Discussion.

Sir RICHARD REDMAYNE remarked that the Paper was very opportune at the present time, when every possible effort was being made to reduce the price of coal. He was so largely in accord with the Author, that it was difficult to criticize the Paper. However, he might say a few words by way of supplement. The Author stated that compressed air and the direct application of steam would always play a considerable part in the use of power at collieries. That was so for two special reasons. In the first place, winding, especially from great depths, was better performed by steam than by any other form of power, because of the various operations which had to be repeated every two minutes or so in the process of raising a load. He knew of no form of power which met the requirements of such a process so well as a simple winding-engine. Electricity might be used to advantage in certain circumstances, as, for instance, in the absence of water, or probably where the whole of the rest of the colliery was electrically driven; but there were cases on record of mining engineers who were so satisfied as to the superiority of steam for winding, that electrical winding-engines had been taken out and steam power substituted. While compressed air could not be compared with electricity in point of efficiency, yet electricity could not be used at the coal-face, on account of the gas danger, and therefore compressed air would continue to play an important part in coal-mining, especially in areas subject to inflammable gas. Extraordinarily high figures could be arrived at for the total consumption of coal in the British coal-fields, by taking the whole of the collieries supplied with electricity from public electrical undertakings, converting the energy so supplied into terms of coal, and adding to this the coal used in all the other collieries. Electricity was most widely utilized in the north-east coal-field of Durham and Northumberland, where the colliery consumption of coal was lower than in any other British coal-field, and where, by reason of the Newcastle Electric Supply Company's ability to produce very cheaply, collieries could utilize electricity for underground haulage, for ventilation, for coal-cutting, screening, and so forth, though even in that area there were very few cases of electric winding. The whole of the electricity used in the coal-fields for power purposes was equivalent on a calorific basis to 1,539,402 tons of coal annually, while the whole of the rest of the coal used for power purposes in collieries was represented by the figure of 16,856,341 tons—a total of 18,395,743 tons, or 6·8 per cent. of the total annual drawings of coal. Taking the price of such fuel at the

Sir Richard Redmayne.

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Sir Richard Redmayne.

somewhat low figure of 10*s.* a ton, because to a great extent inferior coals were used for such purposes, a sum of £9,197,872 was expended per annum in developing power to work the collieries of the country. That offered an enormous field for reduction, inasmuch as by the adoption of the most up-to-date methods the same results could be produced by the use of very much less coal. He had long been trying to determine the cost of power per horse-power at the average colliery in this country, but owing to the difficulty of arriving at the total horse-power generated over a given period, the result could only be regarded as a rough estimate. While the horse-power of some engines in use at a colliery could be ascertained comparatively easily, as they ran at a fairly constant speed, there were others, such as winding-engines, which were worked so intermittently that the horse-power was probably different at every revolution. The figure could therefore not be determined with any degree of accuracy. A well-known electrician had recorded the fact that there was a good deal of difference between the cost that was got out by the engineers of the central electric supply-stations and that which the colliery-manager would require to get out if he wanted to give the cost per horse-power at his colliery. It was doubtful whether the average annual cost per horse-power taken over the whole of the British collieries, was much less than £30, although the increasing adoption of power supplies from public central electrical undertakings must tend towards a considerable decrease in the figure, on account of the lower price at which such companies were able to produce and transmit power, owing to the higher load-factor and to more scientific consumption of low-grade fuel. He had been particularly interested in the Author's observations concerning the application underground of the electric locomotive—whether trolly or battery. He had recently inspected a Westphalian colliery where not many years ago there was an explosion in which ten men were killed, and he had been horrified to see an electric locomotive on the trolly system emitting flashes as it went along within 100 yards or so of the face. That appeared to him to be extremely dangerous. He was doubtful whether an electric locomotive on the battery system, which was reputed to be perfectly safe, would compare in efficiency and economy with the best systems of underground main-and-tail and endless rope haulage. He had therefore been particularly interested to learn from the Author that quite recently the English system of haulage had been adopted, in preference to locomotives, in the Campine coal-field in Belgium. About 40 years ago he had known of a colliery in Durham where the whole system of haulage was by compressed-air locomotives, but they had now all been taken out.

