but they had no means of measuring the electromotive force of the primary circuit directly. They had taken care to state exactly how the measurements were made, and left members to correct their results if they thought the method of making those measurements required it. They were inclined to think that the self-regulation of the "mixed-flow" turbine was as good as the "inward-flow" type; centrifugal action scarcely came into play. The test described was made with the turbine running light, without shafting, &c. In reply to Mr. Pearsall, the reason why they had not made any correction for the velocity of approach was made apparent by the disagreement between Mr. Bodmer and himself as to its influence on the result; they had left members to make the correction themselves. Mr. Pearsall seemed to think that a maximum efficiency of 69 per cent. was not good, but the Authors would have been satisfied with anything over 60 per cent. They quite agreed with Mr. Bodmer that a brake HP. test would have added to the interest of their experiments, but they had not time to make it. The length of the weir was 6 feet 6 inches, and the width of approach the same. The 20 nominal HP. Hyde duplex-boiler had been found to be quite equal to the supply of steam for a 50 indicated HP. engine with a good draught. The Authors.

Correspondence.

Mr. BERNARD DRAKE furnished some particulars of the hydraulic plant at Cragside, where his firm had carried out a considerable amount of electrical work for Lord Armstrong, who was one of the first to use water-power for electric lighting, and had made a large number of experiments to arrive at the best practical results under all working conditions. It was only during the past year that Lord Armstrong considered a complete solution of the problem had been arrived at both mechanically and electrically. The final arrangement was briefly as followed:—The principal plant consisted of a turbine having a fall of 385 feet, the water being conveyed in a 7-inch pipe through a distance of 1,200 yards; the speed of the turbine was 1,300 revolutions per minute. The HP. obtained was 27, which was utilized for driving two dynamos coupled tandem on the same axis, much after the manner since adopted by the Brush Company. The distance from the house was about ½ mile; the current was conveyed partly overhead in the ordinary way and partly by bare copper conductors laid in a long wooden trough and carried by flat pottery supports, fixed in slots formed Mr. Drake.

Mr. Drake. in the inside of the trough. This arrangement, which had been in use several years, was found to answer every practical requirement as regarded insulation, and afforded a simple solution of the problem of carrying electric conductors up to a private house where the overhead wires would be unsightly. One of the dynamos was compound-wound, and was used for the direct supply of lamps in the building, which were all required to be used together, or, if necessary, the supply of water was reduced for the lighting of a fixed portion of these lamps. As switching off a portion of the lights would cause the remainder to be overworked unless the turbine were checked instantly, an electrical system had been worked out to control the turbine automatically. This was effected in the following manner:—The main ring contact switch placed in the house carried a small separate switch, so arranged that before the main circuit was altered, a current was passed through one or other of a pair of magnets fixed near the turbine. These magnets gave a pull of 30 lbs., which was used to open or close a cock leading to the main piston which opened or shut the blades of the turbine. A system of starting and stopping gear worked from the house had also been developed, and had never failed to act. It was merely necessary to touch a button, and the whole of the necessary movements were effected electrically, the main action being somewhat similar to the regulating gear above described. The second dynamo was used for charging the accumulators, which supplied the lights after the turbine had been stopped, and also such circuits as were required intermittently. A distributing switch-board afforded facilities for putting any circuit on to either source of supply as desired. Another smaller plant was chiefly used for the electrical transmission of power. The turbine in this case gave 10 HP. with a fall of 29 feet; the generating dynamo was driven by a belt, and the current was conveyed to the workshops, a distance of 750 yards, by bare overhead conductors. A continuation of this circuit had been made a further distance of 750 yards to the house, by means of which the current could be utilized for electric lighting in case of emergency. The electrical motor which received the current drove, by means of belting, a large circular saw, which was in constant and daily use for purposes of the estate, and a number of other tools and lathes. The motor was compound-wound in a special manner, which enabled the work to be removed suddenly without danger. The type of turbine used was that of Professor James Thomson, made by Gilkes and Co., in which the water was taken in at the circumference and discharged at the centre, the speed being controlled by the alteration of the angle of the guide-blades. Another of these turbines had recently been erected for the Duke of Northumberland in connection with the lighting of Alnwick Castle, where the fall was very low and the HP. over 30. He could not speak too highly of their working. Other water-power installations were in course of construction, and there was every sign of this branch of electric lighting increasing rapidly during the next few years. Mr. Drake.

