12	Gullspang, Sweden ...	18,000	3,000	...	...	...	...	...	...	...	...	170	Detail description in I.E E. Proceedings, Volume 45, p. 442, Head 65 feet.
13	Tya, Norway ...	48,000	...	...	...	...	...	...	...	...	...	150	3,300 foot Head, Pelton wheels.
				Part A	Part B								
14	Malakand ...	40,000	8,000	100	86	26·35	25	20	5	76·35	162·35	262·35	Estimates only, *vide* Appendices F. and G.
15	Lower Jhelum Canal.	20,000	5,000	25	75	38·5	27	25	7	97·5	172·5	197·5	
16	Any 9' Canal fall ...	3,000	750	125	See Part A	140	25	50	20	235	...	360	10 per cent. per annum charges should be taken on this scheme. The cost of Part C.-1 is based on quadruple horizontal sets at 70 r. p. m.

APPENDIX F.

Estimate for a development of H. P. Scheme on the Malakand.

PART A.—This would consist of a regulator some three to four miles of flume and forebay and would cost about Rs. 100 per k. w.

PART B.—This probably would consist of 10 steel tubes of a total capacity of 210 cusecs each and of about 6¼" diameter each. The nature of ground is not known nor the probable slope but assuming a standard slope of, say, ⅓. The cost would probably not exceed Rs. 86 per k. w.

PART C-1.—The machines would be spiral Francis turbines running at a speed of approximately 325 r. p. m. and would therefore be of a size equal to approximately 24,800 k. w. per 1,000 r. p. m. and would therefore cost about Rs. 8½ per k. w. per 1,000 r. p. m., *i. e.*, Rs. 26·35 per k. w. at 325 r. p. m.

PART C-2.—Would be covered by Rs. 25 per k. w. safely.

PART C-3—Would be covered by Rs. 20 per k. w. safely.

PART C-4.—Would be covered by Rs. 5 per k. w. safely.

These are included in appendices B C and E and total Rs. 263·5 per k. w

Adding 10 per cent. for contingent items, we get a total of Rs. 288·6 as follows:—

Part A	100
Part B	86
Part C	76·35
Total ...	262·35
10 per cent. Contingent Items ...	26·25
Grand total per k. w. ...	288·6

or a total for the whole Power Plant of 114½ lacs.

The total annual charges per k.w. year at 8½ per cent. would therefore equal Rs. 24½ per annum, say, Rs. 25 per k. w. year.

APPENDIX G.

Estimate for the development of a L. P. Scheme on Jhelum Canal.

PART A.—This would consist merely of screening and regulating arrangements and would be fully covered by Rs. 25 per k. w.

PART B.—This would consist of 4 re-inforced concrete ducts of 13' diameter each, connecting with Low Speed Francis Turbines fitted with draft tubes of 15' to 20' length and would be fully covered and an open tailrace (not charged to the Power Scheme) by Rs. 75 per k. w.

PART C-1—The machines would be Double Horizontal enclosed type Francis Turbines running at a speed of approximately 225 r. p. m. and would therefore be of a size equivalent to 22,200 k. w. at 1,000 r. p. m. and would therefore cost about Rs. 8⅔ per k. w. per 1,000 r. p. m. *i. e.*, Rs. 38·5 per k. w. at 225 r. p. m.

PART C-2—Would be covered by Rs. 25 per k. w. safely.

PART C-3—Would be covered by Rs. 25 per k. w. safely.

PART C-4.—Would be covered by Rs. 7 per k. w. safely.

These are included in appendices B, C and E and total Rs. 197·5 per k. w.

Adding 10 per cent. for Contingent items, we get a total of Rs. 215 as follows:—

Part A		25
Part B		75
Part C		97·5
Total ...		197·5
10 per cent Contingent Items ...		19·7
Grand total per k. w. ..		217·2

or a total for the whole Power Plant of 86 lacs.

The total annual charges per k. w. year at 8½ per cent. would therefore equal Rs. 18·27 per annum, say Rs. 18½ per k. w. year.

APPENDIX H.

Appendix D shows that the cost of transmission on the Simla Scheme, using wooden H poles and for a line capable of transmitting 1500 k. w. amounted to approximately Rs. 3· per kilowatt mile for a single line and with copper at £75 per ton in Simla.

