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[Despatch Abstract.]

Directing that copies
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FURTHER PAPER, No.

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READ AGAIN ORDER OF GOVERNMENT, DATED
18, No., MISCELLANEOUS.

ENCLOSURES.

CURRENT No.

STATEMENT WITH DITTO.

ORDER OF GOVERNMENT.

LETTER OF GOVERNMENT.

STATEMENT WITH DITTO.

PAPERS NOT FILED UP, BEING MEANT FOR DESPATCH
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20TH DECEMBER 1892, No. 3472 W., PUBLIC WORKS.

GOVERNMENT OF MADRAS.

PUBLIC WORKS DEPARTMENT.

General.
Establishment.

READ—the following papers:—

G.O., dated 30th March 1892, No. 213, Public.

Read—the following letter from A. CHATTERTON, Esq., Professor of Engineering, Madras, to the Chief Secretary to Government, dated 28th January 1892:—

I have the honour to forward herewith, for the information of Government, two copies of a pamphlet entitled "Proposals for utilizing water-power in Southern India" which I have lately drawn up. I may add that I have placed the proposals before certain persons in London with a view to the formation of a syndicate of sufficient financial strength to justify it in applying for a concession of the water-power. In reference to the deposits of corundum mentioned in the paper, I would venture to remark that it seems to me highly desirable that more definite information as to their extent and value should be procured and made generally available. That these deposits are of considerable extent there is no doubt, but whether they are capable of yielding the mineral in the enormous quantities which are likely to be required in the future for the manufacture of aluminium in India or elsewhere is not at all certain. If the suggestions which I have made are ever carried out, 40,000 tons, worth at least 50 lakhs of rupees, can annually be disposed of in these works alone. I would therefore submit, for the consideration of Government, the suggestion that an officer be appointed to examine the deposits in question, to collect fair commercial samples of the mineral from the different localities in which it is reported to have been found, and to determine, with some approach to accuracy, the possibility of any important development of corundum mining and the probable extent which such development might reach.

ENCLOSURE.

Proposals for utilizing water-power in Southern India.

Apart from the actual amount of power obtainable from a waterfall its value, as a source of motive power, is dependent upon:—1, The constancy of the supply of water which it is proposed to utilize. 2, The convenience or otherwise of its situation. 3, The capital outlay required to render the power available and 4, The possibility of being able to usefully employ the power developed.

Briefly examining each of these conditions in view of their application to the project which the author proposes to bring forward—

1. It will be readily conceded that no matter, how great the average amount of power which might be obtained, if it is subject to extreme fluctuations, its value is very small. The keenness of commercial competition makes it absolutely necessary that the plant employed in manufacturing operations should be constantly at work, and this can only be the case when the supply of power is regular. As a general rule it is only worth while to make use of the minimum quantity of power, though in some few cases it may pay to provide the necessary machinery for utilizing the maximum power available, supplementing it in periods of deficiency by steam. In temperate climates, where the rainfall is fairly evenly distributed through the year, a comparatively small expenditure on storage reservoirs may serve to nullify the variations in the supply of water, but in tropical climates where the year is divided into wet and dry seasons the flow of water may be subject to such extreme changes in quantity as to render it

impossible to construct reservoirs of sufficient size to be of any use. Only when the power is obtained from very high falls, when a small quantity of water will yield a large amount of power, and when the configuration of the high land is such as to make it possible to cheaply construct artificial lakes or pools, is there any prospect of commercial success attending efforts to make use of the enormous quantity of power which at present runs to waste in nearly every mountainous region of the world. The hill districts of Southern India present peculiarly favourable features for the utilization of the energy stored in the water which drains from them. Elevated plateaux,—rising on the eastern slopes very abruptly from the plains, with a heavy rainfall over more than half the year, and with few entirely dry months, the construction of comparatively small dams or retaining walls will, in many instances, be sufficient to make it possible to ensure a certain minimum flow of water from them all the year round.

