitated the removal of the rest of the ammonia, and this might be effected by a water douche, or by an absorbent like acidified sawdust or sulphate of iron.

Then followed a very important part of the process of gas purification, namely, the removal of carbonic acid from the gas; for if this were not completely taken out before the gas reached the stage of sulphur purification, it would operate most injuriously, by displacing bisulphide of carbon as well as sulphuretted hydrogen from the foul lime. In many gasworks it was the practice to put a layer of lime upon the first tray of the oxide purifiers; but this practice was unsatisfactory, for the lime could not be apportioned in such quantity as to be fully effective. A set of lime purifiers must be devoted to this particular purpose, and must be carefully watched, so as to prevent the passage of carbonic acid. Next to these there should be a set of lime purifiers devoted especially to the absorption of sulphuretted hydrogen and bisulphide of carbon; for the latter was an acid to sulphide of calcium, and would combine with it in the same manner as its homologue, carbonic acid, would combine with oxide of calcium. To effect this the purifiers must be worked exceedingly foul, and the time of changing must be determined by experimental tests on the quantity of sulphur in the gas. With proper care there was no necessity for further purification; but it was well to have an oxide purifier at last as a safety apparatus. He ought to remark that the action of lime on the impurities of gas was not instantaneous, and, therefore, time must be allowed for it. The contact of the gas with the lime should also be as perfect as possible, and on that account it was better to multiply the trays, and not to have the lime in greater depth upon each tray than 4 inches; for if the depth was increased, the pressure upon each layer became enormous; and—as the lime inevitably caked—the gas would blow its way through some part of the layer and so fail to be acted on.

The aims, therefore, of the manufacturer of gas should be—

1. To produce the gas at as low a temperature as possible;
2. To cool it very slowly on its way to the condenser;
3. To condense it effectively and under pressure, if possible;
4. To wash it thoroughly with ammoniacal liquor, so as to bring up the strength of the latter to about 10 Twaddell, or 20 ounces of sulphuric acid;
5. To remove carbonic acid in the first stage of purification; and
6. To remove sulphuretted hydrogen and bisulphide of carbon at the last stage by means of lime.

With these aims in view, and in successful practice, it was not difficult to produce from Newcastle coal, without the aid of cannel, a good proportion of gas, of fair illuminating power, without a trace of naphthaline, ammonia, or carbonic acid, and with less than 10 grains of sulphur per 100 cubic feet of gas.

Mr. S. Hunter remarked, through the Secretary, that at the Rochdale Corporation Gasworks there were two sets of purifiers; of which one set of six purifiers, each 24 feet square by 4 feet 6 inches deep, was fixed at an elevation. Two of these, charged with hydrate of calcium, were used principally in abstracting carbonic acid and bisulphide of carbon; the other four, charged with hydrated peroxide of iron, were for the purpose of abstracting sulphuretted hydrogen. To save manual labour, near the centre of each purifier a circular funnel, 6 feet in length, was suspended from the bottom of the purifier, to within 7 feet 6 inches of the ground-floor. This funnel was an 18-inch flanged pipe, provided with a door, cross-bar, and screw, and luted with sealing materials similar to those used for retort lids. To empty a purifier, it was only requisite to take off the door, when the oxide or lime could be discharged through the funnel on to the floor below. The spent lime was sold for manure, but the oxide was spread out on the ground-floor, and, after being turned over several times, was used again. The same oxide would revivify fifteen or twenty times, or until it contained fully 50 per cent. of sulphur. The special arrangements for hoisting the lime and oxide into the purifier were as follows: Two wrought-iron lattice girders 3 feet deep, strongly trussed together, extended from one side of the house to the other, a distance of 62 feet, the ends resting upon a carriage on wheels. A line of rails was laid on each side of the house, supported on stone corbels which projected from the inside walls; upon these rails the girders and carriage travelled over the purifiers from one end of the house to the other. Upon the girders an arrangement of hydraulic rams and chains were connected by tubes to a three-throw pump, worked by a small high-pressure horizontal steam-engine. To charge a purifier, the material was placed in a wooden hopper which held about 12 cwt., the chain connected to the ram was hooked on, the engine set to work, and the material was hoisted 20 feet from the ground through a trap-door in the first floor. The travelling girders then brought the hopper into position, the material was tilted out into the purifier, the hopper was run back over the trap-door, and lowered, and the operation was repeated until the purifier was charged. The engine ran full speed the whole time, and the hydraulic pressure was controlled by an arrangement of taps. When the water was not required, it flowed by the bye-pass with the water from the rams, into the cistern which supplied the pumps. The collective internal capacity of the six purifiers amounted to 15,552 cubic feet. By the ordinary mode of calculation they were equal to the purification of 2,000,000 cubic feet of gas in twenty-four hours; but it was not intended at present to purify more than half that quantity in the time named. With that large area the purification was comparatively perfect, and the cost of working very economical. The gas was free from sulphuretted hydrogen and carbonic acid, and on an average there were only about 11 grains of sulphur (other than sulphuretted hydrogen) per 100 cubic feet of gas. In regard to the remarks upon the estimation of bisulphide of carbon, no analysis of gas was made either at Rochdale or in London for that purpose; it was burnt and estimated as sulphur. The atomic weight of sulphur was 32. Now, bisulphide of carbon contained one atom of carbon (weight 12) and two atoms of sulphur ($32 \times 2 = 64$), together equal to 76. The quantity of sulphur having been ascertained, 11 grains in 100 cubic feet of gas, the quantity of bisulphide would be 64 : 76 :: 11 : 13, showing that 11 grains of sulphur were equal to 13 grains of bisulphide of carbon. Recent tests at Rochdale indicated a much less amount of sulphur:—thus, on the 11th and the 15th of January, 1875, the quantities were 7·14 grains and 9·61 grains respectively, giving an average of 8·375 grains of sulphur in each 100 cubic feet of gas. To obtain absolute purity from bisulphide of carbon would entail an expenditure altogether out of proportion to the small or questionable benefits to be derived. If the gas were free from sulphuretted hydrogen, ammonia, and carbonic acid, and had not more than 20 grains of bisulphide, equivalent to from 16 to 20 grains of sulphur, then there would be no reason to complain. In addition to these impurities, an analysis of the purifying material showed that a good percentage of ferrocyanides of ammonia, as well of sulphide and sulphocyanides and ferrocyanides of iron, had been formed in the purifiers, showing the presence of cyanogen compounds in the gas. The economy of the arrangement for working, and the advantage of having such a large area in proportion to the gas purified, might be inferred from the fact that, last year, the cost for materials and labour was less than ½*d.* per 1,000 cubic feet of gas purified.