Although the wooden poles were obtained locally, they had to be carried long distances over extremely rough country to the actual site where used and it may be safely assumed that a single line of standard lattice steel tower construction for the same voltage and carrying capacity would not cost more than Rs. 4·5 per kilowatt mile in the plains. Another 12 mile transmission line, in connection with the Simla Hydro-Electric Scheme but forming part of the Water Works extension, consisting of steel lattice towers with galvanised feet, manufactured in Calcutta and carried to site in sections, bolted and erected at site, and with 75 per cent. of the line consisting of spans varying from a $\frac{1}{4}$ to $\frac{3}{4}$ of mile in length, has cost about Rs. 4 per kilowatt per mile with copper at £83 per ton in Simla. A double transmission line of similar capacity on one set of towers using aluminium cables would probably cost not more than about Rs. 7·5 per kilowatt mile in the plains owing to the extra height of the towers. Taking this as a basis, we can now form an idea of the cost of transmission per kilowatt mile for much larger capacities.

Assuming a constant line current, the sizes of the towers and cables would not vary very largely, the only variable factor being the expenditure on insulators. As these have cost about 10 per cent. of the whole of the steel tower line and as the cost of suspension type insulators varies almost directly with the voltage, *i.e.*, with the kilowatts, assuming a constant transmission line current ; the cost per kilowatt mile for schemes of varying capacity would vary inversely with the size of the scheme generally in accordance with the shape of curve II.

To the actual cost of transmission lines, must be added the cost of step-up and step-down transformers which have cost about Rs. 62 per kilowatt on the Simla scheme. Allowing Rs. 60 per k. w. for schemes of about 30,000 kilowatt capacity, which is well on the safe side, the total cost of a 25 mile transmission per k. w. including both transformers and transmission lines would equal $60+(25 \times 1{\cdot}17)$ rupees, *i.e.* Rs. 88·2 per k. w

Assuming total annual charges amounting to 10 per cent., the additional cost per kilowatt year on account of having to transmit the whole quantity of power *i.e.*, say 30,000 kilowatts to a distance of say 25 miles would therefore amount to Rs. 8·82 per kilowatt year. As ·93 kilowatt years are required to manufacture each ton of calcium, nitrate, manure, the increased cost per ton of manure for having to transmit, would therefore amount to Rs. 8·2 per ton only, *i.e.*, an increase of 16½ per cent.

From this could be deducted in most cases, the cost of an equivalent amount of Railway carriage on the manufactured manure ; unless the factory had to be located on the far side of the falls away from the sale area, which is unlikely. This saving however would in all probability be balanced by the additional expenditure necessary on account of management and labour charges in the factory, owing to the necessity of having two separate operating staffs instead of the whole being under one roof and one management as already proposed, and may therefore be omitted.

While on the question of transmission charges, it is interesting to note in connection with the suggestion to supply towns and cantonments as a bi-product, that for small quantities in the neighbourhood of 2000 k. w. transmitted to a distance of say 50 miles, the total charge for double transmission including transformers, amounts to only Rs. 35·2 per kilowatt year ; which on a 25 per cent. load factor basis amounts to ·2575 of an anna per unit for transmission line charges only.

APPENDIX K.

The chemical formulæ representing the combination of quicklime and nitric acid is as follows :—

$$CaO + H_2NO_3 = CaNO_3 + H_2O.$$

and the atomic weights :—

$$(40{\cdot}1+16) + (2+14+48) = (40{\cdot}1+14+48) + (2+16)$$

i. e., $56{\cdot}1+64 = 102{\cdot}1+18$

i.e. 56·1 parts by weight of burnt lime plus 64 parts by weight of nitric acid are required to make 102·1 parts by weight of Calcium Nitrate Manure. Allowing for, say, 2 per cent. wastage, we therefore require ·56 of a ton quicklime and ·64 of ton of nitric acid per every ton of manure.

1. Power.--The total amount of power therefore required for each ton of Nitric Acid at 700 kilogrammes per kilowatt year is equal to 1016/700 *i. e.* 1·45 kilowatt years per ton of acid.

The cost for power therefore per ton of $CaNO_3$ at Rs. 18½ per kilowatt year equals 1·45 × ·64 × Rs. 18½ per ton = Rs. 17·2 per ton.*

2. Lime.—The amount of burnt-lime required per ton of manure being ·56 of a ton, the cost of burnt-lime per ton of manure, at Rs. 15 per ton of burnt-lime, is therefore equal to ·56×15 rupees, *i.e.*, Rs. 8·4 per ton.

3. Factory.—The annual charges on the factory buildings and equipment may be based on 10 per cent. p. a. of their total capital cost. This would consist of a couple of motor-driven blowers some 10 furnaces for the conversion of atmospheric nitrogen, the necessary cooling chambers and apparatus for mixing and combining burnt-lime with the nitric acid, together with the necessary building, railway tracks, conveying and storing appliances. This may be taken as about equal to the cost of part C of the Power Scheme, *i. e.*, Rs. 95½ per k. w. installed which, at 10 per cent., equals Rs. 9½, say, Rs. 10 per kilowatt year. As 1·45× ·64, *i. e.*, ·93 kilowatt years per ton of manufactured manure are required, the total cost of this item per ton may be safely taken as equivalent to Rs. ·93×10, *i.e.*, Rs. 9·3 per ton.