2. The inaccessibility or remoteness of the situation of the falls may be such that the power is of little value. The cost of opening up the country, of carriage of raw produce to, and of manufactured goods from, the site to the nearest markets may altogether outbalance the advantages which might otherwise be derived from the use of a cheap supply of power. In some few instances also climatic conditions may be so very unfavourable as to preclude any hope of being able to establish the large industrial colonies which must necessarily be provided for in any schemes for the utilization of power on a large scale. The greater the original inconveniences of the situation the greater will be the cost of remedying them, and in proportion to the outlay involved in railways, roads and means of transport must be the scale on which the development of the water-power takes place.

3. Our principal source of motive power is the steam engine, the cost of using which may be divided into (a) Interest on capital outlay and allowance for annual depreciation in value; (b) Cost of labour and superintendence; (c) Cost of fuel. The first is usually a comparatively small item compared with the other two, but in the case of power derived from water it is the principal item and is often so great as alone to exceed the total cost of producing power by heat engines. In England, where steam-power may be generated as cheaply as anywhere, the annual value of a horse-power is about £10, so that if we assume that on the capital outlay required for the generation of power from falling water the annual charge for interest, depreciation and superintendence is 10 per cent., then that capital outlay must not exceed £100 per horse-power, otherwise it will be cheaper to use steam as a motive force. This of course is on the assumption that the situation of the water-power is everything that could be desired, if it is not so then the amount of capital which may be expended on it diminishes as the disadvantages of the situation increase till the point is reached when it will not pay to use the water-power at all though it cost nothing to do so. For this reason so little use as hitherto been made of the gigantic quantities of water-power which run to waste all over the world. In the not very distant future it is highly probable that the electrical transmission of energy by high potential currents will effect a great change in this respect and will throw open a wide field, at present closed, for the utilization of water-power.

4. But wide as that field may be, the supply of water-power is so enormous that even were it possible to get it for nothing no use could be found for it. The millions of horse-power which could be obtained from Niagara would be a white elephant to the neighbouring districts, being entirely beyond the industrial needs of the population. It is evident therefore that any proposals for the utilization of water-power in Southern India, involving no question of the transmission and distribution of power over extended areas, must be equally applicable to many other places less remote unless the conditions are such that the power can be developed at such an extraordinary small outlay as to more than compensate for the disadvantages attendant on the localization of a manufacturing industry in such a place. That this is so the author will endeavour to show in the course of the explanation of his proposals, but before doing so he would like to make perfectly clear the idea which is the basis of the scheme for the utilization of the power after it is developed. As will be subsequently seen, it is contemplated to make use of a larger amount of power than has ever been attempted before and it is because this power can be profitably employed that the following proposals promised such a magnificent financial result. A manufacturing operation which can be carried on in a place far from the markets, which it is proposed to supply, can be carried on in any place where fuel is cheap, and it is therefore absolutely necessary that it should be of such a character that the cost of the power required to carry it on shall be one of the most important items in the cost of production. If then the power can be obtained at an exceedingly cheap rate, it may compensate for all other disadvantages, and the greater its amount, provided there be a practically unlimited demand for the finished product, the greater will be the prospects of commercial success. For instance, suppose that in England a steam engine of 500 horse-power is employed in the manufacture, by some electrical process, of aluminium then the cost of the power alone will be £5,000 per annum and we shall certainly not be very far from the truth if we assume that the capital outlay on engines, boilers and the buildings in which to put them is £5,000. Now, if in Southern India we can set up the necessary plant to develop the same amount of power from falling water, which costs nothing, for one-fifth that sum, we not only start with the advantage of saving four-fifths the capital outlay, but we have a clear £5,000 a year besides. But instead of 500 horse power we propose

to deal with an average quantity 250 times as great and the situation of the source of power would have to be extremely disadvantageous in which with that is equivalent to a bonus of £1,250,000 a year, it would not be possible to engage in a business in which the total amount of material to be transported is not more than 100,000 tons per annum. Moreover, since there is a saving of four-fifths the capital outlay required for the production of the same amount of power in England, that sum becomes available for providing the best possible means for reducing the disadvantages of the site of the works to a minimum. As will be subsequently shown, less than one-fourth this sum will be actually needed to put the site of the water-power which the author proposes to utilize in direct railway communication with the three most important ports on the Coromandal Coast, Madras, Negapatam and Tuticorin. If then it be admitted that the above remarks present a fair statement of the case for water-power it will be at once seen that the project that the author brings forward is one which offers great attractions for the employment of capital.