Mr. C. L. Hett was afraid that the experiments given in the Table, p. 162, might lead to a very false impression as to the efficiency of turbines when working with a short supply of water. In these experiments, when the supply of water was reduced rather more than one-half, the efficiency was reduced nearly one-half, the power being reduced to about one-quarter of that obtained with the full supply. The greater portion of this loss of efficiency might be assumed to be in the turbine. The regulating-gate of the turbine was described as cylindrical. This was rather misleading; the gate was not cylindrical as in the old Fourneyron, but might be termed a cylindrical gridiron valve. This form was an old one which had been employed by many turbine builders in the United States, where it was known as an inside register gate. This gate never gave a good result when the supply of water was short. Its advantages were simplicity and easy working. The inside register gate was inferior to the cylindrical gate of Fourneyron, which was adapted to many types of mixed-flow turbines, and to the swinging-gates of Professor James Thomson's vortex wheel, and its modification called the Leffel wheel. A 21-inch turbine with a sliding-gate would have run only 10 per cent. faster than the turbine employed. Had the use of any particular turbine enabled the Authors to drive their alternators direct there would have been a good reason for selecting a turbine the efficiency of which with short water was its weakest part. In the case of Keswick belt-driving was employed; hence it was rather difficult to understand the selection of this turbine. Mr. Hett.

Mr. Reginald J. Jones stated that in 1885 Messrs. Woodhouse and Rawson installed a turbine plant for the purpose of driving the dynamo supplying the electric light at Arborfield Hall, near Reading (Plate 3, Figs. 5, 6, and 7). This was a 44-inch "Trent" turbine, made by Mr. C. L. Hett, of Brigg, Yorkshire. The head of water was only about 4 feet, and was taken from a stream running through the grounds. There was the usual large sluice, the admission of water through which was regulated at the first start by winding up by hand. A supplementary regulator, which worked on the guide-vanes of the turbine, was controlled by a Porte-Manville Mr. Jones.

Mr. Jones. electrical governor which acted thus:—A wheel had two sets of ratchet-teeth cut in it in opposite directions. An oscillating arm, by means of an eccentric driven off the first-motion shaft, gave a reciprocating action to the two pawls, which were capable of being drawn down by electro-magnets underneath them. The pawl on the one side, when pulled down, tended to turn the wheel in one direction, and when the other pawl was put in connection, the wheel was turned in the opposite direction, causing the guide-vanes to open and close, thereby reducing or increasing the amount of water admitted to the turbine, so that variation of speed was obtained. These pawl magnets were controlled from the house electrically. The machine used was an ordinary shunt-dynamo, and the mains were connected to a relay, situated as near as possible to the centre of the points of distribution. This relay consisted of a long hollow magnet placed horizontally, inside which was a balanced armature in the form of a lever pivoted in the centre. One end of the armature carried an adjustable weight, and on the other were two platinum contacts for making the circuit through two stops, connected respectively with the opening and shutting magnets which controlled the pawls. When the electromotive force of the circuit was normal, the armature or tongue rested in mid air between two stops, and the reciprocating arm with the two pawls simply oscillated without making any movement on the wheel which governed the opening and shutting of the guide-vanes; but if the electromotive force fell, the armature fell on the bottom stop and put the pawl in circuit, which tended to open the guide-vanes, so as to give a greater supply of water. On the electromotive force rising the opposite action took place, the armature or tongue coming in contact with the top stop. This plant had been working for nearly five years; the governing had given the greatest satisfaction, and there had been practically no repairs to the water-wheel and the electrical plant. In order to stop the turbine, a two-way switch had been provided in the house to put in circuit the closing-pawl of the electrical regulator, and shut the vanes until the turbine stopped, thereby saving the trouble of keeping a man to watch the machinery during all the hours that the lighting was required. It might be pointed out to those who had a water-supply, that with a governor of this description, the necessity of accumulators was to some extent done away with, and consequently the cost of the installation was greatly reduced.

Sir David Salomons. Sir DAVID SALOMONS observed that, his name having been mentioned in connection with the light given by the Edison-

