In both cases the revenue from water power was $\frac{1}{7\frac{1}{2}}$ of the total revenue of the canal up to date.

When on the Upper Chenab Canal, in his early service, it had been his lot to have in his sub-division a ten-foot fall on the main line to pass over 9,000 cusecs. In his zeal and ignorance he proposed putting in turbine races to develop power, when desired. The suggestion did not, however, meet with approval, as it was contrary to custom and precedent. It would have made little or no difference in cost to have suitably arranged the fall when constructing it. The cost of the fall as it was had been about Rs. 85,000.

There was an interesting point in Mr. Purves' remark that the canal should supply manure and water together to grow the crops. Did he mean that the manure manufactured at the falls should be put into solution in the canal water so that at a future date a sub-divisional officer would indent for x cusecs of water with y per cent. strength manure ?

MR. LINDLEY thought that the problem of making use of the power now running to waste in canal falls was one that must have occurred to most canal men. The most obvious use was the generation of power for general municipal and industrial purposes, but as the supply of water had to be regulated by the irrigation demand, and as the canals were liable to closures of a month or more, for which sufficient storage could not be provided, such schemes required a full stand-by plant for steam or other power: the benefit was, therefore, restricted to the saving of fuel that would have been burnt in, say, ten months in the year, at the cost of providing a full hydro-electric plant. It would appear sounder, therefore, to reserve the water-power for schemes that were not so limited.

Such a use, and one that Captain Battye did not mention, was the pumping of water in water-logged tracts, for which the speaker believed one small concession had been granted to a private firm. Before hearing, however, of the possibility put forward in the paper, he had begun to formulate as an ideal a much larger scheme. This would eventually involve entirely stopping canal irrigation in certain areas, with proportionate extension into drier areas further away from the canal heads. It would also involve the generation of electric power at every fall of size sufficient for it to be worth while, such power being collected on a net-work, transmitted into the areas now being water-logged, and there used to pump the water required for local irrigation

Such pumping would be done best from lines of wells properly distribute, according to the contours of sub-surface water levels; and it would be a problem to develop these lines correctly against the levels that would be produced as irrigation was reduced and pumping introduced. In fact the problem would be so complicated that the scheme would have to be developed experimentally, piece by piece, but working towards a concrete whole, and this, quite apart from the great size of the scheme, would make it one for State rather than private enterprise.

It was true that water-logging would diminish if irrigation could be reduced to fair limits. It would also diminish gradually as progress was made on lining the channels, in which authorities estimate that twenty-five per cent. of the water entering the heads was at present lost by percolation: but there still remained the water lost by percolation in watercourses, and wasted by irrigators, each estimated as twenty-five per cent. of the water entering the canal heads, and these losses would be reduced only when greater prosperity made those measures possible which more extended demand for the limited supply of water would also gradually compel.

Again, when one saw the wonderful development of hydro-electric power from the Alps, one inferred infinitely larger possibilities in the Himalayas. Lombardy had a net-work of power lines, feeding the factories for which there was no coal nearer than northern Germany, and a considerable step had already been made toward electrifying all railways north of Milan. One company there had a station in the Bernina Pass, 120 miles away, sending down 30,000 H. P. to help its other station nearer Milan. Naples was getting its power from a station 120 miles away. One plant at Glarus in eastern Switzerland, was working in parallel with another near the junction of the Aar and Rhine, and supplying power as far as Mulhausen in Alsace. Accordingly it did not seem too much to expect a development, in time, of power sufficient to supply all industrial and municipal requirements to a distance of a hundred miles or so from the hills. Power might even be cheap and plentiful enough to irrigate by pumping beyond the range of flow of the bigger canals from the snow-fed rivers. The policy of development could hardly be too far-sighted, if the planning of earlier schemes on lines that would not fit in later was to be avoided.

The subject of manufacturing nitrates electrically, by various processes, had been exhaustively described in a paper read before

the Society of Arts, and published in their Journal: but being away from his notes and books the speaker could not quote a more exact reference.

Of the power plants near Milan, one disposed of its surplus at times of lesser demand, for nitrate manufacture; the charge at such times was equivalent to Rs. 7·6 per k. w. year, as compared with the ordinary rate of Rs. 115 to ordinary consumers: this rate was said to place the manufacturers on a level in local markets with the Norwegian manufacturers who could get power as low as Rs. 1·5 per k. w. year. From Captain Battye's figures it would be possible to supply power from ordinary canal falls of nine feet for an average price of Rs. 4 per k. w. year, which placed the industry in a most favourable position in eastern markets.