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Sir Richard Redmayne.

With regard to the Author's remarks as to the application of power to the actual cutting of coal, no doubt his attention had been directed to the case of Westphalia, where the form of coal-cutter now adopted was almost universally of the jack-hammer type. Before the war about 6,000 were in use, but now there were tens of thousands. When down one of the Westphalian collieries a year ago he noticed with interest the great improvement that had been made in the output per man per shift through the adoption of this type of coal-cutter supplied with air from electrically-driven air-compressors stationed some distance back from the face: air was carried through pliable pipes to the coal-face, where every man was equipped with a jack-hammer. The seam was less than 3 feet thick, and a considerable output per man per shift was obtained. The moral of the Paper was that there was room for improvement in the methods of application of power to collieries. There was no need for British collieries to fear comparison with other countries in respect of their best laid-out plants, but considerable improvements might be obtained and savings effected by collieries combining into groups for power purposes.

Sir Arthur Duckham.

Sir ARTHUR. DUCKHAM remarked that the colliery undertakings were to-day in a state of flux. Conditions in the coal-mining industry had forced those responsible to take steps towards increased efficiency and towards the grouping of collieries in order to get better general services. The Paper put forward in a simple fashion the problems presenting themselves to the colliery engineer in his search for higher efficiency. Sir Richard Redmayne had given figures with regard to the coal-consumption in the collieries. That consumption had been very high in Britain, owing largely to the low price of fuel in the old days, when efficiency did not matter so much. A great many of the advances made in other countries had resulted from the fact that fuel was more expensive there, and therefore it was not permissible to waste it. Colliery undertakings in this country had now, however, started to generate electrical power, and had found they could generate it at a very low cost. The Author indicated that it might be advantageous for collieries to become generators of electricity in a general way, under some such scheme as the Government had had in mind for some time past, and he had shown the advantage to the collieries of being connected to a bus main to which they could either contribute a supply, or from which they could draw when necessary. Those collieries which did generate electricity, even in small units, discovered that they could do so at a figure which compared advantageously with the price charged by existing generating-stations. It was of the utmost importance that the question of power-supply from collieries should be carefully

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Sir Arthur Duckham.

considered by those in authority who had in their hands the power development of the country. With reference to the figures of winding-costs shown in Table I (p. 197), the coal consumed with the Stubbs-Perry system was represented as costing £568 per annum, whilst under the ordinary steam system the cost of coal was shown to be £2,368. The difference between the figures was extraordinary, especially in view of the fact that both represented steam. What was the explanation of that disparity? Electrical winding might be advantageous where a group of collieries worked in connection with a central power-station. With ten pits working from one station the load-factor should be very much improved, as it would not be likely that more than one or two winding times would synchronize. An interesting point raised in the Paper was the question of the use of powdered fuel. No doubt in the future there would be a greater demand for clean coal, and foreign markets would be regained by British colliery-proprietors selling clean coal. Coal was being purchased more and more on a calorific basis with a fixed ash-content, and colliery-owners would therefore have to study the question of cleaning coal. The difficulty in the way of cleaning coal by the wet method lay in the smalls, and the Author showed that those smalls, which contained dirt and impurities giving trouble in coke-oven working and with clinkers, could be satisfactorily used as a powdered fuel. The price of 10*s*. a ton taken by Sir Richard Redmayne as the cost of such fuel for power purposes at the colliery was far too high, because it was often an absolute nuisance, and in fact at the present time a colliery was often pleased to have it carted away free. An added advantage in the case of powdered-fuel firing was that the ashes obtained were useful for stone-dusting.

Sir William Ellis.