Mr. G. T. LIVESEY considered that the Paper presented a complete summary of gas manufacture. With regard to the question of stage houses and houses on the ground-floor, he had hitherto always worked with the latter, and he was bound to say that his preference was for the old-fashioned method. But in erecting new houses he should adopt the former plan, because some mechanical form of stoking might be introduced, for which the stage house would prove more suitable. He had tried the mode of fastening the slates both by strong copper and by lead wires, and had given it up long ago, for the sulphurous acid fumes corroded both the copper and the lead. Nothing answered so well as laths of angle iron fitted in with a deal batten 1½ inch square, to which the slates were nailed. For preventing the accumulation of pitch in the hydraulic main, he could not approve of the plan of lengthening the ascension pipe, since it did not accord with the remarks in the Paper, as to cheapness in cost of construction and efficiency in action. The method might be thoroughly efficient in action, but it certainly was not the cheapest in cost of construction. The plan of placing in the old-fashioned main a false bottom, or constructing new mains with a shallow bottom, so that there was no space in which the tar could lodge, was effective, there not being the least viscidity in the tar. He thoroughly agreed with the Author as to the expediency of reducing the temperature in the condenser. It must be lowered somewhere, and it was better that this should be where it could be controlled, than in the streets and in the fittings of houses. He believed the difficulty of insuring the successful action of the scrubber, as commonly arranged, might be overcome by a suitable arrangement of Barker's mill, by which a small quantity of water might be so distributed through the mass of the scrubber as effectually to remove the ammonia, at any rate so far that the gas issuing from it should not stain turmeric paper. That had been his experience for some years, and he was satisfied when such a result was obtained. He had found it a good plan to bring the gas in at the top of the purifier, so that it should work downwards. In ordinary working, the first purifier on being changed became the last; then if the gas worked upwards, its last contact would be with the foul cover of the purifier; if it worked downwards, its last contact would be with the bottom of the purifier. Sufficient purifying material fell through to cover the bottom, and so to prevent the gas from having contact with surfaces impregnated with foul gas. He agreed in thinking that the top of an untrussed gasholder should not be quite flat. It had been the practice in holders with untrussed crowns to make the top nearly flat; but when the crown was trussed there was a considerable rise. In a gasholder of 150 feet in diameter the sheeting would rise 7 feet 6 inches; whereas if the gasholder had been constructed without internal trussing the sheeting would probably only be allowed to rise 2 feet 6 inches. Being engaged in the construction of a gasholder on that plan, of 180 feet in diameter and 45 feet deep, without internal framing, he made some simple experiments to ascertain the relative strain on the curb in proportion to the rise of the crown. He found that, supposing with a 3-feet rise there would be on a certain section of the sheeting attached to the curb say a strain of 3 tons, if the rise were 9 feet the strain would be proportionately reduced, and would be only 1 ton. Puddle, for gasholder tanks, was in his experience a most intolerable nuisance, and exceedingly treacherous. As a lining to a canal, where it was undisturbed for years, nothing could be better, but it was far different in gasworks, where it might be necessary to build one gasholder tank one year and to build another near it after the lapse of only four or five years. In solid blue clay there would be no difficulty, but if the ground was treacherous, and there was much running sand or gravel, in pumping the water for the excavation of the new tank the puddle of the adjoining tank would probably be loosened. As he had found, from time to time, that on constructing a new tank the old ones began to leak, he was now constructing a tank entirely of concrete, without a particle of puddle, and he trusted to make the interior sound by rendering it with Portland cement. He had thus far every reason to hope that the experiment would be successful. He decidedly approved of the throttle-valve governor used by the Author. With reference to the introductory and the concluding remarks of the Author, as to high efficiency and low expenditure, he was afraid the law, as regarded London gas companies, rendered it difficult for gas engineers to do right, if the dictum was, as would be generally admitted, a correct one. The present system offered no inducement to the engineer to cheapen gas. It offered every encouragement to do the best he could for the company in regard to substantiality of work; but when it was the interest of shareholders to get as much money invested as they could, with 10 per cent. practically guaranteed, it would be easily seen that by economising capital the engineer might not please his masters. He did not desire to be understood as making any charge against men, but rather against the system. The present system began in 1847 with the Gasworks Clauses Act, which was enacted at a time of competition, when 10 per cent. was quite out of sight. Since then circumstances had totally changed, but the special legislation affecting gas companies had continued in the same groove, with the result that, practically, all gas companies were able to pay 10 per cent. They had a strict monopoly of the business, and if they could not pay their dividend at one price they charged another that would enable them to do so. There was not, therefore, the inducement to economy that there ought to be and might be. When once a gas company had its 10 per cent. dividend, according to the Act of 1847 all future profits should go in reduction of price; but what inducement was there to make further improvements? This applied with great force to the construction of new works. Shareholders were anxious to increase their investments: they were continually thrusting upon the directors offers of money, and urging them to issue new capital or to make calls, and the directors had often the ungenial task of having to refuse such offers. An engineer had only to say that new works were necessary, and the money was forthcoming at once. In the construction of new works, two courses were open to him, and a man, with the most honourable intentions, might choose either with equal facility, and possibly with equal credit to himself. If he had the charge of fairly efficient works, he might make a copy of those works, using the same specifications and drawings, and so relieve himself of a great deal of anxiety, labour, and responsibility, feeling sure that if the works were a copy of those in existence the shareholders would be satisfied. Or, he might think that the highest efficiency, or the greatest economy, had not been attained, and that he might substitute for expensive materials those of a much cheaper kind; but this would involve him in considerable labour and responsibility, with risk to his reputation in the event of failure. Often a contractor would undertake to do a certain work at a certain price, and, having done similar work before, would guarantee efficiency; but in the case of a new system being adopted, the contractor would say, "I will undertake this work, and will do it as you direct to your satisfaction, but I will not guarantee its efficiency." That would apply forcibly in the case of a gasholder tank. On the old brick and puddle system a contractor was always ready to guarantee. An engineer, therefore, had not the inducement to economise that he would have if it were to the interest of the shareholders to economise their capital as much as possible. It also applied to the question of the purchase of gas companies. There was a scheme before Parliament to purchase them on the terms of the market value of the shares. The companies wanted annuities equal to their dividends, but in either case the terms of purchase would be based on the amount of the capital, not depending on the intrinsic value of the property to be purchased. A company, therefore, which had worked very economically would get a certain sum under either system for its property; whereas if the same company had raised a great deal more capital and spent it, the shareholders would receive a much larger sum in annuities. He had no hesitation in saying that with such purchase looming in the distance, it was to the interest of gas companies to increase their capital as much as possible. It was his own interest, but he believed that in the extension of works under ordinary circumstances an outlay of capital equivalent to £5 per ton of coal used was sufficient to meet the demand. The public felt the unfairness of the present system, hence the outcry against it, intensified as it was by the careful exclusion of the commercial principle from undertakings which were or should be strictly commercial. No doubt gas property was well worth preserving, but he did not think it was possible to retain it for many years unless the present system was altered. His recommendation was to reverse the principle of the Act of 1847, and to say to companies, "With a certain price of gas you may pay your maximum dividend. If you go below that price, you may pay an increased dividend; if you go above it, you shall have a reduced dividend." He believed that some such system would act beneficially for the companies and the public. At present he foresaw nothing but continual turmoil, ultimately resulting in purchase. If the matter were regarded in the way he had put it, he believed amalgamation on a general and effective plan might be an advantage to the whole of London. Partial amalgamations hitherto had discredited the system; but on a plan that would make it the interest of the company to serve the public well, amalgamations might be beneficial.

Mr. HODGSON JONES said that some years ago he was engaged by the Corporation of Nottingham against a bill promoted by the Gas Company of that town, in which there was a clause, called the Auction Clause, limiting the amount of interest on the shares issued, and obliging the company to put them up to public auction. Such a system would probably obviate the unfortunate results to which Mr. Livesey had alluded in regard to directors and engineers, so that there would be no great desire to push engineers into extravagant schemes. He thought the Engineers at Beckton and at Bromley had exercised a wise discretion in using the stage system. In some small works belonging to the Chartered Company at Silvertown, built on the other plan, the settings had sunk considerably, and the workings, therefore, could not be so good as they otherwise would have been. The fires were affected at times by evaporation from the ground. At Havre, fourteen years ago, on taking down some settings that were placed on the ground-floor system, he found that the earth was damp and steaming to a depth of 5 mètres. Under such circumstances, the stage-floor system was to be preferred, although it was a little more costly than the other. In the case of a flood, the fires were raised above the ground, and there was, therefore, less chance of the service being interrupted. The Steam Stoker appeared to him to promise something better than had yet been seen. In the Glasgow Gasworks Mr. Foulis, M. Inst. C.E., used an hydraulic stoker, which was acting very fairly; and the same plan had been adopted in Manchester; so that he hoped, sooner or later, some good mechanical means of stoking would be obtained. This would not do away with the necessity for a covered yard-space. In most of the metropolitan works, and elsewhere in England, the covered yard-space was inadequate for proper working. The coals were at times obliged to be exposed; and it was well known that the use of wet coals produced from 10 to 15 per cent. deterioration, and coke, by exposure to wet, was deteriorated to the extent of 15 per cent. The use of wet coals also led to the production of an increased quantity of bisulphide of carbon and carbonic acid. Dr. Letheby deprecated a higher temperature than a cherry red or a full bright red, anything beyond that breaking up the hydrocarbons in the tar, and he blamed the London managers for working at too high heats. But with good Newcastle coal Mr. H. Jones had found that the best results were obtained by a bright orange, or nearly white heat, 2,200° to 2,300° Fahr. The settings would last for about three working years. He employed D retorts 18 inches by 13 inches by 20 feet long. A bench of seven would carbonize, in twenty-four hours, 8 tons 8 cwt. of coal, giving 5 tons 17 cwt., or 70 per cent., of coke, and producing from 10,200 to 10,300 cubic feet of gas of 13 to 14-candle power with 18 per cent. to 20 per cent. of fuel, using six-hour charges. With that heat, he believed some of the light oils in the tar were decomposed. The anthracine obtained from the tar was a valuable product. Dr. Letheby had made a useful proposal that the exhauster should be placed before the condenser. He quite agreed with the reasons assigned, and should be anxious to try the method. Hitherto the position of the exhauster had generally been after the scrubbers or after the condenser. In many works he had moved the exhauster from beyond the scrubbers to immediately after the condenser. The reason, he thought, why this plan had not been adopted was the difficulty of dealing with the high temperature of 100°, and with so much tar in the gas to pump. The Author recommended rotary exhausters. Mr. H. Jones had used many of these, and had also employed reciprocating exhausters; the result of his experience was that with the latter there was a saving of from 50 per cent. to 60 per cent. upon the former; he alluded especially to wear and tear, and to the consumption of fuel. With suitable designs, and a properly-placed hydraulic main, there should be no stoppages in the ascension pipes. He was connected with many works in which there was no trouble of that kind, and if such a thing occurred, the insertion of a grating at the mouth of the retort reduced the temperature and removed the obstruction. He thought that stoppages in the hydraulic main arose entirely from neglect. Gas engineers agreed that the temperature of the gas should be controllable: it was evident that in the depth of winter, and in the height of summer, there were two entirely different states of the atmosphere to deal with. He unhesitatingly said, therefore, that condensers should be put under cover, as also the scrubbers and the purifiers; it was impossible to keep uniform temperatures when the vessels were exposed to the variations of the seasons. The scrubbers he used were different from any of those mentioned. They were three in number, and were filled with thin boards, on the system adopted by Mr. Livesey at the South Metropolitan Gasworks, exposing a large surface and proving very effective. He washed the gas in large volumes in the first and second scrubbers. Instead of a Barker's mill, which distributed only a small quantity of liquor, he had two entries for it, through which large quantities were discharged, like heavy rain. The result was that he could concentrate the liquor up to about 20 ounces. The strength was not generally so high as that, because the liquor was usually treated at the works; but where it was sent away, it was concentrated to about 20 ounces without difficulty. He finished by cleaning the gas with pure water. The effect of drenching the gas with liquor was to break up the bisulphide of carbon and to enable the gas to be much more easily purified. Lime varied so much in different parts of the country, and was so offensive after being used for purification, that managers were often in great difficulty as to how to dispose of it. In some works he used the lime first for the purpose of removing the carbonic acid gas, and he afterwards got rid of the sulphuretted hydrogen by an oxide. He preferred Laming's system for preparing the oxide, because by it some of the carbonate of lime was turned into sulphite, and that assisted in freeing the gas from carbonic acid that might otherwise pass. The oxide could be treated in two ways—by manual labour, or by sending a blast of air through it by means of steam. He had adopted the latter system in one case, the result being that the purifiers were kept four months in action, the steam being employed for four hours out of every seventy-two hours. When the material was done with, it was worked over again, until it had absorbed all the sulphur that it would take up. He had gradually reduced the number of sieves to only one, putting the lime on thicker; and he found no disadvantage from back pressure. The superficial area at the top of a purifier was, he thought, the right indication of its power of purifying, and not the bulk of material got into it on a series of tiers of sieves. Fifteen years ago he was connected with the late Mr. George Lowe in some works, and they then tried a good many gasholders made without framing; but no great economy was effected; and he had long discontinued their use. There was not much saving in the first cost; there must be a certain pressure to force the gas through the mains, and in the case of medium-sized gasholders without framing so as to be economically constructed, there was not a sufficient weight of metal to give the necessary pressure. In a large gasholder, with a strong curb and heavy plates, he could understand no framing being used, but with holders up to 150 feet in diameter he should certainly always put in framing. The description of material for building a tank would depend much upon locality. In many places he should hesitate to adopt concrete for building a gasholder tank, although he had done so in other constructions for water tanks. The governor, as generally used, was an exceedingly delicate and a correct instrument, not necessitating such additions as a throttle valve. The Ratcliff was a small district, with heavy lighting on the whole of it, and 6 per cent. unaccounted-for gas was certainly under the average. He considered 10 per cent. to be a fair average. In London the public lighting was not equal to that in most other towns. As there was a limitation of 1 inch pressure up to twelve o'clock, and after that only ½ inch, that might partly account for the small loss stated. For the consumers a sufficient and equal pressure and uniform quality of gas were as desirable as cheapness. He thought that recent legislation requiring gas of high illuminating power was a mistake. In the Act of 1860 gas with an illuminating power of 12 candles was named, and since that period this had been raised to 16 candles. The reason why engineers were obliged to use cannel coal, with the Newcastle coal, was not the high heats employed, but the necessity of furnishing gas of that illuminating power, as it could scarcely ever be got out of the best Newcastle coal with a fair yield of gas per ton. If the standard were reduced to 13 or 14 candles, he believed the gas would be more uniform in quality, and the public would certainly have the benefit of a reduced price. The burner generally employed in London, the union jet, was not a suitable one, as it allowed a great deal of gas to pass off unconsumed. He had lately observed in his own room, where there was a six-light chandelier, a close and offensive smell. By employing one of Sugg's London burners, the Argand burner, the atmosphere of the room was at once rendered pleasant, and a greater amount of light was given. The late Mr. Neilson was the inventor of the union jet or fishtail burner, and he always said that it was wrong to adopt it for burning poor gas, it having been designed for consuming the rich gases made in Scotland. He did not patent the burner; but if he had done so, it would, in Mr. H. Jones' opinion, have proved more valuable than his hot blast.