Before entering into a detailed account of the proposals, it will be well to briefly explain that the prospect is to manufacture aluminium by one or other, as shall afterwards be decided, of the now well known electrical methods. The power is to be derived from a supply of water which it is calculated will yield during four months of the year 75,000 horse-power and during the remaining eight months 150,000 horse-power or an average throughout the year of 125,000 horse-power. This amount of power will, it is believed, when converted into electric energy be capable of producing 15,000 tons of aluminium which will be worth, at £200 a ton, £3,000,000.

Source of the water and site of the proposed works.—The Government of Madras are at the present time engaged in diverting the water of the Periyár river, which rises in the Western Ghats and flows into the Arabian Sea near Cochin, from the western side of the watershed ridge to the eastern side, so as to make it available for the irrigation of a large tract of land (150,000 acres) near the town of Madura. The works which have been designed by, and are being carried out under the superintendence of the Chief Engineer, Colonel Pennycuik, R.E., consists in the construction of a masonry dam 155 feet high, whereby the waters of the river will be dammed back to form a lake having a superficial area of over 10 square miles and containing at the level of the escapes 13,299 million cubic feet of water. The water thus stored will be taken through the watershed ridge by a cutting and tunnel, having its site at a level of 113 feet above the bed of the river at the site of the dam. The quantity of water stored, which it will be possible to draw off, amounts to 6,815 million cubic feet, but as the watershed is situated in a region where the rainfall is at least 100 inches per annum, and as the area amounts to about 300 square miles, and as the rainfall is distributed over more than eight months of the year from April to December, it will be possible to draw off from the lake a quantity of water equal to 1,500 cubic feet per second from the middle of April to the middle of December, and as at the end of that time the lake will still be full it will contain enough water to deliver 750 cubic feet per second for three months and the drainage from the occasional showers which fall in the earlier months of the year will be more than sufficient to give the extra months supply which is required. The tunnel through the ridge will be about 6,000 feet long and will deliver the water on the eastern side of the ghats at an elevation of about 2,850 feet above the sea. The hills rise very abruptly on this side, so that in about a mile the water will fall some 1,300 feet, after which it will pass into the bed of the Suruliyár river which will carry it into the Vaigai, from whence it is removed by means of an anicut into the irrigation canals. It is this fall of 1,300 feet immediately after the exit of the water from the tunnel that it is proposed to utilize. It is situated near Kuruvanuth, a small village at the head of the Cumbum valley, some 70 miles from Ammayanáyakanúr, the nearest railway station on the South Indian Railway, which is 320 miles from Madras. It is evident, that if the water-power is to be utilized, it will be necessary to construct a railway from Ammayanáyakanúr to the site of the works, but this will probably have a sufficient traffic on it from outside sources to pay its own working expenses. For further information on this irrigation project, the author would refer to the selections from the records of the Government of India, Public Works Department, No. CCXV, entitled, "Papers connected with the Periyár Irrigation Project in Madras," or to a paper on the project read before the Indian Section of the Society of Arts by Colonel J. O. Hasted, R.E., on the 30th April 1891 and published in the Journal of the same Society.

Source of the Aluminium.—The compounds of aluminium usually employed for reduction by electrical methods are the oxide, Al_2O_3 and a double fluoride of aluminium and sodium, $AlF_3 \cdot 3NaF$, known as cryolite. The former compound is found naturally in a very pure state as corundum, and it is manufactured by various chemical methods, chiefly from Bauxite, a mineral of which extensive deposits occur in various parts of the world. In India, and more particularly in the southern part, there are numerous deposits of corundum which have been worked from time immemorial as a source of emery. They occur in the districts of Salem, Coimbatore, Bellary, North Arcot and Kistna, in the Native State of Mysore, and further off in Hyderabad, Rewah and the Khasi Hills in Assam.* As hitherto these deposits have only been worked on

* A brief summary of the information on the value and extent of the deposits of corundum in India, will be found in the Manual of the Geology of India, Part III, Economic Geology by V. Ball, M.A., F.R.S. London: Trubner & Co., 1881.