Swan glow-lamps, it might prove of interest to give the results which he had found from practical tests and experience. The tests had been made both with direct and alternating currents, the normal pressure being 100 volts, and, facilities existing for varying the voltage above and below the normal. Dr. Hopkinson might be right in finding that an 8-candle-power lamp produced about the same light as a good gas-burner intended to pass 5 cubic feet per hour, the gas being at such a pressure as to enable this quantity to be consumed in the given time. From this statement, it might well be imagined that an 8-candle-power lamp should, with equal effect, replace a gas-burner in a dwelling-house; but the inference was not true. A little practical experience with domestics would convince anybody, in the face of the most severe scientific investigation. The reason was, that the nature of the light was different. A clear globe lamp did not diffuse the light, whereas an obscured one did. Consequently, although the obscuring involved a loss of light, yet in practice a better illumination was produced for daily requirements. The illuminating surface was considerably enlarged, and the glare of the filament was removed. With these modifications the light more nearly resembled a gas-flame. At the same time, whatever might be said to the contrary, it was impossible to see at night-time, with equal effect, unless obscured 16 candle-power lamps replace a 5 cubic feet gas-burner. It was for this reason he started the simple method of comparing the price of gas with that of electricity, namely, by multiplying the cost of the electrical energy per unit by ten, and considering the result as the equivalent of gas per 1,000 cubic feet. The economy of working lamps above and below normal pressure he found to be equal under the following conditions:—(1) When employing an electromotive force 1 per cent. below the normal, whereby less light was obtained, but the life of the lamp was greatly increased; and (2) When working at an electromotive force 2 per cent. above normal, thus greatly increasing the brilliancy of the light, but shortening the lamp-life. He had found that the alternating current blackened the globes far more than the direct, also that the direct current was much in favour of increased lamp-life. From a series of tests made with a direct current upon a number of 100 volt 16-candle-power lamps, the average of the light given for different electromotive forces was, in round numbers, as followed:—For 102 volts the candle-power was 19; 101 volts, 18; 100 volts, $16\frac{1}{2}$ to 17; 99 volts, $13\frac{1}{2}$; 97 volts, 12; 93 volts, 8. Obscured lamps gave a loss of light varying from 16 to 17 per cent.; but the diffusion was far more than

Sir David Salomons.

Sir David Salomons. correspondingly increased. These tests were upon lamps of recent make. Those manufactured two years ago gave nearly 10 per cent. more light, when rendered incandescent at the voltage for which they were made; and, as far as he had been able to judge, their life duration was as good as those of more recent manufacture. The practical bearing of this observation was that the more recent lamps had a lower efficiency than the earlier ones, with no apparent compensating advantages.

Mr. Snell. Mr. ALBION T. SNELL had recently erected several overhead lines for transmitting electricity for power purposes. The tensions used varied from 200 to 750 volts. The cables were practically bare, being only covered by a braiding of hemp soaked in ozokerite, and then coated with wood-tar. For insulation he depended entirely on "fluid insulators" made by Messrs. Johnson and Philipps. For leading in and out of dynamo and motor houses, special precautions were taken to avoid damp. A vulcanized rubber insulated cable was jointed on near the outside of the buildings, and then carried on insulators to the insides, where it was protected by wood casing. The cables were protected from lightning by comb-dischargers at each end and near the middle of the line. In addition to this, a No. 12 B.W.G. galvanized-iron wire was run about 1 foot above the two copper cables. This iron wire was carried on insulators when the posts were of wood, but with iron posts it might be run on the top direct. It was attached at each end, and at suitable intermediate places, if necessary, to copper plates surrounded by coke in damp soil, and had also a few copper discharging-rods attached to it at some of the post-tops. During last summer a severe thunderstorm took place in a district in which he had erected a copper cable about 2·5 miles long. It was protected substantially, as described above. The workmen stated that the lightning visibly played along the wires again and again; but no damage was done to the dynamo, motor, line or instruments. The lightning arresters and discharging-rods seemed to have been perfectly successful.

The Authors. The AUTHORS, in reply, thought that the regulation effected in Lord Armstrong's installation, which only regulated for a definite number of lights switched off or on at once, could not find any general application. The method of regulation described by Mr. Jones, though somewhat complicated, apparently fulfilled its purpose. Mr. Jones did not say within what percentage it controlled the electromotive force. Mr. Hett had arrived at the conclusion that the greater part of the loss of efficiency at half-load was due to the inefficiency of the turbine. This was not so; it was to be accounted for chiefly by the mechanical, exciting, and other electrical losses being nearly the same at light load as at full load; no doubt there was an appreciable loss due to the regulating gate, but they thought that Mr. Hett rather over-estimated the advantages of the other methods of regulation he had mentioned. At the same time, high efficiency was wanted at full load, and it did not much matter what it was at light load. Sir David Salomons had called attention to an interesting point in artificial illumination; but their experience differed from his; they found an equal inconvenience in working with a naked flame as with a clear-globe glow-lamp, which was due to a want of light in the shadows, and too sharp a gradation from light to shadow. Both the flame and the incandescent filament needed a frosted globe, or its equivalent, to diffuse the light, and this was especially the case in rooms with dark-coloured surroundings. They would like to know whether the electromotive force was equally steady in the case of the alternating and direct current in Sir David Salomon's experiments on the blackening of globes and the life of lamps before accepting his results as proving what he contended. They were glad Mr. Snell had found that reliance for insulation upon the points of support of the wires was quite satisfactory. They thought that in every case the points of support deserved special attention in the insulating a line, on account of the durability of an oil insulation as compared with the insulating covering of the wire. The Authors.

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27 May, 1890.

This being the Tuesday in Whitsun week, there was no meeting.
