Correspondence.

Mr. THOMAS HOLGATE remarked that the great progress during the past 2 years in the economical production of calcium carbide naturally raised the question, "What is the probability of further reduction in cost, and will it ever be commercially applicable as an enricher of coal-gas?" If this question could be answered in the affirmative, then it was desirable to consider how the manufacture of calcium carbide and the generation of acetylene could be carried out in the gasworks of the United Kingdom. The principal factor in the cost was that of the electrical energy. The value given by the Author of 7,500 E.HP. hours for the production of 1 ton carbide was very high, and, if this could not be reduced, the prospect would not be very encouraging. Against this estimate, however, there appeared several statements indicating that much less energy, when properly directed, was sufficient. Mr. Raoul Pictet[1] had guaranteed to produce with 2,000 E.HP. hours 1 ton of carbide at a cost not exceeding £4, including a fair allowance for establishment expenses and wear and tear of machinery and plant. Mr. Thomas Glover[2] had stated that 1,804 Board of Trade units, equal to 2,418 E.HP. hours, were sufficient; whilst from Geneva it was reported that the net cost was £6 per ton, out of which 32*s.* was for electrical energy, 17*s.* 9*d.* for lime, 36*s.* for coke, and 40*s.* for wages, grinding and electrodes. This last figure for the cost of energy was unaccompanied by the quantity required, but being produced by water-power, it was probably charged at a low rate per unit. Modern steam-engine practice enabled in Lancashire mills 1,000 HP. hours to be obtained at a cost, for fuel only, of 94 pence. Taking the Author's estimate of energy required, the cost of coal as fuel would be $94 \times \frac{7,500}{1,000} =$ £2 18*s.* 9*d.*; whilst upon Mr. Pictet's figure, the cost would be $94 \times 2 = 15s.\ 8d.$ In many gasworks steam was generated at a smaller cost than elsewhere (except perhaps where water-power was utilized), and it was desirable that a quantity of the coke and breeze should be used where produced. Taking 4 lbs. of coke at 5*s.* 10*d.* per ton, or 5 lbs. of breeze at 2*s.* 6*d.* per ton, to be required for I.HP. per hour, then the cost of fuel for 1,000 HP. hours would be 125 pence and 67 pence respectively. Taking the average of these costs—for a mixture could easily be used—the

Mr. Holgate.

[1] In the prospectus of a Liverpool Acetylene Company.

[2] *Journal of Gas Lighting*, vol. lxxi. pp. 465, 478.

Mr. Holgate. figure would be 96 pence per 1,000 HP. hours, agreeing with the best Lancashire mill practice. If good engines were used of fairly large size, then the fuel account for coke or breeze above stated could no doubt be reduced. Viewed in this way, it was probable that the cost of energy could be brought to a comparatively low figure—say not exceeding £2 per ton of carbide. The other items of cost for generation of carbide were for lime and for coke. It was stated that of the former 16·8 cwt., and of the latter 11·2 cwt., were required for the formation of 1 ton of carbide. In many gasworks the unslaked lime would cost about 12*s.* 6*d.* per ton, and good coke (low in per cent. of ash) 6*s.* 8*d.* per ton. Taking this data, $\frac{16\cdot8}{20}$ cwt. × 12*s.* 6*d.* = $\frac{2{,}520}{20}$ = 10*s.* 6*d.*, cost of lime; $\frac{11\cdot2}{20}$ cwt. × 6*s.* 8*d.* = $\frac{896}{20}$ = 3*s.* 9*d.*, cost of coke. After the conversion of the carbide into acetylene, a quantity of lime remained. What percentage could be recovered and utilized in the purification of coal-gas was doubtful, but if the sum of 4*s.* 3*d.* were allowed for this, then the net cost of lime and coke would be 10*s.* It yet remained to estimate the cost for grinding the coke, wages, electrodes and sundries. This was stated variously at 10*s.* and at 40*s.* per ton. Adopting a mean figure of 25*s.*, and adding 5*s.* for repairs, an estimated total of £4 would be obtained. This appeared to be confirmed by Mr. Pictet's statement. Could then calcium carbide, produced upon a gasworks at a cost of £4 per ton, be used to advantage in enriching the coal-gas, say one or two candles? Taking the enriching value of acetylene as 150 candles (which at present was scarcely realized), then, with carbide costing £4 per ton and yielding 11,000 cubic feet of acetylene, the cost per 1,000 cubic feet would be 7*s.* 4*d.* Thus, 150-candle gas costing 88 pence, and 15-candle gas costing 9 pence—135 extra candles cost 79 pence = 0·59 penny per candle. This figure would probably be eclipsed by the Young oil-gas and by carburetted water-gas, but if the full candle-power of acetylene, viz., 240 candles, could be brought into its enriching value, then it would be a new competitor for this purpose. One advantage that would be gained by using acetylene was the property of the carbide acting as a desiccating agent upon the coal-gas. From the experiments of Mr. Lucien Bremond, made a number of years ago, it appeared that the deposition of naphthalene could be prevented if the moisture could be removed from coal-gas. The retention of the naphthalene would add to the illuminating power, and the abstraction of water vapour was also known to increase the illuminating