RAI BAHADUR GANGA RAM added that the attention of the Agricultural Department should be drawn to the great loss which India was suffering, due to the heavy export of bones from the country. Crushed bones, when treated with sulphuric acid, made a most valuable manure, called superphosphates, and there was no reason why this should not be prepared locally. The sulphuric acid was already being made in India for commercial purposes, and it was for the Agricultural Department to show how to produce phosphates in a crude form by treating crushed bones.

MR. WADLEY thought Captain Battye's subject was of vast economic importance. Any one who had noticed the great difference in substance between English and Indian cereals, vegetables, and fruits, would be struck with the possibilities which lay beneath the question of more scientific agriculture and horticulture in a country of such abundant sunshine as India.

It had long been known that compounds of nitrogen were good for plants. Rivers which contained sewage were especially good for irrigation, as also was the water from the chalk formations, because it contained sulphate and carbonate of lime and magnesia. Succulent plants, such as lucerne and vegetables, were much benefitted by sewage irrigation. Even sewage-fed grass produces fifty per cent. more cream in the milk than ordinary pastures.

Usually Town Corporations in England charged seven shillings per acre for each dressing with sewage, and certain lands

took five dressings per annum. But two dressings four inches deep were sufficient for most crops. The price of sewage should not exceed one half-penny per ton of fluid. The yield of forage and root crops was increased *five-fold* by sewage dressings, and the quality improved. Stable refuse, diluted with two-thirds its bulk of water, also made valuable manure.*

Taking Professor John Scott's figures, and the price of sewage as a half penny per ton of thirty-two cubic feet, the expense of giving a dressing four inches deep would be about nineteen shillings per acre. This is stated to be the maximum price of sewage which agriculture can bear. The cost of two dressings would be thirty-eight shillings or, say, Rs. 28-8-0 per acre. If the price of seven shillings per acre charged by Town Corporations be taken, the cost of two dressings worked out to Rs. 10-8-0 per acre per crop.

Valuable crops of tobacco are grown in certain tracts of the Peshawar Valley, especially near Swabi and Shewa. Goats' droppings were obtained from the hills in trans-frontier territory. The price usually paid was twelve annas to one rupee per bag, weighing one and-a-half maunds. The number of bags used per acre varied from forty to sixty, depending upon the class of soil. The average cost of manuring tobacco might be taken as Rs. 40 per acre. Sugarcane, orchards, vegetables and maize were manured at costs of Rs. 25, 5, 10, and 15 per acre, but no artificial manure of any kind was used. Wheat and barley were not often manured; neither were gram or pulses. The mounds which mark the sites of old villages were excavated and the material carted to the fields and used as manure. In the tract irrigated by the Lower Swat River Canal, this source of manure was *rapidly becoming exhausted*. On the tract to be irrigated by the Upper Swat River Canal, there was still a fair quantity available, but it would probably not last more than ten years, and it was by no means every village which possessed an old site to provide manure.

Having regard, therefore, to the fact that the benefits of manure were already fully recognised in the Peshawar Valley, the speaker thought there would be a permanent demand for artificial manure, if it could be supplied within the costs at present incurred by agriculturists, and if it suited every class of crop

* *Irrigation and Water Supply*, by Professor John Scott.

The scale of cost which agriculture could bear would be somewhat as follows :—

	Rs.	
Tobacco	40	per acre.
Sugarcane	25	,,
Gardens	15	,,
Maize	15	,,
Wheat and barley	10	,,
Grain and pulses	5	,,
Fodder crops	5	,,

The climatic conditions in the vicinity of the Malakand installation appeared to give it considerable superiority over the Rasul installation, and there would be less risk of an interruption of supply, because it would be much closer to the headworks, and the Dargai Nala would permit of a supply being run without interfering with repairs to canal works to any large extent. Any company, however, starting enterprises in tribal territory would, no doubt, have to do so with the consent of the tribesmen, and undertake to obtain produce from the tribesmen themselves

MR. MILNE felt that everyone should be greatly indebted to Captain Battye for the information he had given in his paper, some of which should prove invaluable for running out rough estimates for hydro-electric development schemes. Although the question of the development of canal falls must have already been looked into, had the subject ever been studied from the point of view explained by the author on page 30, where it is stated that " the usual practice of the development is entirely" reversed." Again, had the subject ever been thoroughly investigated by a hydro-electric expert in conjunction with other engineers ? Referring to curve I, the presumption was that the fall in price of oil-seed during the years 1901-1910 was owing to the supply exceeding the demand during times of famine ; this being the case, the author's assumption of the probable cost in the future seemed a very fair one.