On an average of 125,000 horse-power day and night the capital outlay required therefore amounts to only 31/- per horse-power or less than one-sixth the annual cost of the same in the manufacturing districts of England. No wonder then that the author considers that this supply of water-power will be a source of immense wealth to those who are bold enough to make use of it to its fullest extent.

Electrical plant.—It is proposed that each Pelton wheel should be coupled up direct to a dynamo sufficiently large to absorb the whole amount of power developed. The type of dynamo to be employed the author prefers to leave to the decision of those who have some practical acquaintance with the use of the enormous currents which it will be necessary to employ in the reduction works. Similarly, as regards the electrical process to be adopted, the author, from a consideration of the somewhat meagre amount of information that has been published on the subject, merely makes the tentative suggestion that an electrolytic process rather than one in which carbon plays the part of a reducing agent will be preferable. Possibly, however, it may be found advisable to use both, and in order to make this section of the paper more complete, he has added in the form of an appendix a brief account of the Hall electrolytic process as used at Pittsburgh in America and at Patricroft near Manchester and of the Cowles' process as used at Lockport, N. Y., U. S. A., and at Milton in Staffordshire. From these it will be seen that the electrolytic process yields a very pure form of aluminium, whilst the electrical furnace is better adapted to the production of the alloys ferro-aluminium and aluminium bronze. It would be easy to produce the ferro-aluminium on a very large scale as the corundum deposits of Salem are situated at no very great distances from the extensive beds of magnetite, but in the author's opinion the manufacture of the pure metal would prove a more remunerative undertaking. It is impossible, however, from want of sufficient data to give an even approximate estimate of the cost of the dynamos, leads, reduction works and machinery and plant required to produce the aluminium and put it on the market in a commercial form. A lump sum of £1,000,000 will, in all probability, prove ample and upon that the final total estimate of the cost of carrying out the proposals is based.

	£
Preliminary expenses	100,000
Railway	280,000
Water-power	192,325
Buildings, workshops and dwelling houses for staff	150,000
Electrical plant	1,000,000
Total	1,722,325

The out-put of aluminium has been estimated at 15,000 tons per annum, worth £200 a ton, and upon this basis the gross revenue would be £3,000,000 a year, from which must be deducted the working expenses, of which the following is only put forward as an approximation.

	£
Depreciation and renewals of plant	200,000
40,000 tons of corundum or alumina at £20 a ton	800,000
20,000 tons of carbons at £5 a ton	100,000
Salaries and wages	250,000
Stores and plant	50,000
Royalties and patent rights	100,000
Total	1,500,000

leaving a net profit of £1,500,000, which on a capital of, say, £2,000,000, would be sufficient to pay a dividend of 75 per cent.

In conclusion, the author desires to state that his main object in writing the above paper has been to draw attention to the value of water-power when the conditions are favorable to its development. The figures which he has presented are necessarily somewhat rough, but the error lies rather in showing an excess of capital expenditure than in any under statement of what even where it, to cost twice as much as has been estimated, would still be a magnificent undertaking.

APPENDIX.

I.

The following account of the Hall process is chiefly compiled from articles which appeared in "Engineering" in April and October 1890.

The principle of the process is the electrolytic decomposition of alumina by a direct and continuous method. It was adopted by the Pittsburgh Reduction Company after working for a year with a small experimental plant. The material used is an oxide of aluminium which is

manufactured at Goldschmeidn near Breslau in Germany. The mineral Bauxite is fused with carbonate of soda in a reverberatory furnace. The fused mass is lixivated with water which dissolves the aluminate of soda formed in the furnace. The solution is decanted off and decomposed by carbonic acid gas whereby carbonate of soda is formed and alumina hydrate is precipitated; after repeated washings the precipitate is calcined at a red heat, the water driven off, and anhydrous alumina formed.