Sir WILLIAM ELLIS, Past-President, remarked that the important subject of mining engineering had hardly played so prominent a part in the discussions of The Institution as it ought to have done. That branch of the profession had not proved very seductive to young engineers, and too few well-educated young men were entering it. Considering the problems of a technical nature which had to be dealt with, the variety of difficulties in connection with employment in a colliery, the Trade Union questions raised, the Government regulations as to safety in mining, etc., it was evident there was as great a need for brilliant young men in that branch as in any other branch, and he would welcome more evidence of the attractiveness of that line of engineering. The points brought out in the Paper fully justified those views, as the Author referred in detail to questions of technical interest, showing what a wide field there was for highly-trained men. As a result of his reading of a Paper 2 or 3 years ago on the mechanical side of colliery

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engineering, Sir William had realized that the mining engineer, who was primarily responsible for the lives of the men and for the efficient working of the colliery, was burdened with such a variety of work that it was utterly impossible for him to give detailed attention to working out some of the more technical engineering problems associated with the development and upkeep of a colliery. For that reason he thought there was a great opening for mechanical engineers of ordinary training to take up that branch of mining; not interfering with the mining engineer's prerogative, but acting as a help to him in working out the more technical side of his manifold duties. He felt some difficulty in discussing the technicalities of the Paper, but there were one or two points which he would refer to. The matter of steam winding versus electric winding was a very vexed question, depending on the particular circumstances in each case. He agreed with Sir Richard Redmayne that the simple steam-engine had great attractions. Those whose duty it was to go down mines felt confidence in winding-engines of a simple nature, well under the control of, and well understood by, the man in charge; and unless special circumstances came into play, he did not think the days of the steam winding-engine were by any means at an end. He would like to see more progress made with the safe application of electricity below ground. He knew that his views about electricity versus compressed air below ground might require modification, but he felt that the electrical engineer should study this important question with a view to minimize the danger, so as to render it possible to introduce electric power farther inbye. The advantage of electricity for underground haulage was evident, and the farther it could be taken from the bottom of the shaft into the colliery-workings, the greater the economy. The limit of its utilization in that direction had not yet been reached, though proper care must be taken to overcome the danger of possible blowers in certain classes of collieries. He was not advocating its utilization anywhere near the coal-face, but he would like to see developments made in the direction of safeguards against sparking which would enable it to be taken much farther inbye than was possible at present. The question of the use of gas in various ways was a matter of great interest. It might be said that happy was the colliery with a big neighbour who required gas. It saved the colliery a lot of trouble in studying economic methods of using waste gas, and it saved the neighbour the cost of installing expensive plant. The solution of the question whether a colliery should make its own electricity or purchase it from a large neighbouring power-station varied according to circumstances. The suggestion had been made that the question

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Sir William Ellis. of a colliery generating its own electricity depended upon its water-supply. Most collieries had a great deal more water than they desired, but unfortunately it was not generally of the right sort. The quantity of available water suitable for condensation purposes was, however, an important factor. Colliery-owners welcomed the linking-up with a central power-station, one great advantage to the colliery being that at the week-end it could shut down its own plant and obtain from the central station sufficient power to carry on until the ordinary work of the week was resumed; while at the same time collieries could in certain cases, when actually generating power, help the public power-station.

Professor Fearnsides. Professor W. G. FEARNSIDES observed that, as a geologist working in the Yorkshire coal-field, he had during the last 10 years watched with interest the increase in the production of crushed coal. Mines were getting deeper. Twenty or thirty years ago coal was obtained from an average depth of 300 yards under a pressure of something less than $\frac{1}{2}$ ton per square inch, whereas to-day coal was being got from a depth of 800 yards under a pressure of 1 ton per square inch. It was not, therefore, to be wondered at that the action of getting coal created much more powder than it had done formerly. The Author had referred to the difficulty of washing fine coal. It was a very great difficulty. There was a sort of affinity between the surface of coal and water. Mines which had gone down from 300 yards to 800 yards had passed out of the water zone, and much of the deep coal now got was dry. It would be a great pity to wet it, and there was no need to wet it if it could be made use of in the powdered state. The Author had distinguished between those collieries which worked coking coal-seams and those working non-coking coal-seams. Smalls of coking coals, when washed, could all be used in coke-ovens. The difficulty lay in the washing. But this country had no great reserves of coking coals, supplies of which, it was estimated, would be exhausted probably 200 years earlier than other kinds of coal. Smalls from 1 inch to $\frac{1}{4}$ inch of high-ash non-coking coals were as much a drug on the market as was the very fine dust of coking coals, and if those smalls also were similarly powdered they would afford a very large supply of fuel as good for steam-raising as any other sort of coal. An economic outlet for non-coking " slack " should help to reduce the cost of producing the more acceptable grades of house coal.