On page 20, Captain Battye pointed out that it " would be possible to arrange for the whole management of the factory to be carried out by the same staff" and quoted a figure of ten per cent. for extra labour and standing charges on the factory equipment. The arrangement, of course, was ideal, but fifteen per cent. would be a safer figure to adopt. Again on page 30, the author proposed to supply the bi-products (*i.e.*, lighting of cantonments, etc.)

by taking advantage of the overload capacity of the generators; but this could hardly be adopted as standard practice. Makers undoubtedly built machines which would stand twenty-five per cent overload, and would run at the same efficiency at this overload as they did at normal full load. If, however, it was proposed to utilize this overload capacity daily, there was no doubt that particular attention would be drawn to the fact in the specification, and this would result in the manufacturers, in order to safeguard themselves, supplying a slightly larger machine in the first instance than they would otherwise have done, and the cost of the machine would naturally be proportionately increased. It would be better policy to increase (even to the extent of doubling) the size of the generating sets, and have each set coupled to two prime movers ; this latter would have to be resorted to, as the sizes of the turbines quoted in the paper were about the limit of size manufactured at present for the heads under reference. By increasing the size of the units, Captain Battye's figures for parts C-1 and C-3 in his estimates for the development of canal falls would be reduced, and a more liberally designed alternator could thus be obtained.

On page 32, Captain Battye referred to transmission on the Thury system, but it was not clear how this would reduce the cost, as the plant which was to be installed as an alternating current plant, *vide* page 19, where it was stated that the furnaces were operated at a pressure of about ten kilowatts, at a frequency of fifty cycles per second. Captain Battye's figure of Rs. 7·5 per kilowatt mile for transmission in the plains, was well on the safe side, and the actual cost would be considerably less than this It was interesting to note that Dr. Klingberg, in his address delivered before the Institution of Electrical Engineers on December 4th, 1913, quoted a figure of 2*s*-6*d* per kilowatt transmitted for outputs of more than 10,000 kilowatts through undeground cable (not overhead line) ; this equalled approximately Rs. 3 per mile per kilowatt transmitted. Of course, it was out of the question to expect to get anywhere near this figure in India at present.

MR. MORT noted that in England, oil-seed, meals and cakes were considered prohibitively dear as direct manures contributing nitrogen to fields. They contained about 5½ per cent. of nitrogen and cost £ 4-10-0 to £ 8-10-0 per ton in bulk. They were used for cattle food, and so only indirectly for manure in English agriculture. It was news to him that in India (where they formed a local product, and were cheaper) they were used

as a direct manure on a considerable scale. Anyhow it was not oil-cake so much as imported Chili-saltpetre and Bengal (potash) saltpetre, and ammonia salt, that would fix the outside price at which calcium nitrate could be made and delivered to compete successfully.

The paper obscurely expressed the English unit valuation system for nitrogeous manure, which was as follows :—

$$\text{Unit cost} = \frac{\text{price per ton}}{\text{percentage of nitrogen.}}$$

e.g., for Chili saltpetre, say $\frac{\text{£ 10-8-0 (Rs. 156)}}{\text{15·6 per cent}} = \text{Rs. 10 per ton}$ unit. Chili saltpetre would probably cost nearly £2 more per ton landed in the Punjab wheat fields and Oudh sugar fields, than the figure taken, so that Captain Battye had some margin. Calcium nitrate had, of course, a lower percentage of nitrogen than Chili saltpetre (sodium nitrate), while actually the sub-nitrate with a still lower nitrogen percentage was commercially made and marketted as being less deliquescent. These matters affected (*i.e.*, increased) the cost of freight per unit of nitrogen. It was hardly correct to say there were considerable quantities of nitrate of potash in the soils of Upper India, but nitrate of potash was made in Behar and elsewhere from the soil, and about 18,000 tons per year were exported. This was a very old trade, and was one of the main original businesses of the Hon'ble John Company. Thus Capt. Battye's argument in favour of calcium nitrate production in India, in order to provide nitrates for explosives, fell to the ground ; since India already produced and exported nitrates.

Wheat does not need any artificial supplies of potash, or of phosphates ; but what it did respond to were artificial suppiles of nitrate or ammonia, after a number of crops of wheat had been taken from the same ground.

He dissented from Capt. Battye's positive statement that no artificial fertilisers were of any use whatever for cereal crops in India ; he also pointed out that rice was certainly a cereal, and not a garden crop.