Mr. KIRKHAM said the superiority of the stage retort house over the ground-floor system depended, in his opinion, upon the magnitude of the works or the quantity of coal to be manipulated in twenty-four hours; also on the price to be paid for land. In large works the irregularity with which the coal was delivered, and the short time in which it had to be unloaded, necessitated the building of stores, with machinery for discharging and distributing the coal, and the dimensions of the stores could only be determined by circumstances. The advantages of the stage house were the protection afforded to the men, and a saving in labour and fuel. Thus the coke, on being drawn from the retorts by the stokers, fell through a space between the front of the stage and the mouthpieces of the retorts, into vaults below, where it was extinguished by the cokemen, and put into the dealers' carts direct, or thrown back till required. The stokers, whilst drawing the retorts, were not exposed to the heat given off from the body of red-hot coke lying in the barrow, nor had they to wait whilst the barrow, when full, was being removed and replaced by another. Nor had the men to wheel the coke into the yard to extinguish it; thus they were shielded from rain and extreme changes of temperature. This protection to the men enabled them to do more work, with greater comfort to themselves. In the stage house, the furnaces being accessible from below, the removal of clinkers was performed with less labour, and fuel was saved. The total manufacturing wages were not, in his opinion, the correct figures to be employed in estimating the relative cost of labour in the two systems. A certain amount of coal had to be put into the retort, and the coke had to be drawn out and extinguished. In the case of the ground-floor, as mentioned by the Author, the number of men employed for twelve hours, to manipulate 25 tons of coal, was about twelve and a half, the gang consisting of two scoopmen, four stokers, four cokemen, one trimmer, and one fireman and a half. The cost was £3 2*s.* 10*d.*, or 30·1*d.* per ton of coal carbonized. For the stage house a gang consisted of nine men—two scoopmen, four stokers, two cokemen, and one fireman. These men did the same amount of work, and, as stated before, with greater comfort to themselves, than the twelve and a half men in the other case. The cost was £2 9*s.* 6*d.*, or 23·75*d.* per ton of coal carbonized, showing a difference of 6·35*d.*, or 21 per cent., in favour of the stage work.

The cost of a retort house that would produce 1,200,000 cubic feet of gas in twenty-four hours had been £24,400, including heavy foundations, chimney, roofs, coal stores with roofs, machinery for unloading barges, railway over coal stores for distributing the coal where required, and one hundred and twenty retorts set complete and ready for work. A retort house to make 1,000,000 cubic feet of gas in twenty-four hours would, according to that proportion, cost £22,190. Buildings slightly constructed, and consequently at less cost must, in his opinion, necessarily entail greater wear and tear; and this was shown by the two cases cited by the Author, comparing very unfavourably with the aggregate of companies in London. The first company mentioned had a capital of £5 1*s.* 6*d.* per ton of coal carbonized, and the percentage of wear and tear was 5·22*d.* on the capital employed. In the second case the capital was £5 17*s.* 6*d.* per ton of coal carbonized, and the percentage of wear and tear was 4·87*d.* In the case of another large company the capital was £7 8*s.* 4*d.* per ton, and the wear and tear 2·45*d.* The aggregate of all the companies in London showed a capital of £7 2*s.* 1*d.* per ton, and a percentage of wear and tear of 2·5*d.*

With regard to the saving supposed to be effected in the cost of the ground-floor retort house, the Author assumed an extra cost for the stage of £8,000, but how that sum was arrived at he was at a loss to understand. In the case of the stage retort house, to which he had alluded, the actual cost for the extra wall below the stage floor, together with the pedestal for carrying the ovens and the stage itself, with cast-iron columns and girders supporting it, was £3,500. Reduced, in proportion for the smaller retort house, the cost would be £3,200. The interest on that, at 10 per cent., together with 1 per cent. for wear and tear, would give a total extra charge of £352. The saving of labour, as before shown, was 6·35*d.* per ton, and this on 20,000 tons (the quantity of coal required to make the 203,000,000 cubic feet stated) gave a total of £529. Deducting from that the £352, there was an actual saving in favour of the stage house of £157 annual charge.

The contrast between the Ratcliff Company and the Imperial Company was considerable, 20,000 tons of coal being consumed by the former, and 400,000 tons by the latter. If the amount paid per ton of coal for manufacture and distribution, together with the wages and material for wear and tear, were compared, it would be seen that there was a difference in cost in favour of the Imperial to the extent of 3*s.* 6*d.* on every ton of coal carbonized, thus:

	Ratcliff. *d.*	Imperial. *d.*
Manufacturing charges.		
Wages	47·44	37·72
Wages and materials for wear and tear .	68·62	43·78
Distribution charges.		
Wages	8·62	7·12
Wages and materials for wear and tear .	12·05	5·38
	136·73	94·00
Ratcliff . .	94·00	——
Difference .	42·73*d.* = 3·56*s.*	

This on the quantity of coals, 414,176 tons, consumed in 1873, represented a sum of £72,480 extra that would have had to be paid in one year.

With regard to the construction of gasholders, there were great differences of opinion. He had constructed many of various sizes, one being 230 feet in diameter; and his opinion was, that the top of a gasholder should be in the form of a dome, with trussing, in preference to its being flat and without trussing. In the flat top, the strain on the sheeting was very unequal, the plates not being set at an angle, such as they would assume when the weight was brought to bear upon them on the gasholder rising. The rise of the dome should not be less than 1 in 10, and the centre column forming the kingpost should be double that amount. The trussing supported and strengthened the outer top curb. One end of each of the main radius-bars forming the trussing was attached to the curb, the other end to the top of the centre column or king-post. The ends of the tie-rods of the main radius-bars were attached to the main bars near the curb, the other ends passed through a ring at the bottom of the centre column; the ends of the tie-rods were provided with screws, with nuts for adjusting and fixing each main radius-bar in its proper form, and, if equally adjusted, the framing of the top, with the curb attached, might be rolled about like a hoop. The curb with framing should rest on the top of the vertical stays which supported the sides of the gasholder, as a roof on the walls of a building. The sheeting of the top was attached to the framing in such a manner that the weight to be carried was divided equally over its surface. This was effected by clips, which consisted of a cross-bar with two bolts, one placed on each side of the main or other bars, and passed up through the sheeting, to the top of which, at each point, a plate or washer was fixed for the nuts on the upper ends of the bolts to screw down upon; these clips ought to be so arranged that between every four there should not be more than 100 superficial feet. When the framing of the gasholder was screwed up into its proper position, the plates should be put on, not in rings, but in segments, between gusset plates, radiating from the centre. If the plates were put together in rings and riveted, they gathered considerably, causing the top sheeting to be buckled and very irregular. By arranging the plates as before mentioned with gusset pieces, this inequality of the surface of the top sheeting was prevented. He knew of one or two gasholders with flat tops which could not be grounded, or if they were they would never rise again.

The Author had reckoned the leakage at 6 per cent. in the Ratcliff district on an area of 0·8 square mile, where there was little disturbance of the roads. The area covered by the Imperial Company was 25 square miles, and the greater part of the mains were in new roads, where the ground was continually settling, giving rise to a great deal of leakage, which, notwithstanding, did not amount to more than 10 per cent. No fair comparison could be made between a company like the Ratcliff, supplying a densely populated district, and the Imperial, supplying the outskirts of London, the rental per mile of main in the former being 50 per cent. per mile greater than that of the latter.