Mr. Kennedy. Mr. J. M. KENNEDY observed that, although the Author seemed to advocate general electrification, yet he defended the use of the small steam-engine and what appeared to be isolated boiler-plants. In his experience, although not intimately connected with mining

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working, he had always found that it was the small isolated engine and the isolated boiler-plant which ate up coal ravenously, and the substitution of electric motors showed a very large saving in consumption in such cases. He had been sorry to hear Sir Richard Redmayne speak so strongly in favour of the steam winding-engine, though he naturally bowed to his opinion. Sir Arthur Duckham, however, had rather seemed to put the boot on the other leg. He hoped the introduction of electric winders would come about, because he imagined the steam winder could only be really efficient where the boilers supplied steam for the rest of the power requirements of the colliery also. The Author had referred to the steam-consumption of such engines reaching the unduly high figure of 30 lbs. per horse-power-hour. The question of the total cost of production of electricity by a colliery was important. He was in favour of collieries producing their own electricity if they could do it sufficiently cheaply and on a sufficiently large scale. He would draw attention, however, to the fact that the recently-passed Act meant that in a few years time the production of electricity in all industrial areas would be controlled by the proposed Central Electricity Board, and that Board would only derive its supplies of electricity from the most modern and efficient stations. If a colliery or group of collieries were considering in the future whether it could supply electricity to the Central Electricity Board at an economic price, it would not have to consider as at present whether the price at which it generated was lower than the local price at which electricity was sold, but whether it would be lower than the price at which the Central Board could provide electricity from an additional unit at one of the selected stations. The Board's point of view would be that, if the colliery could supply power at a price which was equivalent to the cost of enlarging the nearest selected station, the Board would be glad to take it, but not otherwise. He had been considering that cost very carefully, and it appeared to him that at the present prices of machinery and coal the Board would be able to put turbine-units of, say, 25,000 kilowatts into their stations and produce electricity at prices, respectively, of £2 5*s.* per kilowatt and 0·125*d.* per unit generated, with coal at about 15*s.* per ton. At 30 per cent. load-factor that was equivalent to 0·3*d.* per unit, including interest. It was therefore obvious that collieries would have to produce electricity at about that figure if they were going to be able to supply the Central Electricity Board. That was an argument for the grouping of collieries for the purpose of power-production on a large scale, and he hoped it could come about. Mr. Kennedy

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Major Ivor David.

Major E. Ivor David remarked that the discussion showed there was considerable lack of knowledge as to what the collieries were actually doing. His own company was generating, and distributing or utilizing, more than 310 million units of power per annum. The Author referred to the difficulty of disposing of coke-oven gas. The Powell Duffryn collieries could use all the gas they could produce. They generated annually 23 million units of electricity from coke-oven gas. He was gratified to see that The Institution was paying attention to this problem. The Author had done valuable pioneer work, both in ventilation problems and in the flame-proofness of machines underground. Through his instigation an institution had been established where apparatus could be tested to determine whether it was safe to use in mines or not. With regard to the question of steam versus electricity, if the price of fuel were taken at 8*s*. per ton and the price of electricity at 0·75*d*. per unit, steam would clearly be more economical; but if the price were taken at 0·3*d*. per unit as given in the Paper, or at the figure of the Weir Report of 0·33*d*. for a 45-per-cent. load-factor, or 0·29*d*. for a 60-per-cent. load-factor, then every colliery in the country ought to be electrified. He was prepared to prove that this was a commercial possibility. In opposition to previous speakers he considered not only that electrical winding was very much more efficient than steam winding but also that it was much safer. During the last 17 years two of the biggest electric winders in this country had not experienced a stoppage due to electrical faults. He would like to know if any steam winding-installation in the country could show a corresponding record. Although he concurred with the Author's conclusions, he had found serious arithmetical errors in his Tables. In Table I the Author gave £3,130 for electrical energy for a three-phase winder at 0·75*d*. per unit. That corresponded to a little more than 1 million units, but in Table III the consumption was given as 1,537,600 units, which was a more reasonable figure, corresponding to an efficiency of 45 per cent. for the winder. With regard to the Ward Leonard winder included in Table I, the figure of £2,460 for energy corresponded to 790,000 units, which gave an efficiency of 100 per cent. If the normal efficiency for a Ward Leonard winder were taken at 60 per cent., equivalent to 2·57 units per ton gross consumption, the consumption would be of the order of 1,284,000 units per annum, allowing for winds during off shifts, stop days, and so on. The difference in cost between the Ward Leonard and the Stubbs-Perry winders was shown in Table I to be £2,800. The Stubbs-Perry winder comprised the whole of the Ward Leonard equipment, and a turbine and reduction-gear, a fly-wheel, condensing-plant, piping,