Note communicated by Dr. M. W. Travers, F. R. S., Director, Indian Institute of Science, Bangalore.

In his paper on the production of artificial fertilisers Capt. Battye raises two questions :—Is there a demand in India for

fertilisers which is likely to increase in the near future ?—, and —Is it possible for Government to manufacture calcium nitrate in India and to sell it to the cultivators at a profitable rate ? These two questions may be considered separately.

It may be assumed that Capt. Battye obtained the information which leads to measures, which is summarised in the first part of the paper from members of the Department of Agriculture and that he is not directly responsible for the facts and figures. However, before in considering a proposition of this kind, the question of demand is a matter of the very first importance. I cannot refrain from calling attention to certain misstatements and to erroneous deductions, the elimination of which is essential before we can obtain an accurate view of the situation.

It is stated on the authority of Dr. Leather that "the prices (of oil-cakes) have gone up in certain localities to a point at which they actually exceed the cost per unit of nitrogen of imported manures, such as Chili saltpetre," and from this it is argued that there is an increasing local demand for oil-cakes as fertilisers. Here there are two obvious fallacies. In the first place the nitrogen unit may be used in comparing the manurial qualities of different oil-cakes, but is little more than meaningless when used in relationship to oil-cakes and nitrates. Since, for many purposes, oil-cakes have a vastly greater manurial value, nitrogen unit for nitrogen unit, than nitrates, it is not surprising that the ryot is willing to give a higher price for the former than for the latter, apart from the fact that he naturally prefers the known to the unknown. In the second place the price of oil-cake is practically controlled by the European demand and is only influenced by such Indian conditions as shortage of rain. It is now interesting to note how, having accepted Dr. Leather's statement, we are led to an absolutely false conclusion as to the possible demand for oil-cake in India in the future. Assuming that the price of oil-cake is a simple function of the demand in India, Capt. Battye plots the prices of castor cake in Cawnpore (N-units) as ordinates against time, as abcissae, and finds maxima corresponding to the years 1907 and 1913. He ignores the fact that there was a steady decline in prices from 1907 to 1911, and extrapolating the portion of the curve representing the rise from 1911 to 1913, arrives at the conclusion that in 1920 the *possible value* of castor cake may be as high as Rs. 2/4 per nitrogen unit.

Now if Capt. Battye had extrapolated the portion of the curve representing the decline in prices from 1907 to 1911 he would have come to the conclusion, that, at a date not far distant, castor cake might *possibly* be obtained for the trouble of carting it away. However, the whole curve may properly be interpreted in an altogether different manner. The maxima represent, no doubt, years of shortage of rain, and hence of short supply. Eliminating such fluctuations, the general tendency of prices appears to be only slightly upwards ; indeed, considering the general increase in the price of all agricultural produce over the period under consideration, it is rather remarkable that the increase in price during the past ten years has not been very much greater than is indicated by the curve. It appears to me that it is not too much to say that, relatively to the price of agricultural produce generally, the price of oil-cakes has shown no tendency to increase, but rather to fall.

Capt. Battye's statement that there is no sulphuric acid industry in India is, of course, absolutely incorrect, and there is no foundation for the statement that superphosphates cannot be manufactured in India. Bones, like oil-cakes, are exported because there is a certain and steady market for them in Europe. However, there is no connection between phosphates, and nitrates and I merely mention the subject in order to call attention to this fact.

I can hardly doubt that such important questions as those raised by Capt. Battye in the first part of his paper have received careful attention from the members of the Agricultural Service, and that some expert will, in the course of the discussion which the paper opens up, deal with them in a thorough and scientific manner. Before the suggestion that artificial nitrates should be manufactured in India can be considered as a commercial proposition the fact that there will be certain demand for these products must be established, and, so far as the present paper is concerned, this certainly has not been done.

When one comes to deal with the technology of the manufacturing process which is dealt with in Capt. Battye's paper, one has to remember the fact that in chemical technology generally no fact is published so long as it is of commercial value. Among all the various branches of chemical technology there is none of which the scientific and technical public know less than that branch which is devoted to electro-chemistry ; indeed, the literature of the subject generally conveys the impression that the

more the writer of a paper knows of his subject the less inclined he is to commit himself to figures, and to the description of the details of processes. However, this fact is certain. In Norway where artificial nitrates are certainly manufactured at a profit, we have the cheapest power, transport, labour, and supervision in the world, and beyond all these there are powerful commercial organisations prepared to bear the cost of experiments on a large scale, and to handle the products of the factories. Now even if we assume that the cost of power at the Malakand tunnel is of the same order as the cost in many of the large Scandinavian works, that is to say, about Rs. 20 per kilowatt year, we have still to take into consideration the fact that the cost of labour and supervision will be very high, and if, as Capt. Battye holds, the control of the works remains in the hands of Government, a special commercial organisation will have to be created to deal with the distribution of the products. I do not think that it would be possible to sell calcium nitrate, like quinine, through the post offices.