He quite agreed with the Author as to the importance of keeping the capital account as low as was compatible with the construction of really good works, and with providing for the large yearly increase in the demand for gas. It had been found that the first outlay for properly-constructed works was fully compensated by the lessened yearly outlay for wear and tear. With regard to providing for the increasing yearly demand for gas it was of course a comparatively easy matter, with small companies, like the Commercial and Ratcliff, which could, without much difficulty, be entirely constructed within twelve months; but it was very different with companies, like the Chartered and Imperial, where the yearly increase in the demand for gas amounted to about 2,000,000 cubic feet per day at Christmas for each company. The retort houses, gasholders, and other apparatus required to make and store this quantity (which would be works two-thirds of the size of the Commercial, and double that of the Ratcliff), could not be completed in one year, so that it was absolutely necessary that the extensions should be commenced two seasons before the gas was actually needed, thus causing the lying dormant of a large amount of capital.

He was of opinion that it was impossible to compare the capital and working expenses without knowing all the circumstances of the respective cases. Some of the companies, in their earlier days, spent large sums out of profits for additions to works, which profits had never been capitalised, so that the real outlay on what should be capital account compared too favourably with that of other companies where capital had been properly debited. Upon the whole, he was persuaded that the policy of the large companies of having thoroughly good and efficient works, with a view to the lowest working expenses, was the correct one; and he was not disposed, after giving due consideration to the Paper, to advise the directors of his company to alter their policy in that respect.

Mr. R. MORTON said he considered the most important parts of the Paper related to the retort house and the wages expended therein. Mr. Kirkham had pointed out the error into which the Author had fallen in taking the total manufacturing wages instead of those due to carbonizing alone. Anything beyond that could not be affected by the construction of a retort house. He had arrived at a different conclusion from the Author in regard to the economy of a ground-floor house; having been able to make a comparison from figures obtained in the working of both kinds of houses to about an equal extent in the same works. Taking the year round, allowing for the occasional contingency of removing coke from the stage house, and also for so much coke trimming in the other case as would make the comparison a fair one, there was a saving of 0·73*d.* per 1,000 cubic feet of gas sold as against 0·48*d.* given by the Author. It was said that there "could be no pretence to any further saving of a pecuniary kind." There was, however, a saving in time, which was money, in drawing and charging the retorts; and though that might not be appreciable per 1,000 feet, yet where millions of cubic feet were made in a day it amounted to something appreciable in the course of a year. He did not attach much importance to keeping the stokers under cover; but he found that, in inclement weather, they could measure and load 50 per cent. more coke from a coke-hole than they could from an open yard. With regard to the first cost of the two kinds of house, while the capability of production, in respect to the amount of capital expended, was the main consideration, the space for coals in front of the retorts, in other words, the width of the stage or floor, and the facility for depositing the coals thereon, with the amount of other coal storage, ought to be taken into consideration in making a comparison. It was to be regretted that the Author had not given such details of the houses treated of in those respects, as would enable a judgment to be made of the fairness, or otherwise, of his deductions. Not having constructed a ground-floor house of large size, and not being able to get with any degree of accuracy at the cost of those he was now using, he would take the Author's figures—say £8,500 per 1,000,000 cubic feet of capability a day—and assume that this sum would cover the cost of suitable coal stores, tramways, &c. He did not know how these figures had been obtained for stage houses, but thought that here, too, there had been an error. The most extensive recent constructions of this kind in London were those of the Imperial Company at Bromley, and the Chartered Company at Beckton. In 1870–1 he constructed a stage house, equal to a production of 1,500,000 cubic feet a day, coal storage equal to twenty-eight days' full working, stages 23 feet wide, with tramways over the stores and stages, so that 80 per cent. of the coals consumed in the retort house could be deposited in front of the retorts ready for use, two chimney shafts, with all connections, and a condenser complete, at a cost of £10,600 per 1,000,000 cubic feet per diem. This was about £2,000 cheaper than the cheapest within the Author's knowledge; and instead of £8,000, it was only £2,100 more than the cost of a ground-floor house. The interest of that, at what had been called "the usual rate," would be £210, and allowing 2 per cent. for wear and tear, £42, the total would be £252, instead of £960. The saving of labour was 0·73*d.* per 1,000 feet of gas sold, or on 203,670,000 cubic feet, £619, a sum exceeding the annual charge due to capital by £367. In the light of these figures it would be seen that the argument in favour of a ground-floor house was fallacious to the extent of £1,045 per annum per 1,000,000 cubic feet of capability of production per diem. This sum was made up of the £367 added to the Author's estimate, £678. The only other allusion he would make was in reference to the assertion that a saving of £2 11*s.* per 1,000 cubic feet of gasholder capacity could be effected in the construction of gasholder tanks by using concrete instead of brickwork. When, in 1871, he constructed two tanks, each 185 feet in diameter, at a cost of between £17,000 and £18,000, or £5 18*s.* per 1,000 cubic feet of gasholder capacity, as against the Author's figures of £6 10*s.*, one of the contractors offered to make the tanks of concrete instead of brickwork, and to reduce his tender by £500, or 3*s.* 4*d.* per 1,000 feet of gasholder capacity instead of £2 11*s.*; and another contractor refused to abate his tender a single penny. When the exhauster was placed before the condenser, the gas was condensed under all the pressure of the works, resulting in a deposit of naphthaline in the condenser, which, in the depth of winter, in three or four days completely choked it; he had therefore abandoned the practice.

Mr. V. Wyatt said, with regard to retort houses, it was necessary to consider their site, the disposition of the works, and the supply of material. If the latter was received by road, by river, and by railway, the works should be coextensive with those three methods of supply and of exit; and all comparisons should be with works similarly circumstanced. At Beckton there were three modes of communication, and the works had to be designed accordingly. If all the modes of supply and of exit had to be accommodated, the retort house could not cost less than £15,000 or £16,000 per 1,000,000 feet of gas manufacture per diem. It was necessary to pay special regard to the stability of the works. They should be substantial, so that there might be a minimum charge for maintenance for, say, twenty years. Such a retort house as that represented by the Author would be inadequate for carrying on the business at Beckton or at Fulham. The recently built retort houses at Beckton were 100 feet wide between the walls, and would contain fifteen days' supply of coal on the stages. The works were so constructed, that an amount of 80 or 90 per cent. of the coals supplied was taken directly to the stage in front of the retorts, for easy and direct manipulation by the stokers. It would not do to store the coal away from the retort houses, and then to handle it a second time at a cost of 1*s.* 6*d.* or 1*s.* 8*d.* per ton, or 2*d.* per 1,000 cubic feet of gas made. There was a considerable saving by the employment of fresh coal, and it often happened that the coals were in Newcastle on the Tuesday, and converted into gas for the supply of London on the Friday. The retort-house stages were 35 feet and 40 feet wide; but those represented by the Author did not appear to be more than 20 feet wide; so that they were unfit for carrying on the trade of a large factory making from 5,000,000 to 15,000,000 feet per diem. To show how the sum of £15,000 for the retort house per 1,000,000 feet of gas made per diem was arrived at, he would give the percentage of the different items. There were four railway lines into the retort house at Beckton, two into the coke-hole, and two at the high level to bring in the coal. The cost of these was 31 per cent. of the £15,000 = £4,500. The cost of the stage, which he called the coal store, was 29 per cent., or £4,200. That of the gas-making structure amounted to 40 per cent., or £6,300. He had at present in course of construction gasholders for about 7,000,000 cubic feet. Mr. Kirkham had stated truly that a large gasholder should be trussed. Looking at the gasholder in Plate 2, Fig. 12, supported by props and scaffolding, he would ask whether such a roof of iron should be propped with wood. Engineers who had built gasholders of that form had generally given them up; for they never kept their shape well: the curbs were always drawing in, the guiding rollers and carriages got out of position, and there was an undue pressure on the upper curb of the gasholder. If they were built to anything like the strength of a trussed gasholder, there ought to be three or four times the quantity of metal in the curbs. Instead of trussing by tension-rods and struts, he had adopted a mode of stiffening the roof by light arched ribs forming a dome. The gasholder selected for illustration in the Paper was weakest in the part where it ought to be strongest. The angle which formed the junction at the top of the sides with the upper curb was the part where the most metal should be put, for it was there that distortions chiefly occurred. He was in the habit of inserting a gusset there, carrying the stiffening-ribs of the gasholder from the centre of the dome partly down the post connecting the top and bottom curbs together. This united them thoroughly, and prevented the top curb from running away from the bottom one, and unduly pressing upon the gasholder framing. Unless they were connected together rigidly, it was impossible to get a steady gasholder. A well-trussed gasholder with a good factor of safety could be constructed for £10 per 1,000 feet of storage. With regard to gasholder tanks, he had at present in course of construction what were called compound tanks, partly of concrete and partly of brickwork. He had built concrete tanks in various ways, and water always penetrated the material. In one case an abutment of concrete 12 feet thick did not prevent water from a pipe coming through it like a sieve; it was impossible to keep it out: had there been 2 feet of puddle behind the abutment, it would have been kept out thoroughly. At Beckton the tanks were principally of concrete. The retaining walls and the pilasters carrying the columns were almost wholly of concrete. The only reason for which brickwork was used there was to veneer the face, to keep off the effects of the weather, frost, and other deteriorating influences. There was a point mentioned in the Paper that was evidently aimed at the mode of constructing concrete tanks at Beckton, namely, the use of hoop iron. This was a cheap and useful material, costing but little, and it gave that particular tenacity to the structure which was required. There was no bond in concrete, and a little hoop iron at intervals of 5 feet, vertically in the wall, rendered it more effective. Sound concrete tanks, partly of brick, could be built for £5 to £6 per