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and auxiliaries. Would it be possible to buy the whole of that additional equipment for a 750-HP. plant for £2,800? The sub-station was shown in the Table to cost £3,000. If it was an extension of an existing sub-station, £3,000 was far too much; it was only dealing with a 750-HP. motor, and should not cost more than £1,000. He had found in all cases that the cost of maintenance of electrical plant was about half that of steam plant, particularly in the case of electric winders. Taking the Author's data, and correcting them in accordance with his own figures, the costs were: for the three-phase winder, 2·88*d.* per ton; for the Ward Leonard winder, 2·78*d.*; for the Stubbs-Perry winder, 2·73*d.*; and for the steam winder, 2·54*d.* per ton. From that it would appear, as would be expected, that the steam winder was the most efficient. Several experts on the subject had stated repeatedly during years past that, unless the price of electricity could be reduced below ½*d.* per unit, the electric winder could not be considered. If the cost of a unit were reduced to ½*d.*, then the figures would be 2·11*d.* for the three-phase winder and 2·15*d.* for the Ward Leonard winder. With regard to the case of colliery "B," dealt with in Table II, he could not agree with the Author's figures. A sum of £100 was allowed for repairs to and maintenance of the steam-engine, which was an old reconstructed engine, and £150 was given for the repairs and maintenance of the electric winder. He thought that surely must be wrong. Further, the Table showed a figure of £30 for oil and stores for the steam-engine, and £50 for the electric winder. He thought the figure should be at least £80 or £100 for oil and stores for the steam winder, and at the outside £20 for the electric winder. If his figures were correct, it would be found that the electric winder in the case of colliery "B" was the more economical. The efficiency of the electric winder in that instance was only 37 per cent., which was rather low, even for an alternating-current winder. The Author referred to the difficulty of dealing with fine coal. That difficulty had been realized for a long time in connection with washeries, and the slurry question was one which had occupied much attention in South Wales. It had been dealt with recently on the froth flotation principle, and, as a result, a waste product was obtained which contained only 6 per cent. of combustible matter, with a washed product containing only 4½ per cent. of ash, in a very fine form and suitable for pulverized fuel. The difficulty was, however, that it was bound with water, which could not be separated from it. That was the great trouble in dealing with pulverized fuel in any other way than that which the Author recommended, namely, grinding it in a dry state with all its ash.

Major Ivor David.

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Major Ivor David. If it was dealt with in the washed state, a suitable drier was required, and a drier had not been found which would dry coal satisfactorily. Experiments were being made with a system of drying by hot coke, both in this country and abroad. On the question of cleaning coal generally, it was amazing to find that consumers were willing to buy unwashed coal and pay for its carriage over long distances. Surely it was economical, when the carriage of coal from South Wales to London cost 10*s*. 8*d*. a ton, to wash it before it was put in transit. Washing would make a difference in value of about 2*s*. 4*d*. a ton on coal delivered from South Wales to London. If consumers bought on a basis of calorific value they would always buy washed coal. Further, medium volatile South Wales washed coal with a certain percentage of moisture did not slag on the grate and did not stick on the side walls. In the South Wales collieries with which he was associated a test boiler-efficiency of 73 per cent. was not considered satisfactory. A test efficiency of 87 per cent. was obtained without air-heaters, and with air-heaters 90 per cent. calculated on the lower calorific value of the fuel. Full details of such a test had been published[1]. He anticipated high power- and maintenance-costs for the grinding of high-ash coals, and would like to have the Author's figures. Engineers should weigh all factors before plunging for pulverized fuel, because with suitable coals chain-grate stokers could still show many advantages.