It is of very little use to consider the second question in detail till the first has been answered, but so far as I can see, the proposal that Government should undertake the manufacture of calcium nitrate is not a workable one. However, there is plenty of money available for commercial enterprise at the moment; and were Government to fix the terms and conditions under which they are prepared to sell water power at the Malakand tunnel, and elsewhere, and to publish at the same time statements showing what transport facilities, &c., are available at the different centres, they might possibly induce capitalists to come forward and consider its development.

In conclusion, I have a remark to make with regard to the proposal to manufacture nitric acid for the Indian Ordnance Department. Again the argument which is put forward falls to the ground because the whole of the facts are not taken into consideration. The manufacture of cordite calls for the use of nitric and sulphuric acids and of acetone, all of which are imported or manufactured from imported materials. It is true that so far as nitric acid and acetone are concerned, India could be made independent of Europe; but as there is no Indian source of sulphur, the country must remain dependent on the sea for the supply of that commodity. The 'strategic' position will therefore be affected only to a comparatively slight extent by manufacturing nitric acid in India.

CAPTAIN BATTYE in reply stated that Mr. Barnes had drawn attention to the much larger proportion of nitrogen fixed by bacteria in Indian soils, and quoted crops of senji and gram at Lyallpore. Was it not possible that this might be largely compensated for by the extent to which double—and in some cases even treble—cropping was made use of ? Mr. Barnes had further pointed out that the need of modern methods in agriculture was much more acute than the need of manure. Was it not possible that the visible example of improved out-turn, due to up-to-date scientific manuring, might not open the eyes of the agriculturist to the advantages of up to date scientific methods in general. Surely, the introduction of iron implements and scientific manuring could well be taken hand in hand.

Haber was quoted as saying that the production of fixed nitrogen on the Birkeland Eyde process did not exceed sixteen grammes per kilowatt hour. This worked out to $\frac{16 \times 8,500}{1,000} =$ 136 kilogrammes per kilowatt year as against 650 kilogrammes per kilowatt year actually obtained in commercial practice on the authority of Professor Birkeland himself, to whom the author had referred in the matter. It was not clear from Mr. Barnes' remarks whether the out-put was sixteen grammes of nitric acid or of nitric oxide. The difference, however, would not be great.

The process referred to as that of Frank and Caro was the cyanamide process referred to by the author, which might on further investigation prove the cheaper for India. This, however, involved entirely separate reactions, and it was not clear whether Mr. Barnes was referring only to the second one, in which nitrogen combined with calcium carbide in the electric furnace, or to the combination of both, *i.e.*, this one and the first one, which involved the separation of nitrogen from the air by the liquifaction process. In a comparison of the two processes, the combined process must be considered, and the commercial efficiency of this entirely depended upon the existence of a local market for the bi-product oxygen. Until this could be shown to exist, it was doubtful whether the calcium nitrate process would not prove the cheaper. The new re-action referred to would require the expenditure of a considerable amount of power for the separation of the nitrogen from the oxygen of the air, as in the Frank and Caro process as well as the manufacture of hydrogen by electrolysis, so that even this would have to fall back upon water power eventually. Mr. Barnes' figure of £8 per ton coincided very well with R B Ganga

Ram's, while £7 per ton was almost the universal selling price in north Europe. This price worked out to Rs. 10 per ton unit, and therefore balanced the cost of nitrogen in castor cake at its present market value. The cost of nitrogen in calcium nitrate at Rs. 50 per ton, (the figure arrived at in Appendix L) worked out to less than Rs. 4 per ton unit, and it was unlikely that castor cake would drop below this in the event of a large demand arising. Finally, Mr. Barnes had pointed out that he did not consider the author's proposals feasible *at present*, but neither did anybody else, not even the author. His contention, however, was that the situation ten years hence might be very different from that now in existence, and this being the case, it behoved them to foresee and make arrangements now, to meet the conditions which might exist ten years hence.