1,000 feet of gasholder storage. Concrete tanks were about one-fifth cheaper than brickwork ones. Some remarks had been made about the old gasholders in the neighbourhood of Bow. It was his duty occasionally to pass them, and more inelegant or unfit structures he never saw, and he was certainly surprised to hear them pointed out as models. He was at present engaged, with Mr. Harris, in building three gasholders and tanks adjoining these structures at Bow, but they had not imitated that form, which consisted of a number of spectacle frames or brackets badly united; and he believed that if the four gasholders were not positively attached together they would be blown away. It had been said that the bracket, or standard form of framing was the best, and that the plan of placing columns round the circle was the worst. He had tried both methods by model, by practice, by calculation, and in every way, to ascertain the effect of a hurricane upon the gasholder; this he found would be exactly the same whether brackets, or columns, or stanchions, or pilasters were arranged round the circle. The power of the framing was that of the holding-down bolts added to the weight of the framing. If a number of columns or standards were arranged round the circle and held down by bolts to the masonry, operating upon the diameter of the circle, that was the base of framing to resist movement; and there was only half the height of gasholder operating the other way. Every ton of iron and holding-down power to bolts ranged round the circle gave a power of 6 or 7 tons in favour of stability to the framing; and it was advisable that two-thirds of the iron in the framing should be disposed in the lower half of the system. Whether brackets, or columns, or stanchions were used, the effect was similar. Where the brackets were most effective in one direction they were least so in the other, therefore columns generally had the advantage. Diagonal ties to the columns were inefficient, as any one pair of ties, with its corresponding column, could fall away from the group, so soon as the chain or ring binding the framing together separated. There should be a double rigid wrought-iron ring to bind the parts forming the framing together, to keep the members of the system in uniform action.

Mr. R. H. Patterson dissented from Dr. Letheby's recommendation to employ a low temperature in the retorts, with a view to reduce the amount of bisulphide of carbon in the gas. He thought the most important question in gas-making was that of ascertaining and employing the best temperature for carbonizing the coal, so as to obtain from a given quantity the largest possible yield of good gas. This had been the main object of all the inventions of late years, from Dr. Eveleigh's down to, or up to, Mr. Malam's. It was well known that with a low temperature a large quantity of tar was produced, a portion of which could be converted into gas if a higher temperature were employed in the retorts. Bisulphide of carbon had much to answer for; but if managers were led to adopt any mode of carbonizing which was not the best for producing a large quantity of good gas, it would do great mischief. Gas-making was the principal thing to be attended to—the cost of purification being a bagatelle; indeed the entire cost would be covered by an additional make of about 100 feet of gas per ton of coal. All the inventions, such as Mr. Malam's, claimed to be capable of producing a large additional quantity of gas which would cover ten times the cost of purification. If, therefore, a high temperature was best for this purpose, no question of purification should be allowed to interfere with it. But did a high temperature appreciably affect the amount of bisulphide of carbon? This had not been proved, and he had several reasons for doubting it,—especially as $C\ S_2$ was known to be decomposed at even a comparatively low temperature. There was no necessity to wait for what had long been waited for, a useful, handy pyrometer; for in the large benches of retorts some were overheated compared with the average, and others relatively cool; the gas could be tested from any of them, and if the experiments were suitably conducted over a sufficient length of time, the question might be solved. As regarded purification, strong 20-ounce liquor had been recommended for removing the bisulphide of carbon. When first he had the honour of being appointed a Gas Referee, the prevailing opinion was that gas should be washed with an almost infinite quantity of gas liquor, in order to remove the sulphur. This had wholly failed. Since then it had been thought that the best mode of taking out bisulphide of carbon was by gas liquor of great strength; and to obtain this it was proposed to have scrubbers of unusual height. These he thought quite unnecessary, because the same strength could be obtained by other means. This plan also failed—and it was bound to fail; for, as he had been the first to point out, the longer gas liquor was kept in contact with gas (by which means alone the ammoniacal strength could be increased), the greater the extent to which the gas liquor was carbonated, and therefore rendered incapable of absorbing sulphur in any form. Gas contained from two to three volumes of carbonic acid for every one of sulphuretted hydrogen, and the utmost extent to which gas liquor could be sulphuretted in the ordinary way (and apart from a special process which he had devised) was this, that while two or three volumes would be carbonated, the other quarter, or at most a third, would be sulphuretted. This sulphuretted portion would act; but, being mingled with about three times its volume of carbonate of ammonia, the result was a failure. The longer the liquor was kept in contact with the gas the greater its ammoniacal strength; but the more it was carbonated, and therefore the more inert it was upon bisulphide of carbon.

Mr. VERNON HARCOURT said it was quite true the effect of washing with strong gas liquor was not that which had been sometimes supposed, but there was another advantage in so washing gas. Mr. Patterson had done good service in pointing out how important it was in gas purification to remove carbonic acid as completely as possible, and to deal afterwards with the sulphuretted hydrogen. Mr. Kirkham said too much had been heard about gas purification in London, and he quite understood the feeling which prompted the remark. But one fact as to gas purification ought to be widely known, namely, that the gas engineers of London had in this respect effected a great improvement. In a considerable portion of the gas supplied to London, the quantity of sulphur was less than half what it was three years ago; and although there was some difference of opinion as to how far the sulphur compounds were injurious, it was generally admitted that the more completely they could be excluded the better. The chemistry of the matter was pretty well understood. It was known that the action of sulphuretted hydrogen on soda, potash, or lime was to form sulphide of potassium, or sodium, or calcium. It was also known that when one of those substances was for a sufficient length of time in contact with bisulphide of carbon, or other gases through which the bisulphide of carbon was diffused, there took place a combination between the two substances, forming what was termed a sulphur salt. Dr. Letheby had referred to the analogy between that union of sulphide of calcium with bisulphide of carbon, and the more familiar union of lime with carbonic acid. There was also a further analogy. Carbonic acid, which lime would absorb, was driven from the lime again if a stronger acid, such as sulphuric acid or hydrochloric acid, was poured over the carbonate of lime which had been formed. Similarly, when carbonic acid acted upon the compound formed of sulphide of calcium and bisulphide of carbon, it displaced the weaker acid, and carbonate of lime was formed, and the bisulphide of carbon was again set free. There was a small error in the Paper where it was stated that the effect of this action of carbonic acid upon the compound thus formed was that the bisulphide of carbon was decomposed, and that the sulphuretted hydrogen passed on. The sulphuretted hydrogen did pass on, but it was by virtue of the decomposition of the sulphide of calcium, and not by virtue of any decomposition of the bisulphide of carbon. The bisulphide of carbon was simply set free from its combination; it was no more decomposed than carbonic acid was decomposed when hydrochloric acid was poured over limestone. When gas containing both sulphuretted hydrogen and carbonic acid passed through a freshly-charged lime-purifier, at first both gases were stopped, and the proportion of calcium sulphide increased until most of the lime had been converted, at least superficially, into either sulphide or carbonate. After this maximum had been attained the proportion of calcium sulphide diminished, until ultimately the whole was decomposed, the sulphuretted hydrogen, arrested for a while, having been expelled, and the lime converted into carbonate. In proportion to the amount of calcium sulphide in the purifier was its power of stopping bisulphide of carbon: this power, therefore, would first increase, then reach a maximum, and then gradually decline to zero. But not only did the purifying power cease, but the bisulphide of carbon arrested by the calcium sulphide was given off again, as the calcium sulphide was changed into calcium carbonate. These facts explained the sudden increase of bisulphide of carbon in the gas passing out of the purifier; for, just after the purifier had been most effective, its action was reversed, and the issuing gas contained not only all the sulphur which it brought with it, but a large additional quantity which the lime had received from a previous portion of gas. It was now found that, by a careful working of lime purification, it was possible to bring down the sulphur in the gas to an average of 10 or 12 grains instead of 30 grains in 100 cubic feet. It was found also that, with great care on the part of the manager, that offensive substance, the foul lime so produced, could be disposed of and prevented from causing annoyance. Still he did not think that a satisfactory solution of the problem of gas purification had been arrived at. In one respect it was most unsatisfactory. The sulphur yielded by coal was of considerable quantity and value. Under the old system of oxide purification, the sulphur was used: the spent oxide, as it was called, was sent to the vitriol-maker, burned, and the sulphur, amounting to half its bulk, turned into sulphuric acid. Under the present system, the sulphur combined with the lime, and was not utilised, while the sulphuretted lime was a waste product, or, if applied to the land, was of much less agricultural value than before. He was at present engaged upon some experiments, of which it would be premature to give an account, in order to obtain, by other means than the imperfect system of lime purification, the same degree of purity, and that consistently with the use of purification by oxide of iron.