The total cost of production at the factory therefore amounts to Rs. 42 as follows :—

		Rs.		
(1)	Cost of power for Nitrogen Fixation	17·2	per	ton
(2)	Cost of lime	8·4	,,	,,
(3)	Standing charges on factory equipment...	9·3	,,	,,
	Total ...	34·9	,,	,,
	Add 10 per cent. for labor in factory ...	3·5	,,	,,
	Add 10 per cent. Contingencies	3·5	,,	,,
	Total ...	41·9	,,	,,
	Say ...	42·0	,,	,,

To this must be added, the cost of carriage from site to centre of sale area, which, at 6 pies per ton mile, amounts to Rs. 6¼ per ton for a distance of 200 miles which may be taken as a fair average in some cases. This makes a total of Rs. 48¼, say, Rs. 50 per ton delivered to the sale area, which amounts to Rs. 3·65 per unit of nitrogen.

To this must be added Rs. ·31 per ton or Rs. ·0226 per unit of nitrogen for every additional 10 miles of carriage over and above the 200 already allowed for.

* Note.—"Dr. Drysdale gives an output of 938 kilograms of $CaNO_3$ per k. w. year which is equivalent to 1 08 k. w. years per ton of $CaNO_3$ and a cost for power of Rs. 20 per ton instead of Rs. 17·2."

DISCUSSION.

COLONEL MACLAGAN, Vice-President, in opening the Congress said that he had received a letter from the President, Sir Henry Burt, expressing his regret at not being able to be present, and had also received a similar letter from Mr. Gwyther, Vice-President, to the same effect.

Speaking of the visit arranged for the following day to the new bridge over the Ravi, the Chairman said he was afraid that the only thing of special interest to be seen would be the salvage of the wreckage caused by the high flood of the previous night, which had done a good deal of damage.

Colonel Maclagan then called upon Captain Battye to introduce his paper, and in doing so said that, while there was no time limit, he would ask each speaker to be as concise as possible, and to confine his remarks to matter arising out of the paper under discussion.

CAPTAIN BATTYE, after drawing attention to one or two mistakes in the paper, said that as an introduction of the subject it might be of interest, to quote some of the facts brought out by Dr. Drysdale in his address to the Students Section of the Institute of Electrical Engineers, referred to in the paper.

One hundred and fifty years ago M. Dufermay had announced in the Academy of Rouen that the whole happiness of the Human Race depended upon the supply of saltpetre, and the Committee of Public Safety, during the French Revolution, endorsed the statement, and passed a resolution to conserve and develop the available supplies of nitre. Five years later M Chaptel stated that the best means of obtaining nitrate was by the combination of nitrogen and oxygen in the electric spark.

All such speculatings in the world's food supply were however pushed on one side by the Napoleonic wars, and the influx of food from the North American Continent. Nothing more was done in the subject till recent years. In 1900 however Sir William Crooks, President of the Royal Society, in his presidential address before the British Association, stated that the available supply of natural nitrates would be exhausted by 1931, resulting in an immense reduction in the world's output of food, and predicted the rise of prices which has been so marked of late, and which has been reflected in the various commissions appointed in different countries to enquire into the increased cost of living, and which has undoubtedly contributed

in large measure to the social and economic distress amongst the very poor, which has been such a marked feature of recent years among all industrial communities. He also prophesied that the United States of America would soon cease to be a large exporter of wheat. The Americans pooh-poohed these prognostications, characterising them as being far too pessimistic, and said that the margin of cultivation had not yet been reached, and was not likely to be reached for many years. That was fourteen years ago, and the Norwegian nitrate industry had scarcely come into existence at the time.

Sir W. Crooks' prophecies regarding the reduced output of wheat from the United States of America have been entirely fulfilled, as evidenced by the latest returns of the Board of Agriculture, and the resulting scarcity has been reflected in all the great wheat growing countries of the world. The phenomenal growth of the nitrate industry could be directly attributed to this cause, while there was little doubt that the reduced output of food from the New World had very largely contributed to the success and growth of the Punjab Irrigation Colonies, and in fact to the successful conclusion of all the Irrigation Commission's programme.