Mr. Carne had raised the question of interference due to canal closures. The author understand that a large scale development at Rasul was not practicable as explained in the paper. The Malakand scheme, however, was extraordinarily favourably situated as regards canal closures, owing to the fortunate existence of a large escape, immediately below the side of the Power House This would result in the plant, in all probability, being able to run at full load for something like eleven months in the year. The shut down for one month in the year would only increase the cost of output by approxmately ten per cent. The statement to the effect that all natural water powers suffered in much the same way, owing to interference, was scarcely correct. No properly designed hydro-electric scheme should ever have to be completely shut down. Such schemes had certainly been put up, entirely on grounds of economy, not because it was unavoidable. The development of water power for electro-chemical purposes was not commercially feasible except on a large scale. For these reasons, it was unlikely that such schemes would ever be located on canal branches, and would invariably have to be situated on the highest falls, and as near to the headworks as possible, which two considerations usually coincided. It was of course obvious that the existing canal staff could not run such a plant satisfactorily. The Irrigation Department should have no difficulty however in engaging the staff required for the purpose, provided reasonable conditions of service were guaranteed. Engineers, as a whole, should always be ready to undertake any kind of work which came their way, and the Irrigation Department should in future look upon the manufacture and supply of manure as one of their most important, and by no means least interesting, services. As pointed out in the

paper, for many years to come there was little likelihood of any market for artificial fertilizers except for irrigated garden crops-where double-cropping, and, in consequence, manurings were already absolutely essential. There were, however, a large number of crops in this country which had to be manured in any case, and many other crops which could not even be grown at present for want of the manure, which is unobtainable at any price largely on account of the difficulty of transport.

R. B. Ganga Ram corroborated the statement to the effect that such shemes to be commercially successful must be carried out on a large scale. The normal canal fall had seldom an output exceeding 3,000 kilowatts, and, as far as the author was aware, the falls at the Malakand and Rasul were the only large ones at present in existence, and these had only just been constructed, and this was why the question was now assuming any importance. He would only advocate the development of a standard nine feet fall as an experimental preliminary scheme, the main purpose of eventually developing the larger falls being constantly kept in mind. This speaker had also pointed out that the price per ton unit of imported nitrate worked out to the same figure of Rs. 10 per ton as that now in vogue for castor cake. This fact corroborated, Mr. Barnes' statement that the present price of castor cake was entirely due to export, so that Rs. 10 per ton unit would appear to be the approximate standard market price of manure in Europe. It was probable that no large demand for manures would arise in India until this price could be reduced to Rs. 5 per ton unit or even less, and his contention was that this figure could only be attained by manufacturing locally, on irrigation canal falls, which alone in this country could be developed at any figure approaching that of power in Norway. Rai Bahadur Ganga Ram referred to the use of castor cake amounting to Rs. 40 per acre for growing potatoes in Furrakabad. This was just the sort of market he referred to in his paper, and he contended that, if these zamindars could be supplied with an artificial; which reduce the cost of manuring to Rs 20 per acre or less, they would absolutely drop castor cake, and use Government Department artificials. The existence of such a market would justify the establishment of a preliminary plant at a nine-foot canal fall as explained above.

Mr. Schönemann and Mr. Lindley both advocated the employment of the falls for industrial purposes. This was all very well, but quite apart from the fact that industries do not spring up like mushrooms, it was open to question whether it was

not a mistake to implant occidental industrialism upon the people of this country, instead of putting all their energies into the development of agriculture, to which occnpation the inhabitants were much better suited, and which was likely to yield far more satisfactory returns for effort expended.

Captain Anderson referred to the possibilities of importing sulphur. The author found his remarks on this point had been based on incorrect, or at any rate out of date data, and that several sulphuric manufactories were already in full operation, while a large concern for this purpose had recently been started in Bombay, so that there was every prospect of the export of bones being considerably reduced in the near future Capt. Anderson had also drawn attention to the inadvisability of trespassing on the margin of safety of running the generators habitually at a slight overload. It should, however, be borne in mind that the overload capacity of electric generators was not akin to the factor of safety in a structure, but was usually provided with the express intention of being available for use for short periods in an emergency. Its employment, therefore, for a short period daily might on this view be considered permissible. Mr. Purves' quotation from Sir W. Wilcocks' work on Egyptian irrigation might well be taken to heart by Punjab Engineers. The author only learnt that Egypt was considering the question after he had written his paper, and it would only be commensurate with the importance of the Punjab irrigation works, if this province were the first to introduce a manure rate as suggested. The fact to which he drew attention, that well manured fields only required half the water required by poorly manured fields, might eventually enable much larger areas to be supplied from existing canals, and possibly obviate or postpone the necessity of storage schemes and such like

Mr. Nicholson's reference to the fact that Irrigation Officers had been fully occupied in developing irrigation alone, suggested the advisability of the Public Works Department seriously considering the recruitment of a regular staff of electrical and mechanical engineers in addition to the existing staff of purely civil engineers, or perhaps, better still, of obtaining specially selected civil engineers of six or seven years experience to thoroughly specialize in such subjects. There was little doubt that the State had suffered very considerable loss, owing to the extent to which electrical and mechanical undertakings had had to be carried out in the past by engineers who were practically amateurs in the subject.