Mr. O. C. D. Ross wished to say a few words in favour of gas made from petroleum spirit, not as intended to supersede, but to supplement coal gas, or to be used in small towns, villages, or country houses, where the latter would be too expensive or troublesome. In America fourteen cities and towns were lighted with this gas exclusively, and in many others it was used in combination with coal gas. Its American advocates asserted that it was not as condensable as coal gas, and that it did not lose in illuminating power to whatever distance it was conveyed; that it was one-third cheaper than coal gas; and that the accumulation of large quantities of coal was much more dangerous than the petroleum when properly stored. Its manufacture involved very little toil, one foreman and four or five labourers being sufficient to manage the manufacture of from 300,000 to 480,000 cubic feet per diem, which was the quantity stated to be now supplied daily by the Citizens' Gaslight Company of Brooklyn. The description of gas which he desired to bring under the notice of the members differed, in some essential respects, from that used in America. It was merely carburetted air, the air being little more than the medium for holding the hydro-carbon vapour and conveying it to the burners, with the advantage of aiding the complete combustion of the gas. The apparatus was simple. The air being drawn through a vessel holding the oil, was, at the option of the manipulator, more or less saturated with vapour, and formed an inflammable mixture, in which the quantity of carbon ought to be about equal in amount to the quantity contained in an equal volume of coal gas.[1]

Mr. C. Woodall dissented entirely from the Author's view with regard to stage retort houses. His figures, as already pointed out, should be received with caution. The comparative table of the cost of carbonizing embraced items of charge altogether outside the retort house; for the cost of carbonizing rarely exceeded 3*d.* per 1,000 cubic feet, as against 5*d.* stated in the Paper. He took still greater exception to the plan of comparing the cost of carbonizing,

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[1] A fuller exposition of Mr. Ross's views on this subject will be found in a separate communication subsequently presented by him to the Institution, and printed in this Volume.—Sec. Inst. C.E.

not according to the number of tons of coal, but according to the quantity of gas sold per ton of coal used. This was usually the best method of contrasting the accounts of one company with those of another, but in the present case it was palpably erroneous. It could not be maintained that the placing of retorts upon one level or upon another could have any influence upon the amount of work got out of them, or upon the quantity of gas to be obtained from the coal put into them. Therefore, while from more or less perfection of distribution or manufacture, apart from the retort house, or the quality of coal used, there was a decided difference in the quantity of gas sold by the various metropolitan companies, it would be seen how that method of calculation was open to considerable exception. It appeared, from Mr. Field's analysis,[1] that the cost of carbonizing, or, more correctly, of manufacturing in the Phœnix Gasworks, Vauxhall, was 1*d.* less per 1,000 cubic feet than in the Ratcliff Works. Upon the total quantity of gas sold this 1*d.* per 1,000 cubic feet amounted to £4,990; but the same wages, divided over the number of tons of coal carbonized, showed a difference of 11½*d.* per ton, or £6,500, the difference of about £1,500 being simply due to the fact that the Ratcliff Company sold 9,300 feet of gas for each ton, while the Phœnix sold 8,800 feet. When it was stated that some of the metropolitan companies were not paid for more than 8,000 cubic feet per ton, it would be seen how great the error might be. He was at a loss to conceive how the Author could have arrived at the conclusion that it was necessary to expend twice or thrice as much on the erection of a retort house with a stage as on one without. The cost at the Phœnix Works of a stage house capable of producing 2,000,000 cubic feet of gas per day was under £20,000, or less than £10,000 per 1,000,000 cubic feet. This was without coal stores, which were not a considerable addition to the cost; but, as a large portion of the site was reclaimed from the river, so that the walls had to be made of great depth and exceptional thickness, it was by no means an inexpensive work. Taking the Author's estimate of £8,000 as a fair price for a retort house on the ground-floor, the difference, instead of being £8,000, was only £2,000. He agreed pretty nearly with the statement of the saving to be effected in wages by the use of retort houses with stages. He had found that, with a stage, each man was credited with 7 cwt., or about 15 per cent., more coal than in a house without a stage. At an extra cost of £2,000, and allowing

[1] *Vide* "An Analysis of the Metropolitan Gas Companies' Accounts for the Year 1873. By John Field." Quarto. London. 1874.

interest at 8 per cent., with 2 per cent. for renewal, this made an additional charge of £200 per 1,000,000 cubic feet; while the saving of 15 per cent. upon wages, equivalent to 0·7*d.* upon the gas sold, amounted to £594, or a saving of £394 per 1,000,000 cubic feet of gas. Taking the Author's figures, and crediting the stage with the total saving of manufacturing wages, the difference would be about £6,500 per annum; which was enough to pay 8 per cent. on £80,000—a sum sufficient, within a trifle, to build stage retort houses for all the requirements of the Phœnix Company. But he was content to take the 15 per cent. saving, which would show that the economical advantage was decidedly in favour of the more expensive house. If, however, such a condition of things prevailed at Beckton or at Bromley, that the coke had to be conveyed in barrows into the open yard, he could not but think that even a slight additional cost would be justifiable. The saving of space, also, was of moment on expensive sites; and he was not disposed to leave out of view the health and comfort of the men employed. With regard to the substitution of steam power for manual labour, he had recently had an opportunity of inspecting the hydraulic apparatus, invented by Mr. Foulis, in use at the Glasgow Corporation Gasworks, which promised speedily to put an end to the difficulties in the way of mechanical stoking. The Author's objection to tall scrubbers disappeared if the precautions he so sensibly urged were taken, and the tar removed from the gas before it was brought into the scrubber. With this object he thought a washer or some such apparatus should always precede the use of the scrubber. Two years ago, Mr. Eldridge, the Engineer of the Richmond Gas Company, strongly advocated the use of an adaptation of Coffey's still, as a suitable apparatus for the removal of ammonia. It was justly urged that a washer was a preferable apparatus, as putting the gas and water into more immediate contact, except in cases where a little additional pressure was undesirable. He was glad to find exception taken to the custom of supporting the roof sheets of gasholders by a heavy trussed iron framing, which was often a source of weakness instead of strength. The purpose of such a framing was of a double nature; first, as a floor on which the sheets might rest when the holder was out of action; and, secondly, as a series of struts to keep the top angle, where the sides joined with the crown, in its proper place. If the latter was rendered unnecessary by the strength of that portion of the holder, it was obviously undesirable to carry up and down continually a mass of metal that was serving no purpose. He doubted the wisdom of riveting the crown sheets to the framing. That framing was designed as a strong girder, trussed, to carry a load on the top. He could not understand how such a framing could be suspended from a number of points above it, without upsetting the relation of its parts, and making it (as he had already said) a source of danger. By dispensing with the roof framing, the centre of gravity of the holder was materially lowered, and its stability when full proportionately increased. The timber framing shown in Plate 2, Fig. 12, had been condemned, but he could not see the point of the objection. The framing might be of iron, if possible, of equal strength, and costing less money, or a pillar of stone or brickwork, as in the holders Mr. Wyatt was now erecting. In any case the principle was the same. To carry up and down, possibly for years, a framing of that sort, because some day it might be necessary to land the gasholder, was quite unnecessary. In regard to tanks, he should like to know if Mr. Livesey sanctioned the statement that the tank recently completed in concrete at the South Metropolitan works was effected at the saving mentioned, viz., at a cost of £3 9*s.* per 1,000 cubic feet. About two years ago, having to construct tanks for two gasholders to hold 1,000,000 cubic feet each, he was desired to furnish an estimate for concrete and brickwork. It appeared to him that upon a total of £12,000 the saving in concrete would be about £150, and for such a small sum he declined to advise the surrender of a plan that had been approved by the experience of half a century. The cost of the tank came out at £6 per 1,000 feet capacity. With regard to the question of capital, it was a truism to say that its expenditure required to be watched with care; but it would be seen from Mr. Field's analysis that, on the one item of working expenses alone, there was a difference between the highest and the lowest, of the metropolitan companies, of over 9*d.* per 1,000 cubic feet of gas sold; and as the greatest difference due to disparities of capital amounted to 6½*d.*, he failed to understand the remark, that the whole difference in price was due to the greater or less care with which capital had been spent. At least one company in the metropolis had only been able to reduce its price by a judicious expenditure of an amount of capital out of all proportion to the increase of its business. He thought the dictum tended rather to penny wisdom and pound foolishness; and he hoped that even the joy of reducing, by some infinitesimal fraction, the price of gas would not be held to justify the inclosing of apparatus in sheds, or the subordination of all questions of taste, design, and comfort in erection. Mr. Livesey's remarks as to directors and engineers were, he thought, out of place, entirely unfounded, and not likely to meet with favour. If credit equal to his own were accorded to his brethren, for a regard to the public duties devolving upon them, then it might simplify his view as to the necessities of future gas legislation.

Mr. H. Gore remarked that in the case of a large retort house, capable of manufacturing 1,000,000 cubic feet of gas per day, a certain quantity of coals was required, and, in order that it might be properly carbonized, a sufficient amount of fuel was needed to heat the retorts. Common sense would suggest that, the less the volume of cooled air admitted into the furnace the better, and also that the deeper the fire, commensurate with the construction and solidity of the furnace itself, the better for the purposes in view. Every time an ordinary furnace was opened a cooling effect would be produced, and when fuel was put on, the combustion would be comparatively incomplete until a fresh supply was required. This was sufficient to demonstrate one advantage in connection with a stage house. Another advantage was the facility for rapidly drawing and charging the retorts. When he had the control of a retort house connected with the Chartered Gas Company in Horseferry Road, he was in the habit of timing the charging of the retorts as compared with a ground-floor house, and he found that he could charge five, seven, or eight retorts in a stage house in a third less time than in one built on the other plan. Much, also, was favourable in the stage system to the comfort of the men employed. So confident was he of the advantage of the stage house, that in reconstructing a gas-works in South America he made a pit in front of the retorts, for the purpose of gaining the advantage of a deep fire, less frequent opening of the furnace door, and facilities for drawing and charging. The cost of coal at Valparaiso was £2 15*s.* 6*d.* per ton delivered in the retort house, and the saving effected by the use of deep fires was 33 per cent. of fuel. The system of setting a large number of retorts to a single fire was, he believed, to a certain extent wrong. If the terminal retorts in any large setting were to be of a temperature sufficient to carbonize the coal perfectly, the retorts immediately above the furnace must be at such a temperature as would more or less destroy the illuminating power of the gas, unless these retorts were charged with cannel coal. It was essential to the carbonization of cannel coal that it should be effected as quickly as possible; therefore high heats were absolutely necessary. In Aberdeen, in order to obtain rapid carbonization, it was now the practice to set three retorts to two furnaces; they were worked at three-hours' charges, and the illuminating power of the gas produced was from 26 to 30 candles. With regard to condensation, he wished to ask what was really meant by it. If it was desired to make good gas, the method of procedure of the manufacturers was extraordinary. He always thought it an object to keep as much as possible of the light-giving material in contact with the conveyance employed to transmit it to the burners, especially where coals of a different chemical constitution were used in the process of manufacture, such as a mixture of ordinary bituminous coal and cannel. It was well known that the gases resulting from such a mixture were simply in mechanical contact; and anything which impaired this contact must cause the partial precipitation of the light-forming constituents. He had noticed curious illustrations of the effect of this condensation in gasworks in South America, the result of mixed gases passing through small apertures. The company with which he was connected were bound by the terms of their concession to supply gas of 19-candle illuminating power. In order to produce this, he used from 20 per cent. to 25 per cent. of Boghead or other rich Scotch cannel, 20 per cent. of English or Australian bituminous coal, and the residue of Chile coal. This mixture gave about 10,000 cubic feet per ton of 21-candle gas, measured at the works. The temperature of the gas was never below 60°, generally from 68° to 70°. So long as the gas was conveyed through ordinary-sized mains, or service pipes of tolerably large diameter, no inconvenience was experienced from reduced illuminating power; but whenever it entered small service pipes or fittings, condensation of the hydrocarbons took place. In order to test this accurately, he placed several screens of wire gauze in a condenser, similar to a plan he had seen at Geneva, which was, he believed, a suggestion made by the late Mr. George Lowe. Three screens removed the greater portion of the naphtha and hydrocarbon oils. This principle was in effect the same as that recently patented in this country by MM. Pelouze and Audouin, of Paris. It formed an admirable condenser for gas from ordinary bituminous coal, which was of low illuminating power, and comparatively homogeneous; but when gas was manufactured from mixed coal, it was very injurious, as it caused the light-giving constituents to be precipitated by the concussion of the particles of gas against the sides of the apertures through which it was forced. To some extent he indorsed the opinions of Mr. Livesey, believing as he did that the facility with which capital was raised in this country had placed gas engineers in their present position. If a Paper had been read from twenty to twenty-five years ago, describing the processes then in vogue, it would have been a duplicate of that now brought forward. In other branches of the engineering profession there had been vast improvements: gas engineering was at a standstill; and simply because the incentives to improvement—that of setting brains to work instead of bank-notes—had been wanting. Let those incentives be brought into action, and the day would not be far distant when gas engineering would advance as other branches of the profession had done.