In carrying out the process a molten bath of various fluoride salts is issued. These are not decomposed by the electric current, but in the presence of it they assist in the decomposition of the alumina though the exact reactions which take place are not clearly known. At the Pittsburgh Works a series of open iron vessels or pots are placed on the floor of the melting house. The pots are of wrought iron and are lined with carbon, a depression or well being left in the bottom of each; a framework rising from above each pot serves to support a series of iron rods to the lower ends of which are attached the carbon electrodes; these bars are held in position by binding screws and are connected to the positive poles of the dynamo; the circuit is completed by conductors from the negative poles to the iron pots. Into these carbon lined receptacles a quantity of the fluoride salts is thrown. When the current is passed through this mixture it rapidly fuses but does not undergo any further change, nor any waste save that due to accidental spilling, no matter how long it may be kept in a state of fusion. Into this bath alumina is thrown and decomposition at once begins to take place. The oxygen is absorbed by the carbon electrodes, and the contents of the pots are reduced to a metallic mass which does not mingle with the fluoride bath. As the contents of each pot are run down alumina is added in small quantities, and from time to time the aluminium is ladled from the well in each pot and poured into moulds for subsequent recasting. The process is thus a direct and continuous one, involving the expenditure of a large amount of electric energy, but one into which the action of heat, beyond that necessary to fuse the fluoride bath and the alumina, does not enter. The metal is afterwards remelted and cast into ingots which it is claimed consist of 98.5 per cent. of pure aluminium. At Pittsburgh about 500 horse-power is continuously employed in the production of 375 lb. of metal per day. The alumina costs 5 cents a pound, but as it contains 54 per cent. of aluminium, nearly the whole of which is reduced, only two pounds of alumina are required to produce one pound of metal. The cost of the fluoride bath is merely nominal, the first cost of the materials being insignificant and the amount required, for making good waste, not exceeding 5 lb. for each pot per week. The carbons used for the electrodes are made from the products of the imperfect combustion of natural gas in closed chambers, the powder formed being compressed into blocks of the required shape. The consumption of carbon is equal to the weight of metal produced.

II.

The following details as to the working of the Cowles' process are taken from a paper read by Mr. J. H. J. Dagger to the Chemical Section of the British Association at the Newcastle Meeting in 1889:—

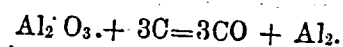
"The English works of the Company at Milton, Staffordshire, contain twelve furnaces with a 500 horse-power dynamo, built by Messrs. Crompton, and said to be the largest machine in England, and probably in the world; it furnishes a current of from 5,000 to 6,000 amperes, with an E. M. F. of 50 to 60 volts. The production of these works is 2,300 lb. of aluminium bronze (10%) and 1,800 lb. of ferro-aluminium (10%) per 24 hours, or 410 lb. of contained aluminium.

"The furnaces are rectangular in form, and are of fire-brick; into each end is built a cast iron tube, through which the carbon electrodes enter the furnace; each electrode consists of a bundle of nine carbons, each 2½ inches in diameter, attached to a head of cast iron for a ferro-aluminium furnace, and of cast copper for aluminium bronze or alloys containing copper. This head is secured to copper rods, or 'leads,' which can be readily connected with or disconnected from the flexible cables supplying the current.

"Each cable is secured to slides travelling on an omnibus bar of copper overhead, and so can be brought into position opposite the furnaces to be used. The electrodes are arranged so that it is possible, by means of a handle and screw, to advance or withdraw them from each other in the furnace. The first furnaces were lined with charcoal, but it was found that the intense heat converted it into graphite, which, being a conductor, not only meant loss of power but destruction of the furnace walls. This difficulty has been overcome by soaking the charcoal in lime-water and carefully drying before use; each particle of charcoal is thus coated with an insulating shell of lime.