power. The troubles that arose in consumers' fittings could be minimised if a dry gas were sent through the mains, and if dry meters were used for its measurement. He had already emphasized the desirability of desiccating coal-gas.[1] If the Author could give fuller details as to the toxic properties of acetylene, they would be appreciated, especially in view of the statement made by the eminent German technical chemist, Dr. H. Bunte—"That the poisonous properties once attributed have proved visionary, and that pure acetylene is now recognised as a relatively harmless gas." Mr. Holgate.

Mr. CHARLES WEISS thought there was justification for the statement that calcium carbide was first obtained by German chemists, since Wöhler had prepared it in 1862, and Dr. Borchers had shown in 1880 that all the metallic oxides previously held to be irreducible could be reduced, and that an excess of carbon produced the metallic carbides. From the formula, $CaO + 3C = CaC_2 + CO$ (p. 6), it would appear that 0·875 lb. + 0·563 lb. = 1 lb. + 0·438 lb.; the Author gave, 0·8805 + 0·6344 per 1 lb. CaC_2. The ratio 0·875 : 0·563 was as 100 : 64·3, so that, if in practice the proportion was 100 to 63 or 67, the results of theory and practice coincided. Acetylene was formed according to formula, $CaC_2 + 2H_2O = Ca(HO)_2 + C_2H_2$; or 1 lb. + 0·5625 = 1·1562 lb. + 0·4063 lb.; *i.e.*, 0·009 cubic foot water to 1 lb. of carbide. The Author gave 0·525 lb. water (= 0·0084 cubic foot). He would be interested to know particulars of how the Author arrived at the theoretical HP. (p. 6). What specific heats had he assumed, and did 2·189 represent E.HP.-hours? Professor Lewes, Mr. Worth and others had obtained 0·5 lb. carbide per E.HP.-hour, whereas the theoretical value given in the Paper was 0·4565 lb. In a description[2] of the Spray plant, 1 E.HP.-hour was calculated to give 0·91 lb. carbide, and Dr. Bötticher, who saw experiments at Spray, stated that 0·5 lb. was obtained, and that a yield of 0·625 lb. was anticipated. With regard to relative cost of power, steam- and water-power had been mentioned, but not gas-power. In Switzerland, the Zürich and Oerlikon tramways used electricity, generated by Dowson gas and gas-engines. In a Paper[3] on the "Mond Gas-Producer Plant," Mr. Humphrey had stated that for a large plant (10,000 HP.) power could be supplied at 0·137*d.* per E.HP.-hour, or say £5 per E.HP.-year. The carbide factory at Vernier, Geneva,[4] took Mr. Weiss.

[1] Minutes of Proceedings Inst. C.E., vol. cxxvii. p. 280.
[2] Engineering and Mining Journal, 1894.
[3] Minutes of Proceedings Inst. C.E., vol. cxxix. p. 201.
[4] L'Éclairage Électrique, vol. xi. p. 351, 1897.