It was interesting to consider what the state of the world's food supply would have been at the present time if the Irrigation Commission had not exhibited such commendable foresight. Owing to the success of her irrigation projects, India had been able, to an appreciable extent, to make up for the shortage in food output from other countries, but could only continue to do so till such time as the margin of cultivation had not been reached. There was little doubt that apart from the new areas opened up by irrigation, the margin of cultivation in this couutry had been reached long ago, and that therefore the maintenance of its role as a World's Food Supplier entirely depended upon the carrying out of further irrigation projects, and for this reason alone, all irrigation projects now under consideration should be sanctioned and pushed through with the least possible delay, and on no account shelved.

Until the margin of cultivation was reached there was little or no need for intensive cultivation, so that for the present at any rate the demand for artificial fertilizers was limited to expensive garden crops such as sugar, rice, tea, etc. What however was to happen when all the existing irrigation projects had been completed, and all proposed ones carried out, and the margin of even irrigated cultivation reached say ten years hence ?

We should then be approaching the complete exhaustion of the natural supplies of nitrates, and should be dependent upon the Norwegian nitrate industry for our supplies. For a single group of companies in one or two countries to *control* the whole supply of artificials on which the food supply of the whole civilized world depended, was to be faced with a situation of extreme danger, which could only be prevented by the Governments of all countries, which possessed large water powers, conserving their water rights, (as has been done in nearly every country possessing such resources with the one exception of India) and developing the falls as necessity arose.

India was one of the most favoured countries, and by taking up the development of a few of its water powers *now*, and using them for meeting the demand for artificials at present existing, we should ten years hence, when the demand for large schemes arose, not only be ready and capable of carrying them out, but be ready equipped with the necessary knowledge and experience. It was necessary to exercise some of the commendable foresight shown by the Irrigation Commission.

The paper was intended as an attempt to show how such preliminary schemes could be started to meet the comparatively small demands now in existence and extending as time went on to the larger and more ambitious ones which must, of certainty, follow.

MR. BARNES, Principal of the Lyallpur Agricultural College, in opening the discussion on Captain Battye's paper, pointed out that the nitrogen problem was a world-wide one, and was not confined to India alone. Though we were only in the early stages of our investigations in this country, and as yet knew very little about the losses and gains of nitrogen in the soil, we still knew enough to see that the problem was not so acute in the tropics as in the temperate zones. He considered that the paper presented two main points of view from which it might be discussed. *Firstly* the utilisation of energy now running to waste in the canal falls, and *secondly* the utilisation of this energy for the particular purpose of manufacturing calcium nitrate for agricultural purposes. He did not propose to deal with the first, as that was at present a purely engineering problem, and confined his remarks to the second, summarising them under the following three main heads :—

(1). The agricultural aspect as summarised under the author's statement that the prime need in Indian agriculture was manure, and principally nitrogenous manure.

(2). The efficiency of the electric arc for the oxidation of atmospheric nitrogen as compared with other methods of fixing nitrogen.

(3). What might be termed the ɔmmerical aspect.

Mr. Barnes prefaced his remarks by pointing out that the manurial value of fixed nitrogen depends on the fact that it promotes vegetative activity, as distinct from phosphates which stimulate ripening and root production, and potash salts which promote carbohydrate formation.

Normally nitrates were supplied from two sources (1) as the result of the decay of animal and vegetable tissue and refuse and (2) by the bacterial fixation of atmospheric nitrogen. He said it might be taken for granted that North India was deficient in the former class of manures, but with reference to the latter there was a considerable amount of evidence now forthcoming to show that Indian conditions were such as to give good promise of much higher results in the amount of nitrogen fixed by the bacteria present in Indian soils, than was the case in the more temperate climates of England and the continent of Europe. He mentioned that such crops as "senji" and "gram" at Lyallpur show a fixation of nitrogen amounting to 150—200 lbs. per acre per annum, or from three to four times as much as that found in old pasture land at Rothamsted in England. Experiments with drain gauges at Pusa and Cawnpore also showed from two to three times as much combined nitrogen in the drainage waters as in the Rothamsted drain gauges.

Recent scientific investigations lead us to believe that practically the entire stock of combined nitrogen in circulation in animal and vegetable life was originally fixed in this way by the agency of bacteria. The conditions of Europe were such that the limits of improvement had been reached in methods of cultivation far in advance of anything yet attempted in India, which was to-day practically where England was 150 or 200 years ago. European countries had been forced by competition, and population density, to maintain their position by improved varieties of plants, and by the stimulation of partially exhausted soils with artificial manures.