"Lining the furnace is the first operation; the bottom of the trough is covered with a layer of prepared charcoal, the electrodes are arranged in the furnace, and a 'former,' a sheet iron box without top or bottom, each end being arched to fit over the electrodes, is inserted; charcoal is then rammed into the space between it and the fire brick walls. This done the charge of ore, mixed with coarse charcoal and the metal to be alloyed with the aluminium, in the form of turnings or granules, is placed inside the iron box, after which this is carefully withdrawn; the space between the electrodes is bridged with some broken pieces of carbon, the charge is covered

with coarse charcoal, and the furnace closed by a heavy cast iron cover, having a hole in the centre for the escape of gases evolved during the reaction; the cover is luted so as to prevent the entrance of air. The commencing current is about 3,000 amperes, and is gradually increased to 5,000 amperes; a 'run' occupies about 1½ hours. The furnace is allowed to cool; the next, ready charged, is connected with the cables, so that the process is a continuous one, the furnaces being successively charged and connected. The crude metal from the furnace is then re-melted in an ordinary reverberating furnace, a sample being taken from each run and assayed for aluminium. The nature of the re-action which takes place in the electric furnace is not very easy to ascertain; the conditions are unlike those of any other known: the reduction of the aluminium taking place in absence of air and in presence of an enormous excess of carbon, it may be assumed that, at the intense heat of the electric arc, the ore melts and gives up its oxygen to the carbon:—



"In the absence of copper the liberated aluminium absorbs carbon and is converted into a carbide of the metal. The escaping gas which burns at the orifice in the cover is almost entirely composed of CO."

Order—dated 30th March 1892, No. 213, Public.

The Government has perused Mr. Chatterton's pamphlet with much interest, but it will be pointed out to him that in having, without the previous sanction of Government, communicated with persons in London in view to the formation of a syndicate to obtain a concession of the water-power alluded to by him, and in making use, as he has, of information of which he has become possessed in his official capacity, he has committed a breach of a standing rule.

The Chief Engineer will be requested to report on the proposals contained in Mr. Chatterton's pamphlet, and also on the question of appointing an officer to specially investigate the subject of the supply of corundum available in Southern India.

(True Extract.)

(Signed) N. S. BRODIE,
Ag. Under Secretary.

Memorandum by the Chief Engineer, Public Works Department.

The fact that an enormous water-power would be available at Kuruvanuth on the completion of the works for the diversion of the Periyár has long been known to all who are interested in the subject, and Mr. Chatterton's pamphlet is an useful, though somewhat crude, contribution to the discussion of the important question as to the best means of utilising this power.

The works are designed and intended primarily for purposes of irrigation, and the Government would probably refuse to listen to any proposals which involved the subordination of irrigation interests to the utilisation of the water-power; the amount of power available depends, therefore, mainly on the amount of water which has to be drawn off from the lake for use in the Vigai valley, and not, as Mr. Chatterton seems to think, on the amount which "it will be possible" to draw off.

According to the latest proposals, the amount required to be drawn off through Periyár tunnel is in round numbers 1,400 cubic feet per second in July, August and September, 950 cubic feet in December, January and February, 700 cubic feet in October and November, 500 cubic feet in March and May, and nothing in April.

It will probably be necessary in any case to provide for the entire closing of the head sluice during a fortnight or so in each year, for the purpose of examination and repair of the tunnel gates and gearing, but, subject to this necessity, it will not be difficult to arrange for a minimum quantity of 600 cubic feet a second being sent down throughout the year, and this minimum is the true measure of the power available, as for manufacturing purposes a fluctuating water-power is of very little use; it is not worthwhile to erect plant and employ establishment for the utilisation of power which is only available for a few months in the year.

The actual fall available is about 1,000 feet, and the power which could be obtained from 600 cubic feet a second with this fall would be about 50,000 horse-power. This power would be available day and night, and if it were proposed, as for most manufacturing purposes would probably be the case, to work for only 10 hours out of the 24, it would be practicable, without detriment to irrigation, to send down a rather larger proportion of the daily supply during these hours.