Mr. A. F. Wilson expressed surprise that the Author had omitted to mention almost anything that had not been known for the last twenty years, and had given so little indication of his ideas of possible improvements. He could not but conclude that this reticence was intentional. No Paper, with such a title, was complete, that did not include an exhaustive consideration of the principles of gas-making. Works should be subordinate to the method, not the method to the works. He agreed that one of the main points to be considered was the retort house; but the retorts themselves, not the mere shell of the building, should be principally studied. Upon the manipulation of the retorts, and the use of the exhauster, most gas companies depended for their dividends, and improvements in this direction were the chief means of cheapening production. What was greatly needed was to overcome the inability to control the temperature in the retort. Dr. Letheby's suggestions only related to the starting points from which distillation began. Nothing was really known of the temperature at which coal was or should be distilled, and the sooner that fact was acknowledged the better. A profound ignorance existed as to the effect of temperature on the various combinations formed during the distillation. Coal was put into a glowing retort, and immediately the heat fell. The absorption of caloric by the coal was in excess of the conductibility of the retort; and for a considerable time the heat was low and irregular, only the outer crust of the coal encountering it; and carbonic acid and carbonic oxide were formed in the filtration of gases from the interior, which, under other circumstances, would probably be avoided. The remedy lay in smaller charges, and, if possible, in continuous charging; not in ingenious mechanical stokers, but simple mechanical stoking, with the retorts built to suit the working. Retorts set diagonally, instead of horizontally, would suit, and the coke would be improved by cooling gradually of itself in air-tight vaults, instead of being disintegrated by the present 'drowning-out' process. It did not seem impossible to design such a bed of retorts or such a system of stoking. Want of control over the temperature was felt as an evil by all who really thought of the matter; and there was no doubt gas-making would never be an exact science so long as the present method was pursued. The pioneers in bringing about a change ought to be the metropolitan gas companies, who, although no doubt they must be credited with a certain desire of improvement, were really not earnestly seeking it; and it was to be hoped the law would be altered, so as, without harshly bearing on the shareholders, to stir them up in the matter. He trusted his suggestion would not be lost sight of, as to obtaining some useful data, from those persons in a position to give it, of the comparative advantages of very large works, such as that at Beckton, with its facility of position for the receipt of coal, and its concentrated apparatus and superintendence, but with the attendant disadvantages of distance from the field of supply of gas and coke, entailing the necessity of large trunk-mains, and loss in the wholesale removal of the coke, as against smaller works more centrally situated for the supply of both. He inclined to the former, although conversant with both sides of the question.

Mr. R. Jones wished to correct an error made by Mr. Kirkham, who spoke of carbonizing wages in a ground-floor house as being 2*s*. 6*d*., and in a stage house 2*s*., per ton. He had been the Engineer of works at Stepney, where there were no stage houses, and the carbonizing wages were somewhat below 2*s*. per ton. Mr. Kirkham had also, in the enumeration of his gang of carbonizers, given two more barrow-men than were actually employed. In reply to the observations of Mr. Gore, he was able to speak from an experience of forty years. Twenty-five years ago, the price of gas in London was 6*s*. or 7*s*. per 1,000 feet, with an illuminating power of 10 or 11 candles; the price now was 3*s*. 9*d*., with an illuminating power of 14 candles. In the provinces, coal was carbonized almost exclusively in ground-floor retort houses, the stage house being peculiar to London. The days of the manufacture of gas at a low temperature were the days spoken of by Mr. Gore. High temperature had been the result of recent legislation, by which the price of gas had been reduced to a minimum, though the material employed was exposed to great fluctuations in price. The higher the heats, the greater the quantity of gas obtained from the coal. The evils that had undoubtedly existed were now being overcome, to a great extent by the engineers of the metropolis; and the result was that, with a minimum price and a high illuminating power, most of the companies were paying the maximum dividend permitted.

Mr. H. E. Jones, in replying upon the discussion, said he felt that the principal points raised in the Paper were such as called for discussion. Believing as he did that the construction of gasworks in the metropolis had lately been drifting in a direction that was needlessly expensive, he had addressed himself to the task before him; and if the Paper failed to carry conviction, it would at least have served the purpose of eliciting the views of those who differed from him. With regard to Dr. Letheby's remarks on the temperature best suited for carbonizing, he believed every engineer would agree that low temperature failed to secure the best results from coal, having regard both to quantity and quality. What was wanted was the greatest number of candles that a ton of coal could be made to equal in illumination; and that could not be obtained by a low temperature, the employment of which was an imitation of the process of the mineral oil maker, who endeavoured to get all the liquid product of distillation he could, to the exclusion of the gaseous product. The gas-maker, on the other hand, used a high heat to obtain permanent gas with as little liquid or tar as possible, robbing the latter of its light hydrocarbons, and leaving it poor in secondary products, not rich, as was suggested. Dr. Letheby cast a stigma upon the London Engineers for truckling to the board-room in using a high heat to make much poor gas. That was quite beside the question. The illuminating power was fixed by an independent authority, and that must be obtained, whether the directors liked it or not. The object of the engineers was no other than to obtain the best possible results. In reference to the remarks as to the efficacy of washing gas with strong ammoniacal liquor for removing bisulphide of carbon, he might mention that at the Ratcliff works 36,000 cubic feet of gas per hour were washed by 900 gallons of ammoniacal liquor (from 14 ounces to 18 ounces). According to Dr. Letheby's calculation, the bisulphide of carbon normally due to that quantity of gas ought to be combined with the sulphuretted hydrogen in the ammoniacal liquor 133 times over; and if it was said that the liquor would in time get charged and there was an end of its action, the reply was that the liquor was changed every twenty-four hours. Nevertheless, without using lime he altogether failed to modify the bisulphide of carbon. That being so, the sooner the pernicious notion that had been propounded was abandoned the better. The gas was cooled because in winter it had to be distributed through mains, some of them not far from the surface of the ground, which were liable to great fluctuations of temperature; and it was useless to send out a body like gas, containing condensable illuminating vapour, at a temperature of 60°, when, before it reached the burner, it had to pass through a temperature of 30°. It only resulted in filling the syphons with liquid, while the naphthaline, condensed out of it, gave the consumer endless annoyance by causing stoppages in the pipes. Mr. Livesey's only objection to a ground-floor house was that it did not admit of mechanical stoking. But he knew of no patent of any value which sought to imitate exactly by machinery the manœuvres of a human agent. What was wanted was mechanical carbonizing; and to effect that the whole retort house must be swept away. It was obvious that a system having the coals at the top, the gas passing away in the middle, the coke going out at the bottom, and the tar running off elsewhere, would be all that could be desired; but if Mr. Wilson would endeavour to realise his beau-ideal, he would find serious mechanical difficulties in the way. With regard to the distribution of the liquor at the top of the scrubber, however well it might be arranged, there would always be a gummy oil that would choke up the pores of the material and divert the liquor. Mr. Hodgson Jones referred to some retorts on a ground-floor that had settled; but they would have equally settled, with a bad foundation, if built on a stage. Objections had been made to his comparison of the manufacturing wages in a stage and a ground-floor house, and to his taking the figures from the Home Secretary's returns, which included wages foreign to the stoking house. He had preferred to go to the most authoritative source for his information, rather than travel into the region of speculation, and fall into such serious error as he would show Mr. Kirkham and other speakers had done. It was true that the figures he had quoted included a few insignificant charges not due to stoking; but he contended that the comparison was a fair one and substantially correct, inasmuch as in his own case 78 per cent. of the entire sum was for stoking wages, including foremen, scurfers, &c., and all the other companies returned their accounts on the same system. Mr. Kirkham's estimate for wages was quite wrong. A gang of men to carbonize 26 tons, in the Ratcliff ground-floor houses, was only nine and a half, viz., two scoop-drivers, four stokers, two barrow-men, one fireman, and half a coke-trimmer, one coke-trimmer doing the work for two gangs. The cost came out at 2*s.* a ton, not 2*s.* 6*d.*, as Mr. Kirkham said, estimating for twelve and a half men, or three more than were actually employed. He had been informed by Mr. Harris, of the Chartered Gas Company, who worked both systems, that there was no saving whatever in the wages by the use of a stage house as compared with a ground-floor house. Mr. Kirkham put the cost of a stage house for 1,000,000 cubic feet at £22,190; and he was glad to hear that statement, because Mr. Morton and Mr. Woodall seemed to doubt that they cost so much, and stated that they made houses for little more than half the money. In allotting only £3,500 as the extra cost of the stage, he thought Mr. Kirkham had overlooked the foundations required for the extra height of the walls, and the additional thickness of the walls of the whole building, rendered necessary by the expanding and contracting of the iron stage, which was subject to extreme variations of temperature; indeed, in no other way could he account for so high a figure of total cost as that given. Mr. Kirkham's remarks on gasholders, of which he had constructed a large number, were entitled to great respect; nevertheless, such holders as he disapproved were found to work well, and not to be subject to the difficulties suggested. His plan of tying down the sheets to the truss obviously threw unequal strain upon them, and prevented their taking that form in which they bore equally over their area the strain due to the entire weight of gasholder.