The results obtained at the Lyallpur Agricultural Station showed that the staple crops of the country respond in a marked manner to better methods of soil cultivation, and to the ploughing in of green crops like "sann hemp." This all meant the enrichment of the soil with fixed nitrogen derived from the

atmosphere, better aeration, and the conservation of soil moisture ; and it was the speaker's opinion that the first and greatest need for the improvement of Indian Agriculture lay in the direction of improved methods of cultivation, Both pure science and practical farming pointed this way. The speaker moreover thought that of the main staple artificial manures, phosphates and lime were probably the most needed in the Punjab. He did not agree with the author that the prime need in Indian agriculture was a cheap supply of nitrogenous manure, but felt rather that good cultivation would supply the necessary amount of this and other things in addition necessary for the successful growth of crops, and that no amount of manures could correct the evils attendant on bad cultivation and neglect of the land.

Mr. Barnes then went on to say that it would probably be of interest to the meeting to know that the electric arc was not the most economical method of bringing about the fixation of nitrogen. By this method the production of fixed nitrogen, according to Haber, did not exceed 16 grams per kilowatt hour, and this only when the gases did not contain more than $2\frac{1}{2}$ per cent. of nitric oxide. These unfavourable results were due to the fact that the thermo-dynamic equilibrium between nitrogen, oxygen and nitric oxide had a low value at the temperature available.

TABLE I.

(Showing percentage of nitric oxide in equilibrium with air at various temperatures) :—

Percentage	Degrees, Centigrade.
0·1	1,230
0·5	1,660
1·0	1,930
1·5	2,140
2·0	2,300
3·0	2,590
4·0	2,840
5·0	3,060

At the temperature of the arc therefore only a small fraction of the nitrogen could enter into combination, and Haber had shewn that, though this might be increased by using small arcs, there was little hope of improvement on a manufacturing scale.

Conditions were more favourable in the process of Frank and Caro who obtained as much as fifty grams of nitrogen per

kilowatt hour by the intermediary use of calcium carbide forming calcium cynamide. This was why nitrate was manufactured only where cheap power was available, and the cynamide in the more advanced industrial countries. It should not be forgotten that both were made for export and were not used at the seat of production.

A new reaction had come to the fore more recently in the combustion of hydrogen in an atmosphere of nitrogen, forming ammonia. The heat of combination here was according to thermo chemistry a positve value, and it was only due to lack of reaction velocity that these two gasses did not unite at ordinary temperatures. Unfortunately the value of the reaction fell as the temperature increased, and it did not need a very high temperature to make the thermo dynamic value of the equilibrium so low as to appreciably hinder the production of ammonia on an industrial scale. At a temperature of 1,000° C for which many catalysts were available the yield is minute.

TABLE II.

(Showing the percentage amount of ammonia in the equilibrium of the reaction, nitrogen + hydrogen = ammonia ($N + H_3 = N H_3$)).

Pressure in atmospheres.	Temperature Centigrade.				
	550°	650°	750°	850°	950°
1	0·077	0·032	0·015	0·009	0·005
100	6·7	3·02	1·54	0·87	0·54
200	11·9	5·71	2·99	1·68	1·07

At 500° C very few catalysts existed.

A catalyst had been found in Osmium or Uranium in a fine state of division, and with these it was found possible to work at between 500° and 600° C, and more than one kilogram of ammonia was produced per hour per litre of catalyst space. The reaction itself produced the necessary heat. Much trouble had been experienced in the construction of furnaces to work at high pressures, and in the limits placed on the catalysis space

by the high pressure used. However the Badische Amilin Co. had taken this up, and were developing it, and the process promised to offer severe competition to nitrate of lime or cynamide (Haber & Le Rossignol, Zeitscrift für Electrochemie, 14-19-14).

The inference to be drawn therefore was that the investment of capital in the manufacture of this manure in India appeared a doubtful speculation on the grounds mentioned before. It was true that nitrate of lime had been tried at Lyallpur, and results there appeared to indicate that it was commercially feasible, should its farm price be between four and five rupees per maund (about £ 8 a ton); but against this it must be remembered that the farm on which it had been tried was an up to date one, and under scientific management, and though they could scarcely claim to have reached the limits of good cultivation still they were a long way ahead of the zemindar.

The speaker dwelt lastly with the cost figures in Appendix K and with the author's curves for the price of castor cake. He pointed out that nitrate of lime was never pure in the commerical state, and never contained more than 70-74 per cent. of nitrate of lime. He considered the curves for the rising price of castor cake and the author's deduction, misleading, without a full knowledge of the causes which have led up to this steady rise. It was unlikely the rise would continue as forecast by the author, should the use of castor cake as a manure and as a cattle food be taken up on a large scale in the country. At present the bulk of the seed was exported as such, and the oil crushing industry was in its infancy in India. An artificial value had been placed on oil cake for manuring hop fields, thus stimulating the crushing of oil seeds in England, and retarding the importation of oil without the seed residue. In the speaker's opinion a demand for oil cake for agricultural purposes in India would lead to the development of the oil crushing industry in this country, and after this had got a fair start the price would certainly fall far below the European figures.