Mr. Weiss. 2,000 HP. from the Chèvres generating station of the city of Geneva at 36 francs (say 29*s.*) per E.HP.-year. He thought central station engineers should follow this example and improve their load curve by selling power during the day for carbide manufacture. One of the first estimates as to cost of production [1] had stated that at Spray the works-cost was anticipated to be about £3·12 per ton of 2,240 lbs.; this assumed the E.HP.-hour as producing 0·91 lb. carbide, but did not include interest, depreciation, repairs, packing or central expenses. Korda [2] gave £9·17 to £10 per ton of 2,240 lbs. as total cost, including all items; 1 E.HP.-hour producing 0·36 lb. carbide. The *Electrical World*, 1895, gave the total cost at Spray as £4·16 per ton of 2,240 lbs.; while *L'Éclairage Électrique*, 1897, gave the price at Vernier, Geneva, as £6·6 per ton total cost, taking 1 E.HP.-hour for 0·306 lb. carbide, and power at £1·45 per E.HP.-year. The latter plant (Vernier) was of great interest. Power was transmitted at 2,700 volts, losing 400 volts in transmission and in transformers, being then reduced from 2,300 volts to 57 volts. There were eight portable furnaces, each of 460 E.HP. The heat of the transformers was used to warm the mixture of lime and coke before charging the furnaces. Whilst residing at Foyers he had seen the carbide works started, and had noted some ingenious contrivances for controlling the huge arc in the furnace and also for preventing the dynamo from racing. At that time one furnace took practically the whole current of one dynamo—7,000 amperes at 64 volts. But he understood that the Acetylene Company proposed to try smaller units of furnaces. They also intended developing a water-power in North Wales and building their own works, instead of taking power from the British Aluminium Company, and using alternating current instead of continuous current as at present. Some of the carbides had been classified by Mr. Moissan [3] as follows:—Carbides acted on by water (*a*) producing pure acetylene, CaC_2, BaC_2, SrC_2, Li_2C_2; (*b*) producing acetylene and methane, YC_2, ThC_2, CeC_2, LaC_2 (72 per cent., 48 per cent., 76 per cent., 70 per cent. acetylene); (*c*) producing little acetylene, methane (80 per cent.), hydrogen and other hydro-carbons (Ur_2C_3); (*d*) producing equal parts of methane and hydrogen, Mn_3C; (*e*) producing pure methane, Al_4C_3, Be_4C_3. Aluminium carbide in bright yellow crystals was frequently found in the aluminium furnaces at Foyers. Carbides

[1] Engineering and Mining Journal, 1894.
[2] Zeitschrift für Elektrochemie, August, 1895, p. 175.
[3] Comptes rendus, 1896.

not acted on by water included CSi, CTi, CZr, CVa; also CMo_2, CWo_2, CCr_4, CFe_3. Stress should be laid on the packing of the carbide for transport, especially in such damp districts as the Highlands, North Wales, &c. Research on carbide of calcium was still in active progress. By oxidation of a solution of acetylene in water, oxalic and acetic acids and alcohol had been obtained; and a further field was offered for the manufacture of cyanides. Mr. Weiss.

Mr. FOWLER, in reply to the Correspondence, considered that Mr. Holgate had considerably under-estimated most of the items in his calculations of the cost of calcium carbide, and would point out that no allowance had been made for depreciation, interest on plant, &c. Except under special circumstances the lime remaining after the conversion of the carbide into acetylene would have little value. The question of using calcium carbide as a desiccating agent for coal-gas was no doubt a fascinating one, but some means would have to be devised to insure the percentage of moisture in the gas being constant, or, owing to variation in the acetylene made, the candle-power would fluctuate, which would be very undesirable. He thanked Mr. Weiss for pointing out some errors which had crept into his calculations. In working out the theoretical HP., the specific heats of the coke and lime were taken as 0·2017 and 0·17 respectively. The E.HP. required per lb. of carbide per hour was 2·189, equivalent to 0·4565 lb. of carbide per E.HP.-hour. He was aware that higher results than these had been stated to have been obtained practically, but they referred to commercial carbide in which the pure carbide was often mixed with coke or lime. Mr. Fowler.

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22 March, 1898.

Sir JOHN WOLFE BARRY, K.C.B., LL.D., F.R.S., President, in the Chair.

The discussion upon the Paper "Calcium Carbide and Acetylene," by Mr. Henry Fowler, was continued and concluded.