It may, therefore, be assumed without risk of error that for practical work 70,000 horse-power would be available throughout the year.

The best method of obtaining this power from the water (irrespective of the question of its utilisation when obtained) is one of great interest both from a mechanical and financial point of view, as there is certainly no place in the world where so large a body of water is obtainable under complete control with so great a working head.

At Niagara proposals are now being considered for the utilisation of some 7,000 cubic feet of water per second, but the head there is only about 200 feet; the enormous head available at Kuruvanuth, while it increases the value of the water, increases also the difficulty of utilising it.

Mr. Chatterton proposes to bring the whole supply to the foot of the ghât by a steel-lined tunnel or inclined shaft 10 feet in diameter, and to distribute the power from the bottom of this shaft to thirty Pelton wheels, each capable of giving off 5,000 horse-power.

This arrangement, the object of which is to avoid the heavy cost of steel pipes, does not appear a good one.

In the first place it is by no means certain that sound rock would be found in the line of the tunnel throughout its whole length and the slightest unsoundness would be fatal to the whole construction. The steel liner is, as its name denotes, a mere inside skin and is not to be counted on for resisting the pressure of the water; it would burst at once if the support of the surrounding rock were removed.

The pressure on the inside surface at the bottom of the shaft would be over 60,000 lb. on the square foot, an amount not excessive for really solid rock, but exceedingly dangerous for any material short of this. The smallest unsoundness in the rock, even a slight irregularity in the cement grouting between the face of the rock and the back of the liner, and the latter would burst.

Before the work could even be begun, a very elaborate and costly examination of the ground would be necessary in order to find the angle at which the shaft must be sunk in order to ensure a minimum thickness of from 60 to a 100 feet of solid rock according to a level between the shaft and the face of the rock; this examination means nothing less than the removal of the soil overlying the rock throughout the entire length of the tunnel, for no borings could be accepted in such a position and the whole of this expense would be thrown away if it was discovered, as it probably would be, that the construction of the shaft was impracticable.

The excavation at the foot of the shaft to enable the connections between the latter and the motors to be made would be a far more troublesome business than Mr. Chatterton has any idea of. There is probably not less than 50 feet of earth gravel and boulders overlying the solid rock (and possibly a good deal more) and this must be cut away in order to drive the connecting heading, or else a brick-lined tunnel large enough to take the whole thirty pipes must be driven through it.

Another and very serious objection to Mr. Chatterton's proposal is that the regulating gear for starting and stopping the different motors must be at the bottom of the shaft, where it is under the full head, instead of at the top, where the pressure is next to nothing, as it can be with an independent pipe to each motor.

It is certain that the water must be conducted from the mouth of the tunnel to the motors by means of pipes, and the cost of these would not be so great as Mr. Chatterton supposes, for it is not necessary to use the whole available fall in one step; it can be divided into two, three or more steps, the loss of head at each step being insignificant as compared with the total fall, while the thickness and consequently the cost of the pipes would be greatly reduced.

It is useless at this stage to go minutely into figures, but it is certain that if steel pipes 3 feet in diameter were used, the fall of 1,000 feet being divided into three stages of 320 feet (40 feet being allowed for loss), the cost of the pipes and

motors would not exceed Rs. 45 per horse-power against the 31 shillings (or say 26 rupees) of Mr. Chatterton's estimate, a figure which would probably be greatly increased in practice.

The difference is not important as the cost of provision of power is only about a ninth of the total capital expenditure proposed.

For the utilisation of the power, it is probable that Mr. Chatterton is right in recommending the use of Pelton wheels, which are certainly the simplest and most economical. If the power be made available, and the quantity of ore required for working on a large scale be procurable, it is probable that no better method of utilising the power could be found than the manufacture of aluminium. At first sight it seems a startling proposal to carry ore 250 miles from the quarry to the place of manufacture, and to carry the finished product a still greater distance to a market, but after all this is simply a question of cost. All ore has to be carried some distance before working, and even if the works could be set up and the finished material disposed of at the quarry itself, the saving in carriage would not amount to more than Rs. 60 per ton. The cost of steam-power would certainly not be less than Rs. 180 per horse-power (24 hours daily) per annum, whereas at the Periyár, including maintenance, working and interest on plant, it would not be more than Rs. 20, if so much. As it is stated to require eight horse-power for one year to make a ton of aluminium, this implies a saving in the cost of manufacture (as compared with steam-power at the quarries) of at least Rs. 1,280 per ton or more than twenty times the cost of carriage.