At a later stage in the discussion in reply to some minor questions raised by members of the Congress Mr. Barnes said that, as a chemist, he thought there was an opening for an electrolytic soda plant in the Punjab, and suggested this as an outlet for the power available at the canal works at Rasul. Caustic soda was imported into India for soap making, and there was an internal market for chlorine and bleaching powder in the cotton and woollen mills of the country. He thought this worthy of consideration,

and if such a factory were established a small experimental plant for the arc flame fixation of nitrogen and the manufacture of calcium nitrate might be tried. Beyond this he did not think Captain Batty's proposals at present feasible.

MR. CARNE noted that the author had, in particular, put forward the case of the available falls on the Upper Swat Canal at Malakand, and the Lower Jhelum Canal at Rasul, the latter scheme being one for utilizing the available head between the upper and lower canals. He was led to assume from the paper that, at the Rasul site, as also at the Malakand site, interference would not be caused by canal closures, or that the interference would be slight. Was this not a fallacy, at any rate for the Rasul site? He would like some member of the Congress, who was acquainted with the facts, to say what such interference was likely to be at the sites selected.

Among hydroelectric projects for utilizing the power of canal falls, there were likely to be two wood pulp making concerns, one on the Upper Bari Doab Canal, and one on the Sirhind Canal. In this industry he had been informed by Mr. Raitt, who was the adviser to the syndicate, that, as the wood pulp business had been brought up on, and developed to pay on available water power in Scandinavia, and other parts of the world and that as all natural water power schemes suffer in much the same way as the proposed canal schemes would suffer, owing to canal closures, the business could, if water power and floating of timber rates were fixed low enough, be made to pay all right under the unfavourable conditions of canal rotational closure systems. Such conditions seem to be nearly always inevitable in the case of canal water power, because on the main lines of canals there were usually no falls.

The question of the rate at which calcium nitrate could be out-turned seemed to depend as much on the continuity of the water supply as on any thing else, and if canal falls were to be brought into use, except in a few exceptional cases, the factories would have to be located on canal branches, which would be favourably situated for the disposal of the finished product, but unfavourably situated with respect to the raw material, *viz.*, the lime.

One unfavourable condition about canal power was the small number of falls of any height, there were very few of even ten feet descent, a few of eight feet, but mostly about five feet. The turbines used had therefore to be large and expensive;

and due to running at low speeds gearing up to a considerable extent would be required, or the electric generators would also have to be large and costly.

As to Government running such a factory this was of course not a bad idea from the author's point of view, but the existing canal staff could not manage such a job. It would no doubt be possible to erect such a factory, and rent it out, but business on these lines was unsatisfactory and the Canal Department was not, in the speaker's opinion, keen on taking up such jobs. Something might however be done if the Agricultural Department came forward to run the show.

As to the question of the cultivator taking to the use of fertilizers, some progress might be made, and the cultivator induced to buy and use a fertilizer through the influence of the Agricultural Department, but on canals and in districts where the influence of that Department had not made itself felt, it seemed unlikely that at present, at any rate, the cultivator could be induced to buy and use a fertilizer.

On canals, such as the Sirhind, rainfall had a remarkable influence, and cultivators would scarcely be likely to run the risk of losing not only the crop, but also the cost of the fertilizer owing to a failure of the rainfall. The well area was comparatively small, and there was always an uncertainty in the canal irrigated area as to whether particular fields would get sufficient water for maturity. Much larger areas were sown in the Rabi than could be fully watered with the restricted supply available during the spring ; rain was always hoped for in order to help things out. The Kharif crop was as yet quite undeveloped.

On the Sirhind Canal there seemed to be but little prospect of the cultivators taking to fertilizers. At the outside water was only available for 40 per cent. of the commanded area as against 50 to 75 per cent. on some other canals, and the speaker thought there would be an infinitely greater prospect of cultivators on the Lower Chenab Canal taking to fertilizers, where, in order to keep his grown family, the cultivator, owning only one square, had to sow, and mature all he could. Double cropping being the natural result, the soil would in time, require fertilizers.

RAI BAHADUR GANGA RAM said, he proposed making a few observations as a zemindar and not as an engineer. In 1910, on his visit to England, he interviewed the agents of the company with the view of ascertaining whether nitrates

could be economically produced on a small scale, by the power obtainable from canal falls in India, but he was told that the smallest sized work required 20,000 H. P., and as he did not know whether there were any falls of this magnitude available, he did not pursue the matter any further. Yet he was anxious to see what results the use of nitrates gave if used on Indian lands. With that view in 1912 he bought a ton of nitrates, made in Norway, and paid £7 a ton delivered f. o. b. The consignment did not arrive in time to be used for the wheat sowings of 1912, but was used in the sowing of 1913, and in a month's time he would be able to say what difference the use of nitrates made in the yield of wheat. He would however give the cost. The price delivered in his village was seven rupees per cwt., and as it contained thirteen per cent. nitrogen, the cost per ton unit worked out to Rs. 10—the same as given by Captain Battye for castor cake. It so happened that the cost per ton unit, for crude nitrate of potash, also worked out to the same figure.