Mr. Pochobradsky. Mr. B. POCHOBRADSKY thought that the Author had sounded a note of warning in regard to the diversity of conditions that determined the most suitable kind of plant to be installed. It had been stated that mixed-pressure turbines utilizing exhaust steam were not necessarily an economic success. He was responsible for a very large percentage of the mixed-pressure turbines installed in this country, and he had never experienced a case of economic failure in connection with such turbines. But he had to confess that he had not always been anxious to install them; the conditions must be investigated before a decision was taken. Table I showed the steam winder at a very considerable disadvantage. Apparently in that particular colliery there was no outlet for electricity or for compressed-air energy, otherwise the exhaust steam would have been utilized for that purpose. It appeared that the quantity of exhaust steam was 35,000 lbs. per hour, which was sufficient, after allowing for losses, to generate 1,000 kilowatts. If that had been generated by high-pressure turbines it would have required 16,500 lbs. of steam per hour, and that steam would cost an additional £1,850, according to figures given in Table I for steam-

[1] "Steam: its Generation and Use," p. 134, London, 1927.

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generating costs. A mixed-pressure turbine was more expensive than a high-pressure turbine to install, and about £500 had to be allowed as a standing charge for that difference. Therefore, the gain by the mixed-pressure turbine would be £1,350, to be credited to the steam winder. That would make the steam winder more economical than the other types mentioned in the Table. The Stubbs-Perry winder appeared to consist of a turbine, gear, fly-wheel, and generator. That design of machine had been known for many years before a claim was made for its authorship, and he therefore thought it was only fair that the machine in question should receive a rather different title, such as the Ward Leonard winder with steam-turbine drive. When the cost of energy was reduced from 0·75*d.* per unit to the figure mentioned in the latter part of the Paper as the possible cost of generation when the collieries were re-organized and power-production was put on the desired basis, then purely electric winders would undoubtedly be superior to steam winders of both types. The latter part of the Paper contained a bold suggestion in advocacy of the policy of power-production generally, apart from the requirements of the colliery. Two different types of power-plant entered into that scheme, namely, the steam plant and the gas-engine. The figures given in Table V showed that, while the cost of a gas-engine plant was £400,000, and that of a steam plant of the same output only £200,000, the cost of production of power was lower in the steam plant than in the gas-engine plant. That provoked an alternative question, namely, what would be the cost of generation of power if steam plant were used, but with gas as fuel instead of coal? He found that the power-generation would be cheaper in the steam plant when gas was used for firing the boilers than it would be if gas were used directly in a gas-engine plant. There was, of course, another advantage—not only an economic one, but also a practical one—namely, that the power-station would not be equipped with composite plant, and would be capable, therefore, of employing larger and more economical units of the same type.

Mr. Pochobradsky.

Mr. H. M. MORGANS observed that the Author gave the steam-consumption of the steam winder as 30 to 60 lbs. per indicated horse-power-hour. He wondered whether that included the stand-by losses, which were very considerable. A colliery-manager had recently remarked to him that he liked the steam winder because, when pressed for output, he could speed up the winder. That was one advantage the steam winder possessed; nearly all the other advantages lay with the electric winder. The Author stated that the pumps used at collieries were invariably of the centrifugal type except for a few Hathorn-Davey rod pumps. That was rather

Mr. Morgans.

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Mr. Morgans. too strong an assertion, though it was true that centrifugal pumps were being used in increasing numbers. The Author also stated that inbye pumps were preferably air-driven. That Mr. Morgans took to mean from the point of view of safety in the workings, and not from the point of view of the pump. With free choice as to power-supply, electricity would be used for the inbye pumps. The Author stated that in shafts compressed-air drills on stands were always used, but surely many shafts had been sunk with air-hammer drills which were not on stands? The Author compared compressed air with electricity, and showed how much more economical electricity was. A percussive coal-cutting machine required about 20 HP. at the compressor to drive it, whereas an electric machine doing the same work used only 5 HP.