Mr. Nicholson's remarks fully justified his contention that insufficient attention had been paid in the past to the advisability of providing for electric power developments at a later date. Such provision was always kept carefully in view in all American irrigation projects, and it was the rule, rather than the exception, for irrigation in the Western States to be combined with hydro-electric schemes, which were often employed for pumping the irrigation water up to higher levels, so as to serve uncommanded areas. The time had arrived for Indian Irrigation Engineers to take up the question seriously.

There was little doubt that, owing to the pressure of work, and to divisions being chronically under-staffed, whenever a fall had had to be designed, a printed standard plan was taken out of a drawer and embodied into a project : it would have taken only a few days at most to design the fall in such a way as to permit of its economical development at a later date, and such a modification would probably have involved little or no extra expenditure in the first place. The working out of such designs would present no serious difficulties to a power engineer fully acquainted with the requirements, and it would probably be feasible to have all falls in future on new canals, especially those in the head reaches, concentrated as far as possible, so as to increase the head and the amount of power available per fall, and to have all such falls specially designed in consultation with an experienced power engineer so as to permit of a chemical development at a later date.

Mr. Lindley asked whether a hydro-electric plant would be justified in the saving of ten months' fuel. A "stand-by" steam plant could of course be erected at a very much cheaper rate per kilowatt than one required to maintain a continuous supply, while the cost of fuel at, say, one-third of an anna per unit for ten months at ninety per cent load factor, which was that usually met with in electro-chemical industries, worked out to Rs. 135 per kilowatt per annum which was obviously more than the capital charges on a hydro-electric plant. Electro-chemistry carried out by fuel power was out of the question. The stoppage of one month in twelve only increases the manufacturing cost of a material (including capital charges of course) by approximately ten per cent. Pumping from water-logged areas was akin to pumping up irrigation water for serving uncommanded areas, and Mr. Lindley's figures at the end of his notes appeared to be approximately one-tenth of what they should be. Surely, the decimal place had been shifted. The

scheme. Since writing his paper, he had visited the Malakand, and considered his original estimate unnecessarily liberal, especially for part A. This could easily be reduced to Rs. 50 per kilowatt, and allowing a reduction of Rs. 10 on part B, this reduced the over-all cost per kilowatt to Rs. 202 or practically the same figure as for Rasul. This worked out as shown in Appendix L. to Rs. 50 per ton or 3·65 per ton unit, and there was little doubt that the sale of manure at such a figure would rapidly result in a large demand.

Circumstances governing the Malakand development were certainly favourable, not the least of which was the fortunate existence of an escape immediately below the tailrace, which would enable the power station to be run at full load while the rest of the canal distributaries could be shut down for repairs. These were all features which had not been sufficiently appreciated heretofore, and there was little doubt but that the Malakand scheme, if carefully designed, would prove one of the cheapest hydro-electric developments in the world.

Since writing his paper, he had found that the power factor of the current employed in the Birkeland Eyde process was very low, and this would tend to increase the cost of the generators. Mr. Milne's proposal for increasing the size of the generators and driving each generator by two turbines was a good one, and would in all probability be adopted in actual practice. This would tend to reduce the cost of the generators, and probably compensate for the increased cost due to the low power factor in his estimate. He doubted whether he would actually adopt as a standard the practice of running machines daily at 25% overload for a couple of hours. He drew attention to the possibility of doing so with a view to emphasize the "bi-product" nature of the supply to cantonments and the consequently extremely low cost at which this could be done. Mr. Mil[illegible] had misunderstood his reference to the "Thury" system. [illegible] suggested this for distributing the small amount of [illegible] in cantonments and small towns within [illegible] station, and not for the transmission [illegible] chemical purposes.