Zemindars did not mind spending money on manures of this kind if they could get increased yield to justify the extra cost. For instance, at Farrukhabad, castor cake is largely used for growing potatoes, and there, as much as forty rupees worth of castor cake is used per acre. Of course he would not say whether the land in other parts of India was equally suitable for the use of such manure.

MR. SCHONEMANN said that Captain Battye was looking ahead, and quite rightly so; for although the Punjab, generally had not yet arrived at a stage of intensive processes of agriculture, it would not be long before those processes would be found necessary. The conditions of the Punjab as regards soil, climate, and people greatly resembled in many respects those of the south-east of Spain, the inhabitants of which were quite as primitive and conservative in some respects, as they were enterprising in others. The Murcian or Valencian agriculturist, if clad in a *dhoty*, might easily pass for a Panjabi.

For at least fifty or a hundred years past, intensive cultivation had been practised in south-east and east Spain, for crops such as rice, alfulfa, oranges, olives, beans, tomatoes, pepper, and vines. Guano was imported in vast quantities; and besides guano various other substances were used for restoring the soil of Valencia, which would otherwise soon be worked out. Every peasant had a right to the silt, which he was obliged to remove from the watercourses within his ow estate. This he threw on

the banks for three months, then spread it out in the sun for a few days, and then deposited it in a pit prepared for manure. With it he mixed the calcareous dust which he was allowed to scrape off the public roads, provided he substituted gravel or sand. He added stable litter, rotten vegetable matter, etc., and formed a thick black manure, of which the chief danger was its too great strength. To prevent this, common earth was mixed with it, and the manure heap was frequently watered to prevent fermentation. The speaker wondered when the Punjabi peasant would rise to this pitch of enterprise ? He felt quite certain that canal engineers out here would not refuse a zamindar permission to utilize silt clearances for manure ; and that the engineers of the Buildings and Roads Branch would be only too pleased to allow some of the kankar dust of the roads to be similarly utilized !

Another means of manuring employed in Spain was by growing a crop of beans, which were meant to be mown down, but not carried off, before their fruit ripened, and then ploughed into the soil.

For intensive cultivation, however, the spur of a great pressure of population on the soil was necessary. In Valencia there was a population of a hundred and sixty people on a hundred acres of land ; and cases even occurred of a single family subsisting on the produce of two-fifths of an acre. In the Punjab we had not arrived at antyhing like this density of population ; and the principal crop was wheat, which would not repay the cost of intensive cultivation.

There were other directions, however, in which, as pointed out by Captain Battye, the hydro-electric power obtainable from canal and reservoir projects might be rendered remunerative ; as, for instance, in chemical industries. In a single corner of France, round about the town of Grenoble, there were hydro-electric installations at work generating over 500,000 H. P., whilst others, to the extent of an additional 700,000 H. P. were under consideration. Of the 500,000 H. P. already generated, only 155,000 H. P. was devoted to the production of light, and 10,000 H. P. to mechanical traction, the rest being employed in metallurgy, chemical productions, and manufactures generally.

Year by year, as the cost of living increased, and the more primitive and obvious natural resources of the country became exhausted, hydro-electric power projects were bound to force themselves more and more upon the attention of the Punjab

Government, and of the Punjab Public; and Captain Battye's Paper was welcome as a step in advance.

CAPTAIN ANDERSON said that the average production of wheat per acre in 1911 in different countries had been given in one of the technical papers as follows :—

	Bushels.
Great Britain	33
New Zealand	29
Canada	17½
Australia	12
India	11

and, consequently, he thought that any scheme for the manufacture of artificial manure had great possibilities. He would like to know whether a system of rotation of crops as practised in England would also be necessary in India if artificial manures came into use, and whether the zemindar could be got to adopt it. Regarding phosphates he had often wondered whether it would not pay to import the sulphuric acid and make the phosphates locally, instead of exporting all the bones and making phosphates elsewhere, to be again imported into this country."

The author had proposed to make use habitually of the overload capacity of his electric generators to furnish power for lighting, but this did not appear to be a very safe thing to do; it seemed rather like trespassing on the margin of safety provided to prevent accidents.