It is of course necessary that railway communication should be made between Ammayanáyakanúr (the nearest existing railway station) and the site of the proposed works; this, as Mr. Chatterton rightly assumes, is an essential condition of the scheme. I have little doubt that a railway from Ammayanáyakanúr to Cumbum would give a reasonable return, not from the Kodaikánal traffic which is, and must always be, quite insignificant from railway point of view, but from the ordinary traffic of the Cumbum valley and the forests in the neighbourhood of the Periyár lake.

Whether the corundum deposits of Salem are of such extent as to justify working on the scale suggested by Mr. Chatterton is a question rather for the Geologist than for the Engineer, but the enterprise would be a lucrative one even on a much smaller scale.

Although the manufacture of aluminium is the most obvious and probably the best method of utilising the enormous power available from the Periyár, it is by no means the only one; the electrical transmission of power is still in its infancy, and he would be a bold man who should venture at present to set limits to the probable development of this principle even in the near future. It is by no means improbable that before many years are past it will be found practicable to supply both power and light from the Periyár to the towns of Periyakulam, Madura or even Trichinopoly.

I am certain that the question of the utilisation of the power derivable from the Periyár lake is one of the highest importance, and though its solution may not perhaps be within the direct province of Government, it will undoubtedly be to the advantage of the latter to give its support and encouragement to any well-considered scheme having this object in view. A charge of ten rupees per horse-power per annum, a charge so small that it would hardly be felt by the payee, would add about 20 per cent. to the revenue expected from the works, or increase the rate of return on the capital expenditure by something like 7 per cent.

MADRAS,
17th October 1892.

(Signed) J. PENNYCUICK, Colonel, R.E.,
Chief Engineer, P.W.D.

No. 4467 C.

Transferred to the Public Department with reference to G.O., dated 30th March 1892, No. 213, Public.

18th October 1892.

(Signed) J. PENNYCUICK, Colonel, R.E.,
Secretary to Govt., P.W.D.

No. 1831, Public.

The papers are transferred for the further necessary action to the Public Works Department with the notes of Honorable Members of Government in original.

22nd November 1892.

(Signed) J. F. PRICE,
Chief Secretary.

ORDER—dated 20th December 1892, No. 3472 W., Public Works.

His Excellency the Governor in Council observes that the papers recorded above show that on completion of the Periyár Project enormous water-power will be available and that its utilisation for industrial purposes may very largely increase the anticipated returns from the project without in any way prejudicing its primary use. These facts are, in the opinion of His Excellency in Council, so important as to justify a reference to the best engineering specialists at home. The papers will accordingly be forwarded to the Secretary of State for India in view to some practicable scheme being elaborated, for which a premium might be offered.

2. The papers will also be forwarded for the information of the Government of India with a request that this Government be furnished with copies of any reports which Mr. Holland may have made in regard to the corundum deposits in Salem or elsewhere, or with a special report from that gentleman with reference to the possibility of the supply of the mineral for the utilisation of the Periyár water-power when it becomes available.

[Here enter No. 3473 W., Public Works, dated 20th December 1892.]

(True Extract.)

[Signature]

Major, R.E.,
Under-Secy. to Govt., P.W.D.

To the Superintendent of Works, Periyár Project.
„ Public Department.

Exd. T. K. Narayana Aiyangar.
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G.O., 20th Dec. 1892, No. 3472 W.

26/12
A. Chatterton Esq.
The Educ. Dept.

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DECEMBER.

Water Power

Passing orders on correspondence regarding the utilization of the — which will become available on completion of the Periyár Project.