The Author The AUTHOR, in reply, expressed his appreciation of the comments which had been made on the Paper. The question of the relative merits of steam and electric winding had attracted much attention, but, taking all factors into account, it became simply a question of the price at which electric energy was available. Several speakers seemed loth to part with the well-tried steam winder, which, however, would disappear if bulk supplies of electric energy were obtained cheaply enough. As Major David had stated, power-production at the colliery from coal at 8*s*. per ton was clearly more economical than purchasing energy at 0·75*d*. per unit, and public electricity undertakings must realize that if they wished to supply the collieries of the country they must place themselves in a position to supply energy at prices certainly below 0·5*d*. per unit. Major David had acted as a pioneer in that direction, for he had under his control a large power-station which was also a colliery group station, and it was an open secret that he was supplying the collieries of his group at a price well below 0·5*d*. per unit. The problem for the Powell Duffryn Steam Coal Company was therefore solved on the lines advocated in the Paper. Mr. Kennedy, however, did not seem to appreciate the fact that a small colliery turbo-generator taking steam produced from coal at 8*s*. per ton would produce energy at a cost lower than that at which it could be produced by a super power-station burning coal at 20*s*. per ton. It surely was obvious that not even the substantially higher thermal efficiency of the large station could wipe out the disadvantage of high coal-cost and costly transmission. Electrical engineers in this country seemed to have their ideas fixed on the large "modern and efficient station," forgetting that to the industrialist efficiency must be measured in terms of cost, and that efficiency *per se* might be too dearly bought. Of course, if the "modern and efficient station" was installed close to the colliery and utilized coal at 8*s*. per ton, a minimum cost of

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energy would result, and this was precisely the line of action advocated in the Paper. But apart from the question whether a public station or a colliery group station could supply energy at a cost low enough to satisfy the requirements of the Central Electricity Board, the Author had pointed out that an increasing proportion of the nation's fuel resources lay in high-ash fuels difficult to clean, and he suggested that all fuel and power engineers should apply themselves to the problem of the utilization of such fuels. The comparative smallness of the national reserves of coking coals, mentioned by Professor Fearnsides, made this question specially important. In view of Major David's experience that many inferior coals could be burnt successfully on chain-grate stokers, it might prove that certain fuels were better utilized in this manner. It was equally certain that pulverized-fuel firing would be the best solution in other cases, such as the actual case instanced in the Paper; but this was a question for individual investigation, and in no sense affected the fundamental argument. Many attempts had been made to dry washery-slurry, as had been remarked by Major David, whose experience was interesting. The Author believed that the extraction of fine dust in the dry state and its utilization in pulverized-fuel boilers would prove to be the better solution. He could not agree with Major David's wholesale advocacy of the electric winder as superior in reliability and cost of maintenance to the steam winder, and feared that, as an electrical engineer, Major David was somewhat biased. As a mining engineer the Author's only concern was to obtain a reliable and economical machine, and his experience showed little difference on these counts between the two types. The maintenance figures given in the Paper had been taken from the actual costs of existing steam winders, and he saw no reason to modify them. Major David also questioned the items for the cost of current in Table I, but those figures were perfectly correct as they stood. He was in error in attributing the whole of the 1,537,600 units shown for the winder load in Table III to the individual engine for which Table I was calculated; actually this item included the energy required for another and smaller winder. He had also apparently overestimated the total number of winds per annum. The total units consumed by the three-phase winder in Table I were 1,001,600, and the efficiency 58·9 per cent. In the case of the Ward Leonard winder the units consumed were 790,000 and the efficiency was 74·7 per cent. The relative costs of the Ward Leonard and Stubbs-Perry winders had also been questioned; the figures given in the Paper applied to actual quotations given for the plants. The low coal-consumption of the Stubbs-Perry system, referred to by Sir Arthur Duckham, resulted from the fact that this winder was operated by a condensing

The Author.