MR. ROBERTS (Professor of Agriculture Lyallpur,) said that rotation was already well understood by the Indian zemindar. Mixtures of crops were also common, and in these there was invariably a leguminous crop, *i. e.*, crop capable of fixing air nitrogen. There was reason to believe that these leguminous crops in India were able to fix very much more nitrogen than corresponding crops in Europe.

The area under intensive cultivation was small, and the use of castor cake in the Punjab was chiefly confined to Lahore, Sialkot, and Amritsar. Most of the cake produced in the oil mills in Lahore was exported to Bombay. Still he thought there was plenty of room for the use of castor cake in the Punjab.

Most of the oil seeds of India were exported to Europe for crushing, but, of the small amount crushed locally, cake to the value of forty lakhs was exported in 1906.

As regards the yield per acre in various countries, the yield in the United States was only about half a bushel higher than the yield in India. Again, the yield in Britain had only been increased four bushels since the introduction of artificials and this increased yield was probably due to improved methods of cultivation, and to the restriction which had taken place in the area under wheat, which resulted in only the best heavy land now being used for wheat.

SIRDAR LENHA SINGH asked whether there would be any prospect of small schemes—say, a quarter or even half the size of the Simla hydro-electric scheme—paying.

MR. R. E. PURVES said that some of the older members, who were present at Rupar in 1882 at the inauguration ceremony of the Sirhind Canal, would perhaps remember that the Viceroy in his speech significantly remarked that 'water and manure' should ever go together. Now, as if to remind Canal Engineers in this Province of an important and neglected subject, came Captain Battye's well considered and thoughtful paper. The paper had come at an opportune moment, when many Irrigation officers were looking round to find the means of improving the vast properties in their charge. It seemed a reproach to the Department not having done anything in this direction, but they had not been standing still since 1882. The Sidhnai Colony Canal, the Sohag Colony Canal, the Chenab Colony Canal, the Jhelum Colony Canal and the comprehensive Triple Canals Scheme had all been constructed. The irrigated area had been increased from two to nine millions of acres, more or less. The Department had been fully employed in building new canals ; in bringing into use the water of the great rivers ; in perfecting the designs of canals in every detail ; in solving new problems and in improving the revenue administration with a view to develop the Province along those lines which had promised greatest produce and largest returns. The Government's Punjab Canal systems spoke for themselves and bore testimony that the Department had not been idle through the [illegible] decades.

The Department was now considering what could be done for the storage of some of the surplus monsoon flow in the rivers ; how absorption losses could be reduced to a mininum, and what could be done to cure and prevent water-logging. To these, the speaker felt assured that the coming men would add, the development of canal water power for the production of artificial manure, and other purposes. The future held out

promise of advance in many directions, and they could trust their successors to carry on the good work with greater ability, resource, and success than they of the past have done.

Egypt, which was the cradle of irrigation science, was only now advancing in the direction of the manufacture, distribution, and sale of artificial manures. This is what Sir William Wilcocks wrote in 1904 in the second edition of his work on Egyptian Irrigation, " It would be a healthy innovation, indeed, " if the provision of suitable manures were to be considered as " an essential part of a project for providing perennial irrigation. " The day is not far distant, I believe, when governments, " which provide irrigation works, will also provide manures, " and sell the water and the manures together, one being as " essential as the other ; I know well, from observation, that a " well-manured field needs only half the water that a poorly " manured field does ; and in years of drought and scarcity " manures almost take the place of irrigation. Why should " there not be a manure rate as well as a water rate ? " Once " more in his third edition of the same work, he writes, " It is " the intention of the Egyptian Government to utilize part of " the power of the Aswan dam to manufacture pure nitrates " from limestone, or from the Sebayan rocks, and sell them to " the fellahin. If the Egyptian Government can perform this " task on a scale commensurate with its importance, it will have " been the first in the world to introduce a manure rate, as it " was undoubtedly the first to introduce a water rate. "

This was the position of affairs elsewhere. The time was at hand for a similar move in India and in the Punjab.

MR. NICHOLSON said he was glad to hear a senior officer state that Irrigation Engineers had been so overworked in the past that their whole time had been absorbed in the development irrigation, and that consequently they had not been able to give much attention to the development of power from canal falls. It had, however, struck him that the money which had been spent on mills, as shewn by an inspection of this year's Administration Report, had been a very remunerative investment for Government as shown by the following figures :—

	Capital Expenditure to date. Rs.	Revenue, 1912-13. Rs.	Total Revenue to date. Rs.
U.B.D.C. ...	1,47,530	1,14,731	39,50,926
S.C.C. ...	33,167	1,15,495	23,25,486

In both cases the revenue from water power was $\frac{1}{72}$ 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