It had been pointed out tha[illegible] for royalty. The margin of pr[illegible] ample to meet such charges—p[illegible] could be kept in the neighbourh[illegible] that a sufficient allowance had n[illegible] operate the factory. On a [illegible]

[illegible] spent a few minute[illegible] ive after shillings thrown [illegible] he reason, have wondered [illegible] ired before it reaches the bot[illegible]

development of a nine-foot canal fall, this would result in a very appreciable increase in the cost. On a large scale scheme however this would not be of much importance when compared to the capital charges, while the fact was not sufficiently known to what a large extent Indian labour could be employed to take charge of running machinery, provided that machinery was kept in first class condition, which could always be ensured by the good European supervision of one, or at most two men.

As there was not likely to be a market during the early stages sufficient to justify anything like such a large out-turn, as the Malakand scheme would produce, it was interesting to consider what results could be obtained with a small preliminary development on a standard nine-foot canal fall. He had worked out rough figures for such a scheme in Appendix M. which might be of assistance to any one requiring to consider the possibilities of such a small development.

Such a scheme might well be taken up by government at once, and the introduction of an artificial manure at a price not exceeding Rs. 5 per ton unit stimulated by a government grant. The results might be stupendous, while, if the scheme did not prove a success, the loss to government would be insignificant.

The criticisms received from Mr. Mort of the North-Western Railway, and Dr. Travers of the Bangalore Research Institute would be of interest for inclusion in the Proceedings.

Mr. Mort's figures for the cost of oil-seed cakes in England confirmed his contention that the market price of manures at home were in the neighbourhood of Rs. 10 per ton unit. It would be interesting to know what the Agricultural Department would have to say to his contention that wheat did not require any artificial supply of phosphate. His remarks confirmed the author's contention that double-cropping tended to make up for the abnormal nitrification of soil in India. Mr. Mort misunderstood his remarks regarding the use of artificial fertilizers for cereal crops in India. He meant that they were of no use in practice, on account of their high cost compared with the low value of cereal crops in this country, not because they would not stimulate the growth, but because the agriculturist who grew wheat could not afford to manure.

Dr. Travers had misunderstood the value to be attached to the cost per kilowatt of the development at Tya in Norway that

is Rs. 150/ per kilowatt. This was quoted because of its extraordinary low price, which he believed to be the world's record. He did not even know whether this plant was employed for the manufacture of nitrates or not, but there was little doubt that most of the other plants in Norway employed for this purpose cost considerably more than this figure, and were on the average very much nearer the figures quoted for India. This of course vitiated all Dr. Traverse's arguments about the cost of power. His conclusions also seemed to be based on a confusion of thought as already explained, namely that £ 7 per ton was not the manufacturing cost, but the market price in North Europe, and there was every reason to suppose that the actual manufacturing costs were very much lower and more nearly approaching those quoted for India in his paper.

A combination of very cheap developments in connection with irrigation projects, and large reductions in railway freights, would undoubtedly permit of manure being sold in the neighbourhood at Rs. 5 per unit.

APPENDIX M.

Ordinary 9 feet Canal Fall.
3,000 k. w.

	Rs.
Generating plant at Rs. 360 per k. w. Capital cost	10,80,000
Factory plant at, say, Rs. 100 per k. w. Capital cost	3,00,000
Total capital cost	13,80,000
Say	14 lacs
Annual (ten months out-put) at 1·45 k. w. years per ton) = 1,775 tons $Ca(NO_3)$	
Cost of maintaining and operating Power House per annum, say, 2½ per cent. ...	27,000
Cost of maintaining and operating Factory per annum at, say, 7 2/3 per cent.	23,000
Cost of lime 1,775 × 4·6 or, say, 2,000 × 4·6 (Appendix K)	9,200
Total costs	59,200

Therefore cost per ton $= \frac{59,200}{1,775} = 33{\cdot}4$ or, say, 35.

Taking the selling price at Mr. Hamilton's figure of Rs. 5 a maund or Rs. 10 per ton unit, *i.e.*, the field price now actually paid in the district Rs. 140 per ton, and allowing Rs. 12 per ton for carriage (see Appendix L) left Rs. 128 per ton, or a difference of Rs. 128 – Rs. 35 = Rs. 93 per ton for profit, *i. e.*, Rs. 16,500 per annum profit, which was equivalent to 11·8 per cent. interest on the capital. Allowing depreciation at 4 per cent. there remained a balance nett profit of 7·8 per cent. which was sufficient to cover royalties.

To increase the demand and enlarge the market it might be necessary to sell at Rs. 5 per ton unit. This would still leave 3·43 per cent. interest on capital which would be sufficient to meet royalties and justify Government sanctioning such a project as a preliminary experimental installation.