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The Author. steam-turbine taking only 10 lbs. of steam per horse-power-hour, as against four times that quantity required by the non-condensing steam winder. The effect of the fly-wheel balancer in the former case was, moreover, such as to ensure practically a constant load on the turbine. In reply to other criticisms by Major David, the Author would say that the item of £3,000 for a sub-station, charged against the electric winders in Table I, referred to the proper proportion of the actual cost of a new sub-station attributable to the winding-engine. Again, the winder at colliery "B," for which figures were given in Table II, must operate at a lower efficiency than did the winder at colliery "A," since in the former case a three-deck cage was used, which necessitated changing decks three times, involving extra controller losses and also compelling the use of a parallel drum with a tail rope. In the latter case simultaneous decking was adopted. In reply to Mr. Pochobradsky, at colliery "A" the existing winder had to be replaced by a new one, and therefore an opportunity had arisen to consider the use of the most efficient type of steam winder. As coal was drawn on one shift only, live steam would have to be taken by a mixed-pressure turbine run in conjunction with the winder for 16 hours a day, and the lower efficiency of the turbine on live steam wiped out the saving resulting from the utilization of exhaust steam during the coal-winding shift. In connection with the suggested use of gas-engines in a colliery power-station, the Author entirely disagreed with Mr. Pochobradsky that gas could be used more economically for steam-raising than in gas-engines. It was difficult to reach an overall thermal efficiency of 20 per cent. with a steam station, whereas the gas-engine test given in Appendix A showed that the gas plant could reach a thermal efficiency of nearly 30 per cent. In reply to Mr. Morgans, the Author must confess that he had overlooked the growing use of compressed-air hammer drills in shaft sinking. That was certainly a growing practice in colliery sinkings, but had been first developed in metalliferous mines, of which Mr. Morgans had special knowledge. Sir Richard Redmayne had drawn attention to the increasing use of compressed-air picks for coal-getting in Continental collieries, and the Author had observed the same tendency. As a result of visits to Continental collieries he had recently tried the same method in this country, but he did not find these picks suitable for English conditions, especially in longwall working. They had a limited use in headings, but tended to produce too much slack and thus spoil the coal for the English market. Finally, the Author would like to express his appreciation of Sir William Ellis's very helpful remarks. Such rapid strides had been made during the last 20 years in the mechanical equipment of collieries as well as on the

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mining engineering side that a supply of men thoroughly skilled in the various branches of colliery engineering was a necessity if progress was to continue. In addition to the provision of mechanical and electrical engineers with specialized knowledge of colliery requirements, the mining engineer (who must always be the captain of the ship) should receive sufficient technical training in mechanical and electrical engineering to appreciate what developments were required. At the moment many factors combined to prevent the encouragement of the best men, and any assistance The Institution could give in that direction would be of benefit to industry generally. The Author.

The PRESIDENT stated that at a luncheon at which he had been entertained at Ottawa on the 29th December by the Engineering Institute of Canada, those present had desired him to convey to the members of The Institution their cordial greetings and best wishes for 1927. The President.

Correspondence.

Mr. A. C. ANDERSON observed that he could not agree with the Author's sweeping statement that there was little to choose between the alternating-current and the Ward Leonard system. There was no doubt that the control, which was very important, with the Ward Leonard system was very much superior to that possible with the alternating-current system with regard to fineness, reliability, and safety. Further, the Ward Leonard fly-wheel arrangement was very much easier on the power-supply system. The Author mentioned a case where a three-phase winder had been put in simply on account of lack of a sufficient supply of good feed-water. That must be an isolated case, and it would be interesting to know whether evaporating-plant had been considered. Referring to the Author's remarks on p. 199, it would seem that the best power solution for a group of collieries at the present day consisted in their generating their own power, possibly at two interconnected stations one smaller than the other, so as to provide some stand-by for essential services in the event of breakdown. He did not consider that supply from a public supply company would provide the proper economic means of driving colliery-plant. A power-company made power for the sole purpose of selling it, whereas a colliery-company made power in order to make money out of winning coal—quite a different thing. He thought that the instances of gas- and oil-engines driving ventilation fans would remain very few. He was not Mr. Anderson.

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