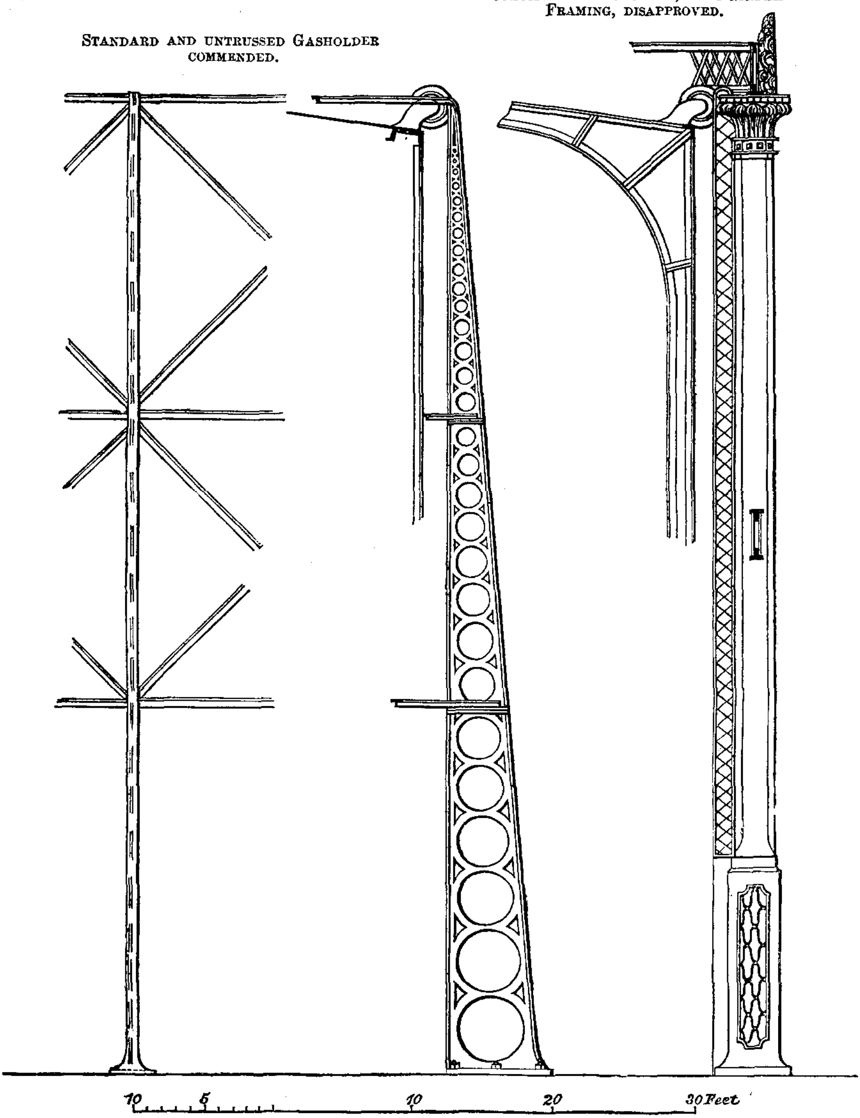
Mr. Morton spoke of a saving in wages of 0·73*d.*; but how that was obtained was not apparent, though, as he had retort houses on both systems, he ought to know. It would seem that the ground-floor labour in that case must be conducted on a very expensive system to furnish such a figure; indeed, it appeared from Mr. Field's analysis that the wages were ¾*d.* per 1,000 cubic feet of gas sold in excess of the average of all the companies, and that might partly explain the difference. The sum of £10,600 per 1,000,000 feet for the cost of stage house was very cheap. The coal storage, however, was only equal to twenty-eight days' consumption, as against six weeks at the Commercial and South Metropolitan gasworks, and something must be added to that sum to make the comparison good. Mr. Wyatt put the cost at £16,000 per 1,000,000 feet, with scarcely any coal stores, and the sum would have to be raised to Mr. Kirkham's figure if more than fifteen days' consumption had to be provided for. In these days, when there was a liability to serious difficulties in the labour market, and colliery strikes, an engineer who should provide for only fifteen days' consumption would, he thought, commit a serious blunder. With regard to the wholesale condemnation of an untrussed gasholder, it might carry conviction, if it were not that there were plenty of such gasholders at work, for instance, at the Phœnix, Commercial, and Bow Common works. Mr. Wyatt's plan of strengthening the angle between the top sheeting and the side by a ponderous gusset plate was only necessary to support the cumbrous girder he chose to suspend there. The sheeting of the top would rest upon the gas alone. Mr. Woodall had only lately constructed a gasholder without a gusset, plate, girder, or trussing of any kind. With regard to the theory that, whether with standards, pilasters, columns, or brackets, so long as a certain weight of metal, held down by so many bolts, was arranged round the circle, the effect upon the gasholder was the same, a more astounding proposition had never been advanced, meaning as it did that the strength due to a certain weight of metal was independent of the form in which it was disposed. Mr. Wyatt's objection to the commended guide framing at the Bow Common works was thrown away, as he would do well to imitate a structure which did its work perfectly well with less than one-fifth of the metal he employed in similar works. Fig. 1 showed both types. (See next page.) The standard was superior to the column, because its proportions increased in weight and strength in conformity with the increase of strain, by leverage, which was thrown upon the lower portion of the upright when the fully inflated holder was subject to a side wind, and exerted pressure through the top roller. The nearly parallel column was defective, and if sufficiently heavy near the base involved much waste of metal near the capital. Again, so long as the ties at the heads of the uprights remained intact, no strain could be thrown on them laterally, or other than in a direction radially outward from the centre of the gasholder, and from front to back of the upright, a lateral strain only occurring when, through disruption of the ties, the structure was being wrecked by the falling over of the holder. The column was of equal strength laterally and from front to back, again involving waste of metal as compared to the standard, which had, from its slight proportions, little or no lateral strength. Thus, as compared with the square or cylindrical column nearly parallel throughout its height, the narrow, deep, and tapering standard exhibited the minimum of metal yielding the necessary resistance.

As to Mr. Vernon Harcourt's correction, he did not contend that the sulphuretted hydrogen was driven forward by the carbonic acid gas, so much as that the sulphuretted hydrogen which went forward resulted from the combination of bisulphide of carbon with hydrosulphide of lime in forming sulpho-carbonate. He agreed that no satisfactory solution had been arrived at of the lime question. It was hard upon the companies that chemists like Dr. Letheby should insist upon the removal of the bisulphide without giving some chemical reagent that could be effectively employed for the purpose, which chemists had hitherto failed to do. He was perhaps right in calling it a "*bête noire*," rather than a really substantial evil; at any rate, he raised the bugbear himself, and then did not lay it.

FIG. 1.

COLUMN AND GASHOLDER, WITH GIRDER FRAMING, DISAPPROVED.

STANDARD AND UNTRUSSED GASHOLDER COMMENDED.



Back view. Side view.

Mr. Woodall's comments were very fair. His estimate for a retort house was low; but as he had not allowed for coal stores, from £4,000 to £5,000 must be added to his figures. His objection to the 1,000 feet of gas as a unit of comparison, and his preference for the ton of coal, were ill-founded. Extravagance in the use of coal increased the tonnage due to a certain manufacture of gas, and brought out a lower quotient in dividing the expenditure, giving a fictitious appearance of economy. Mr. Woodall could only have arrived at the saving of 15 per cent. in wages by the stage house by taking Mr. Kirkham's erroneous figure for the ground-floor house labour, to which Mr. H. Jones absolutely demurred. The statement that *6d.* per 1,000 cubic feet was the widest difference between the cost of gas for interest on capital between any of the London companies was not borne out by Mr. Field's analysis for the year 1873, wherein it would be found that *8d.* was the difference due to capital interest, and this was a figure which no improvement in management could modify. As to the saving in the concrete tank, he had Mr. Livesey's authority for the statement. Two tanks of a similar size were constructed, and the difference was found in the actual cost of the relative works. He desired, in conclusion, to apologize for dealing briefly with some points, which he was compelled to do in going over so wide a ground, so that the Paper was necessarily imperfect in many details.

Mr. Harrison, President, said the Paper had at any rate elicited the fact that gas manufacturers were not unanimous. He hoped their differences would result in an active competition to improve the process of manufacture; and if that could be accomplished at a diminished cost, they would receive the hearty thanks of the country.

January 19 and 26, 1875.

THOS. E. HARRISON, President,
in the Chair.

The discussion upon the Paper, No. 1,407, on "The Construction of Gasworks," by Mr. Harry E. Jones, occupied the whole of these evenings.